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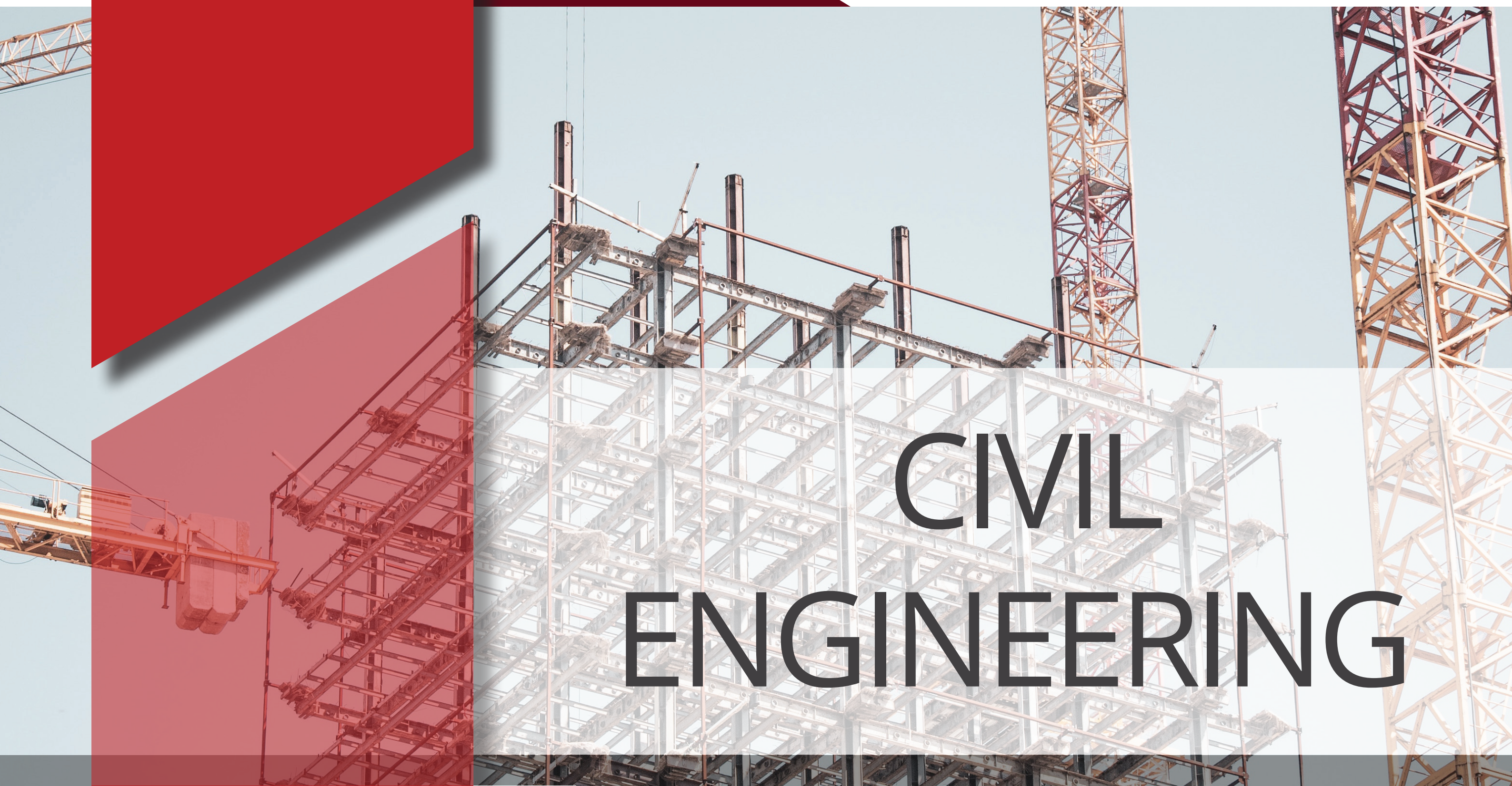

CIVIL ENGINEERING

Building construction 1

UNIVERSITY
OF APPLIED SCIENCES
UPPER AUSTRIA

VŠTE

EUROPEAN UNION

CONTENTS

1. INTRODUCTION TO BUILDING CONSTRUCTION

1.1. Basic terminology

Civil engineering means the art of construction or science or the constructional doctrine. Civil engineering is often confused with the word “architecture”, although building engineering concerns mainly structures while architecture predominantly deals with a form.

The building construction is the production sector, which is focused to survey, design and construction work, as well as renovation and maintenance of buildings and the final results are the finished buildings.

Architecture is, in the narrower sense, a building art that produces works that, in their shape and space, correspond to the practical purpose and the ideological requirements of the times, and the individual building that appears to be the architectural design. In the widest contemporary conception, architecture also includes the formation of the entire environment by artistic means in connection with available scientific knowledge.

The construction is a summary of supplies of building materials, materials, parts and works, often machines, equipment used to create a work on the basis of relevant documentation, and is generally firmly connected to the ground.

Building structures can be defined as structures, whose larger part is located on the earth's surface. The ground structures include buildings for housing, civic buildings (health care buildings, school buildings, sports buildings, cultural buildings, services and trade, construction sites for transport, administrative buildings, ...), industrial (production halls, workshops, warehouses, etc.) and agricultural buildings (stables, haymakers, greenhouses, ...).

Building object is spatially coherent or technically individual purpose-built part of the construction. The most common form of a building object is a building, a bridge or a road. The building is a set of building structures creating a spatial structure. The building structure must fulfil the required function.

Due to the limited physical and moral life of the buildings, besides realization of production and non-production buildings, another task is also maintenance, modernization and reconstruction of the buildings:

- **Maintenance** reduces the degree of degradation of structural elements, usually involves the renewal of protective surface coating.

- **Modernization** is an increase in the utility value of a building or its part without changing the purpose. The goal is to improve the standard of use.
- **Reconstruction** is to restore an object or its part into the original condition with the utmost emphasis on preserving the original appearance and design solution.

The basic objective of the building activity is to create a quality environment for the purpose for which the object is designed, while the quality should be ensured for the entire expected life of the building.

1.2. Basic requirements for building construction:

Architectural requirements:

- Urbanistic requirements: requirements for the structure and development of municipalities, intensity of land use and location of buildings

- Operational requirements: disposition (typological) requirements, divided and interconnected spaces, communication links

- Aesthetic requirements: shaping of the whole and its parts, color solution, monument care.

General requirements for building safety and use:

- Mechanical resistance and stability
- Fire safety
- Health protection of persons, animals and healthy living conditions and the environment
- Protection against noise and vibrations
- Building safety
- Energy saving and thermal protection

Resistance to external influences

Requirements for the well-being and quality of the indoor environment

Technology requirements

Economic requirements

Environmental requirements

1.3. Modular coordination

Modular coordination or dimensional unification ensures consistency between the dimensions of the building and its building components. This is a set of rules for determining the compositional dimensions of objects and elements. Basic rules for modular coordination of dimensions in construction are laid down in ČSN 73 005 (1990).

The module, labelled M, is the agreed length unit used to determine and coordinate dimensions in construction. Depending on the spatial layout, the ground module and the height module are disguished.

The basic (metric) module in the construction is equal to M = 100 mm. Until 1960, a 150 mm module was used. In accordance with EU regulations, the 125 mm module can also be used.

The derived modules are multiples or fractions of the base module:

- The enlarged module (200, 300, 500, 3000 and 6000 mm) is used as ground plan dimensions, i.e. the distance of walls, columns, pillars, etc.
- The reduced module (50, 20, 10, 5, 2 and 1 mm) is used, for example, for coordinate dimensions of the cross-section of building elements (columns, walls, beams, boards, etc.). Values of 20 mm or less are used to determine thicknesses of thin-walled elements.

The composability is a property of spatial parts of objects that allow them to be sorted, assembled, and deployed without the need to change or adapt their dimensions and shape. The dimensions of the construction elements must allow their mutual assembly to the larger assemblies.

- The coordinate (dimensional) dimension of the element is the dimension that the element occupies theoretically in the modular space network of the structure, i.e. including the relevant part of the joint, e.g. burnt bricks 150 x 75 x 300 mm.

- The basic dimension (formerly production dimension) of the elements is the size prescribed for the element production, assuming a zero tolerance. The basic dimension of the element is smaller than the composite dimensional dimension, e.g. burnt bricks 140 x 65 x 290 mm.

Prescribed basic (production) dimensions are technically impossible to always observe. The actual dimensions of the manufactured elements may differ from the prescribed basic (production) dimensions by the tolerance allowed (deviation).

1.4. Typification and prefabrication in construction

Typification is a process aimed at selecting a limited number of system building elements and technologies. Its goal is to reduce recurrent solutions, accelerate and increase the economic efficiency of construction. Typification is the unification of dimensions in the construction industry. Typification is used for individual elements or for whole objects:

- Elemental typification includes the manufacture of individual building components, such as ceiling panels windows, all of which are then assembled structures. The condition for their reusability is compliance coordination module dimensions.
- Object typification involves the complex solution of whole building structures or parts thereof, e.g. apartment buildings. The advantage of volume typing is the economy of construction. The disadvantage is uniformity and low variability.

Dimension unification allows universal use of the same elements mass-produced for different purposes.

Prefabrication is the production of structural components or parts thereof outside the site of their use (site). The individual prefabricated pieces are then brought to the construction site from the factory and the actual construction of the rough construction takes the form of assembly of the individual parts.

2. CONSTRUCTION SYSTEMS

2.1. Characteristics of construction systems

The construction system of the building is a complex of interconnected and interacting structural elements that interact with each other in relation to the surroundings. The most important function of the construction system is the load-bearing function. The construction system must also withstand the effects of the environment - static and dynamic loads, temperature, humidity, noise and other physical, chemical and biological effects. Each building is divided into floors and tracts.

The main components of the building include foundation structures, vertical load-bearing structures (walls and columns), horizontal load-bearing structures (ceilings, balconies, ledges), staircases, ramps and roof construction.

According to the static effect, the construction structures are divided into load-bearing structures and non-load-bearing structures:

- Load-bearing structures transmit any load acting on the object, e.g. bearing walls, pillars, roof structures, foundations.

- Non-load-bearing structures do not carry any load (except their own weight), they usually have a splitting or insulating function, such as internal partitions, peripheral insulating walls, doors and windows.

Cooperation of elements of the structural system must ensure system stability. Stability is the ability of a building to resist the external effects of the load without deformation (change of shape), deflection or total destruction.

The choice of the construction system depends on the parameters of the proposed building and it is based on the general requirements for the construction of the building structures. For the design of the construction system, the following parameters must be taken into account:

- Purpose, spatial and shape solution of the object
- Territorial and site conditions
- Dimensions and loads of ceilings
- Construction height of the floors
- Material base and technical possibilities
- Foundation conditions
- Environmental influences
- Fire safety
- Operational technical requirements

- Architectural requirements
- Energy performance of construction and operation
- Life expectancy
- Investment and operating costs, etc.

Design of the construction system should take place in dialogue and co-operation between the architect, designer and the technologist in order to achieve an optimal solution for taking into account all requirements. Due to the variety of requirements and their mutual harmonization, the proposed construction system is always a compromise solution.

2.2. Basic classification of construction systems

Construction systems can be divided into:

- Construction systems of multi-storey buildings: are characterized by vertical load-bearing structures carrying all the loads into the foundation soil. These supporting structures ensure the stability of the whole object. Construction systems of multi-storey buildings include wall systems, skeleton systems, their combination or core construction systems and superconstruction.

- The construction systems of hall buildings are characterized by their roofing and free interior layout.

Floor (storey) is part of a building defined by two consecutive levels of the upper surface of the supporting part of the ceiling structures. At the lower floor, based on the raised terrain or embankment, the plane is defined by the upper level of the underlying floor structure.

The vertical distance between the upper surfaces of the support structure ceiling is referred to as structural floor height. The headroom is defined by the vertical distance between the floor surface and the lower level of the ceiling structure of the same floor.

The tract is the space part of a building defined by two consecutive vertical planes passing through the geometric axes of vertical wall or column structures. The building can be single-tract or multi-tract. Depending on the position in the building, we recognize the tracts of the transverse tracts and the longitudinal tracts:

- Longitudinal tracts are parallel to the longitudinal axis of the building.
- Transverse tracts are perpendicular to the longitudinal axis of the building.

According to the arrangement of the vertical structures of the object relative to its longitudinal axis, the construction systems are divided:

- Longitudinal systems
- Transverse systems
- Two-way systems

According to the building technology used, the following construction systems are recognized:

- Brickwork systems (masonry) made of pieces building material connected to a mortar or other bonding layer.

- Monolithic systems made of ductile building materials deposited into a mold and solidifying directly in the structure.

- Prefabricated systems composed of pre-fabricated components which are interconnected in the joints.

- Combined systems

3. CONSTRUCTION SYSTEMS OF MULTI-STOREY BUILDINGS

3.1. Basic classification of construction systems of multi-storeys buildings

The construction system of multi-storey buildings is characterized by the predominance of vertical load-bearing structures, transferring all loads to the foundation soil.

According to the type of vertical load-bearing structures, the construction systems of multi-storey buildings are:

- Wall construction system
- Column construction system (skeleton construction system)
- Combined construction system
- Core structures
- Superconstruction

3.2. Wall construction system

The loading of ceiling structures and the effect of horizontal forces are transferred to the foundations by means of load-bearing walls. Wall systems are used in buildings with requirements for smaller indoor spaces (e.g. Accommodation facilities). The inner load-bearing walls must meet the static requirements. In addition to static functions, the outer load-bearing walls must also meet the thermal-technical parameters. Openings in the load-bearing walls must meet the requirements without compromising static feature walls. The wall construction systems are divided according to the layout of the supporting walls in the building:

LONGITUDIAL CONSTRUCTION SYSTEM

The load-bearing walls are arranged parallel to the longitudinal axis to form longitudinal tracts. The ceiling structure is normally laid in a direction perpendicular to the longitudinal axis of the building.

Spatial rigidity in the longitudinal direction is provided by the longitudinal supporting walls themselves. The stiffness in the transverse direction is ensured by the ceiling structure, possibly by the transverse stiffening walls (e.g. gable wall, staircase wall, mezzanine wall, etc.). Objects with a longitudinal wall system are usually made of bricks or blocks.

Due to the static function of the load-bearing walls, the size of the window openings is considerably limited, the facade is a massive impression without architectural variability. The advantage of the longitudinal construction system is openness of disposition and variability. The disadvantage is the small architectural variability of the facade, the lower stiffness of the system and the resulting usability only for buildings with a small number of floors.

TRANSVERSE CONSTRUCTION SYSTÉM

The load-bearing walls are perpendicular to the longitudinal axis of the building and form transverse tracts. The ceiling construction is realized in the longitudinal direction.

Space stiffness and stabilization are provided by the supporting walls themselves in the transverse direction. In the longitudinal direction, stiffness is ensured by additional walls and a longitudinally laid ceiling structure.

Internal load-bearing walls can be used to ensure that acoustic requirements are met between rooms (hotel rooms, apartments, etc.). The peripheral non-bearing walls are mainly function to protect the internal environment against climatic conditions (heat-insulating function).

The disadvantage of the transverse construction system is less variability and dispositional freedom. The advantage is better structural stability and suitability for objects with more floors.

TWO-WAY CONSTRUCTION SYSTÉM

In the case of a two-way (bi-directional) construction system, the supporting walls are arranged in the longitudinal and transverse directions. Ceiling structures can be stored in both directions.

The advantage is high room stiffness and stability. The bi-directional system is suitable for high-rise buildings. The disadvantage is the very limited layout and low variability of the interior space.

3.3. Column construction system – skeleton system

Principle of the column system consists in separating the load-bearing function and the function of cladding. All loads carry vertical elements - columns. Non load bearing walls perform the function of separating and insulating (cladding, partitions). For columns, only heavy-duty materials such as steel, reinforced concrete or wood are used.

The advantage of column systems is the relaxation of the layout and the variable design of the building. The disadvantage is lower spatial rigidity compared to wall systems.

According to the method of transferring the load, the column system is divided:

- Frame skeleton system (beam and column system, post lintel system)
- Flat slab with column capital skeleton system
- Flat slab skeleton system

FRAMES SKELETON SYSTÉM

The basic element of the frame skeleton is a frame made up of two columns and a beam. Ceiling loads are transmitted to the columns via frame bars. Frames can be single or multi-storey. According to the arrangement of frames in a building distinguished:

- Longitudinal frames: The beams are parallel to the longitudinal axis of the building. Due to the low space stiffness, this system is mainly used for low-rise buildings. Bracing provide intermediate transverse walls (e.g. gable walls) or cross beams (girders). The disadvantage is the shading of the interior space and the limitation of the possibilities of façade rendering. An advantage is the free layout for longitudinal distribution.

- Transverse frames: The beams are perpendicular to the longitudinal axis of the building. Transverse frames are well-resistive to horizontal loads and are also usable for larger buildings. The transverse frames allow for a variable appearance of the facade and do not interfere with the interior of the building. The disadvantage is the more complicated management of longitudinal installations.

- Two-way frames: The beams are positioned in the transverse and longitudinal directions. Two-way (bidirectional) frames are characterized by high stiffness and are suitable for high-rise buildings or for buildings with substructures or seismically unstable areas.

FLAT SLAB WITH COLUMN HEAD SKELETON SYSTEM

Flat slab with column head skeleton system carry the load on the columns through the expanded column heads (capital). The column capital protects the ceiling slab from piercing and shortens its effective span.

Flat slab with column head skeleton are very affordable and are suitable for objects with a large load of ceiling structures, especially for manufacturing and storage facilities. The disadvantages of skeleton with column head are the visible column head and the more difficult to guide the vertical installation.

FLAT SLAB SKELETON SYSTEM

Flat slab skeleton system has a ceiling structure supported directly by columns. In thin slabs real danger puncture plate column. There is a real danger of piercing the slab by column. The piercing of the column can be prevented by increasing the reinforcement above the supports. Flat slab and column joining can be done either with a hidden column head or a hidden beam.

Flat slab skeleton system has low spatial stiffness and must be complemented by wall or core fasteners. These skeletons are used in buildings with a small load of ceilings, especially for civil buildings and residential buildings.

The advantages of the flat slab skeleton are the flat ceiling and the possibility of bi-directional installation guidance.

3.4. Combined construction systems

Combined construction systems are based on the advantages of individual construction systems. The combination of load-bearing walls and columns creates diverse spatial formations with high stiffness and minimum weight. The column construction allows for free variability and layout options. Columns carry the load from the ceiling structure and the walls fill the stiffening functions and provide spatial stiffness and stability.

Combined construction systems can be implemented in a number of variations:

- Combination of longitudinal wall system with inner column system
- Combination of transverse wall system with inner column system
- Combination of transverse and longitudinal walls with inner column system
- Combination of two-way (bidirectional) column system with inner core

3.5. Core construction system

The core construction system transfers the load to the building foundation with a central stiff core. All functions and operations that do not require lighting and direct ventilation are designed to the core (lifts, staircases, installation shafts, etc.).

The construction of individual floors of core systems can be carried:

- Primary lower horizontal supporting structure cantilevered overhang from the parterre core which carries the secondary uprights upper floors.
- Primary upper support structure disposed in the core head, on which the ceilings of the lower floors are suspended.
- Ceilings individually executed from the core into which all loads are transmitted directly.

Core systems are used mainly for the construction of high-rise buildings with a square or circular ground plan. Their advantage is the release of the ground floor and easier ways of setting up. The possibility of significant architectural design attracts architects, even though it is statically and structurally complicated solution.

3.6. Superconstruction

Superconstruction is two-stage building constructions that arise by concentrating loads into a limited number of massive elements of the main (primary) supporting structure into which a secondary (secondary) structure is inserted. The superconstruction is especially used for extremely tall buildings over 50 floors. The primary structure is proposed with a long life, thus allowing the possible change of the secondary structure.

The primary load-bearing structure is typically formed of a super-frame by which each floor having a height corresponding to the height of several storeys inserted. The secondary structure is then inserted into the super-frame space, and the secondary structure is made up of subtler elements. The secondary structure can be mounted or suspended on the superconstruction. There can be a free open hall space between the suspended and stored floors.

4. CONSTRUCTION SYSTEMS OF HALL BUILDINGS

4.1. Construction systems of hall buildings

Hall buildings allow the creation of free spaces with little or no internal support. The characteristic feature of hall buildings is a large ground plan and a relatively small height. Hall objects are used especially for single-storey buildings. Unlike the construction systems of multi-storey buildings, the hall buildings are characterized by a supporting roof structure.

The hall object can also include internal built-in floors with different height requirements:

- Two-storey halls
- Large-scale halls
- Combined monoblocks

The hall buildings are characterized by extremely high variability. The repeatability of the types of indoor buildings is significantly lower compared to multi-storey buildings, they are far more individual objects.

Hall objects are used especially for:

- Cultural purposes (theatres, cinemas, exhibition pavilions, gathering, etc.)

- Sports purposes (multipurpose and sports halls, tribunes and stadiums roofing, swimming pools, etc.)

- Manufacturing and storage purposes (production halls, warehouses, markets, etc.)

- Traffic purposes (station halls, platforms roofing, car and bus garages, service halls and repair shops, docks, etc.)

In most cases, hall objects have a split supporting function and cladding. The load-bearing function transfers static and dynamic loads to the foundation structures. Cladding provides the desired state of the internal environment and consists of roof cladding, curtain wall and substructure.

The design must be solved, depending on their spatial stiffness, in order to capture the horizontal forces in the pushed and drawn systems, to allow for greater deformability of the structure (especially for drawn systems). The interaction of the subsystem and the assembly (packing) structures and the overall stabilization of the roof sheets in the tensile systems is of considerable importance.

From the viewpoint of static stress, hall structures can be divided:

- Bending construction systems
- Compressive construction systems
- Tensile construction systems

4.2. Bending construction systems

The basic element is a bend-loaded, simply inserted or interlocking element that transmits primarily vertical loads. All load on the simply stored element is transmitted by bending stress in the middle of the span. The load capacity then depends on the cross sectional modulus of the beam and the permissible stress of the material. If the beam structure is cantilevered into the support (the structure is rigid), a bending moment is created in the support area, which is also transmitted by the supporting (vertical) structure of the frame system. As a result of the interaction of the supporting structure, the bending moments in the frame are reduced. Since the upper beam of the beam and the frame beam are stressed, stability must be ensured before turning. Structural systems stressed mainly on bending include plate systems, trusses and frame systems.

PLATE SYSTEM

Plate systems, as it is already apparent from the title, are made up of different types of boards (with reinforced ribs, cellars, etc.). They are designed to stretch to 24 meters and element widths up to 3 meters. To ensure stiffness, the boards are interlocked.

A plate structure could be formed of uni-directionally or bi-directionally tensioned structures carrying bending loads in both directions. The system consists of plates from planar or spatial lattice trusses.

TRUSSES SYSTEM

Truss system consists mainly of the roof trusses (beam elements) deposited on the columns, beams or walls. Trusses can have different shapes (straight head, rack, saddle, arc etc.), various structural solutions (solid panel, lattice etc.) and various material design (reinforced concrete, steel, wood etc.). The roof trusses are stored within the roof surface elements (ribbed or cassette panels with lightweight slab) or roof purlins carrying the roof cladding.

FRAME SYSTEM

The frame system transfers the frame bending moment to the frame stand as a result of the rigid connection. A disadvantage of bending stress of machinery frame can be partly eliminated by a continuous frame structure design. The course of the bending stress in the structure depends on the bending stiffness of the stand and the riser, and the ramps are also affected. The higher bending moment is then concentrated in places with higher bending stiffness. The frame structure may be in the form of a cantilevered frame, two-hinge or three-hinge frame or cantilever frame. The construction can be solved from concrete (reinforced concrete structures, monolithic or prefabricated), steel (thin-walled or full-body profiles) or wood (solid or lattice, etc.).

4.3. Compressive construction systems

If the arc shape or flat structure designed in the shape of the load pressure line (resultant line or area), the structure transmits pressure loads. Since the shape of the structure is stable but the load is not necessary, part of the load is transmitted by the bending moment. The design should be designed to convey the prevailing load by its own weight and snow. This creates a parabolic shape of the compressive structure. The static effect of the compressive structure can be achieved by shaping the frame construction so that the frame bending capacity is zero. The support system then transmits the vertical and horizontal responses of the arched (compressive) structure. Compressive construction systems include arc structural system, flat compressive construction system (vaults and shell), rod structural system and folded slab structure system.

ARC STRUCTURAL SYSTEMS

Arch structural systems have a support system designed for buckling pressure in combination with a bend. The stiffness of the sectional structure prevents buckling in the plane of the arc. Stiffness of the ceiling boards and own flexural rigidity prevents deviation from the plane of the arc. Arcs can be clamped, two-or three-jointed articulated. Most often steel or reinforced concrete is used as a material. The construction itself can be lattice or full-body. Spans these structures may reach 100 m.

FLAT COMPRESSIVE CONSTRUCTION SYSTEMS – VAULTS

The vaults are loaded with buckling pressure and bending. The stresses are transmitted by overvoltage of the cross section due to the prevailing vertical load. The construction result is a massive vault construction and limited ability to transfer point loads. For correct design, it is important to know the shape of the result line from the load by the weight of the structure. The material is used mainly stone or brick. For the proper functioning of the vault, the shape of the resultant line is significant from the load by the weight of the structure itself. The pressure lines must always remain inside the cross section core (in the case of the rectangle in the inner third of the height).

FLAT COMPRESSIVE CONSTRUCTION SYSTEMS – SHELL

The shells have a small structural thickness and the bending loads are transmitted only to a limited extent. The stability of the compressive parts is ensured by using the shape of a double curvature construction or by co-operating with reinforcing ribs and shell faces.

ROD STRUCTURAL SYSTEM

Rod structural systems have to a certain extent similar effects as a flat construction of the same shape. The principle of a slab or rod structure is an effort to replace the static effect of a flat structure with bars made of reinforced concrete, steel or wood. The cylindrical vault-shaped rod structure acts as a cylindrical shell clamped into rigid front walls.

FOLDED SLAB STRUCTURE SYSTEM

Folded slab structure is formed from flat triangular elements creating a rigid spatial system. Suitably selecting the shape of folded slab can be achieved by translational or rotational surfaces.

4.4. Tensile construction system

The tensile construction system includes suspension systems, pneumatic systems and suspended systems.

SUSPENSION SYSTEMS

The suspension systems may be truss, panel, cable and membrane structures. The elements do not have bending stiffness and are arranged in parallel or radially in a single layer or multilayer arrangement. Load transfer occurs through the normal force in the profile and the horizontal component of the supported reaction. This component lifts the support system high above the terrain. This requires its efficient construction design.

PNEUMATIC SYSTEMS

Pneumatic systems are carried by overpressure of the internal air. The construction consists of a thin membrane preloaded with internal overpressure. In the case of low-pressure structures, the overpressure in the entire space is 100-300 Pa and is stabilized by large spans in combination with surface stiffening ropes. For high-pressure structures, the air pressure is 0.1-0.5 MPa and is concentrated in the so-called skeleton of the object (ribs, curves). Less sponge up to 25 m are used.

SUSPENDED SYSTEMS

The principle of the suspended system is the suspension of the roof beam by means of bars anchored to pressed pilots, arcs or frames, etc. It is a multistage system reminiscent of the so-called supersconstruction in multi-storey buildings. It therefore belongs to efficient roofing systems for large spans (150 m or more).

5. DILATATION OF BUILDINGS

5.1. Dilatation of buildings

The construction joint is defined as the distance between the two building blocks. This type of joint does not have the volume or shape changes - the gap is constant.

The expansion joint is a joint that divides buildings or their individual parts into smaller rigid units. Dilatation is performed to prevent transmission of non-force effects from one part of the structure to another so as not to interfere with the required functions.

The expansion joint is carried out in areas predicted extreme loads, loss of stiffness of the structure, structural changes, changes in the construction system and layout, in places of change of height of a structure or object, in places of geological breaks and irregularities.

Unforced effects include:

- Volume changes due to temperature
- Volume changes due to moisture
- Rheological effects (creep of concrete and shrinkage)
- Changing the shape of the foundation joint (bottom surface)

Unforced effects cause mechanical stresses in structures that often exceed the stresses due to common force effects (self-weight, wind load, etc.).

Splitting the structure of a building into individual components, which tend to vary in shape and different subsidence, is appropriate for reducing stress. Expansion units can be defined as smaller parts of the structure separated from the whole by expansion joints.

Expansion joints eliminate:

- Static effects - volume changes, uneven settling
- Dynamic effects - shocks
- Acoustic effects - noise transmission of structures and vibrations
- Heat-technical effects - Heat and moisture transfer of structures

5.2. Volume changes

Each material changes its dimensions with a change in temperature and humidity.

Volume changes can be caused by:

- Changing the temperature of the external and internal environment (thermal expansion of materials) - each material

- Changing the moisture of the materials (drying and swelling)

- Rheological changes of the materials

    - Shrinkage - Volumetric changes due to drying of water from the structure of solidifying and hardening concrete, shrinkage depends on the composition of the concrete mixture, its processing, dimensions and reinforcement of the elements.

    - Creep of concrete - volumetric changes due to the load size and the time depends on the composition of the concrete mixture, its processing, and the dimensions of the reinforcement element, load size, load type (permanent, accidental, dynamic) and the time of the load.

- As a result of chemical processes in materials (e.g. corrosion)

Stress elements due to volume changes can lead to:

- Element breakage by tensile cracks
- Compression element failure
- Expanding effect on surrounding structures
- Creation and expansion of joints between element and surrounding structures
- Rheological changes of materials

5.2.1. Structural principles and structural solutions

Expansion joints pass through the whole object except the foundations. On the contrary, the foundation structure is reinforced to eliminate uneven settling. The width of the dilatation joint is proposed in the range of 10-30 mm. The number of expansion joints can be influenced by appropriate architectural and volumetric solutions. Expansion joint must allow movement in all directions.

Maximum distance of expansion joints in masonry with lime mortar:

- burnt bricks 100 m
- sand-lime bricks 50 m
- concrete blocks 50 m
- natural stone 60 m
- reinforced concrete 40 m

For plain or weakly reinforced concrete, the maximum lengths of monolithic expansion units for the protected structure are 30 meters and for the unprotected structure 24 meters. The maximum size of the dilatation units of the steel structure is determined by static calculation.

Construction design of the expansion joints:

- Duplication of supporting structures
- Unilateral sliding fit
- Cantilevered ceiling structure
- Inserted field with slide bearing

5.3. Uneven settling

- Irregularities in the substructure of the object - irregular and oblique loading of soil layers with different compressibility, different levels of groundwater level, undermined area, additional changes in the subsoil or level of ground water level

- Different loads in the footing bottom - different height of the part of the building, different utility loads in different parts of the building, inappropriate design of the area of individual flat foundations

- Different foundation structures of parts of the building – the combination of shallow and deep foundations

- The time interval between the realizations of the different units of the building - the new part follows the older one, where the settlement has already taken place.

5.3.1. Structural principles and structural solutions

Design principles for expansion joints:

- Expansion joints must allow vertical displacements
- Expansion joints pass through the whole object, including the foundations
- Foundations must not interfere with one another
- Must comply with the required thickness joints

Design solutions for the implementation of expansion joints:

- Sided cantilevered horizontal structures
- Reversible cantilevered horizontal structures
- Fields inserted
- Modulation adjustment

6.SUBSOIL AND EARTHWORKS

6.1. Foundation and subsoil

The foundation engineering is engaged in designing and establishing the foundations manner. The foundations are load-bearing components of objects that provide the load carrying structure into the subsoil. The foundations must be designed to safely transmit all loads with minimal distortion and without breaking the subsoil. According to the way the load is transferred, are distinguished shallow foundations and deep foundations.

Subsoil is a functional part of the building. The footing bottom is an area where the foundations meet the subsoil.

Soil is unpaved or slightly hardened rock

Rock is a heterogeneous mixture of various minerals, sometimes organic compounds, volcanic glass or a combination of these components.

Topsoil is the upper thin layer (100-300 mm) on the surface with plant and animal residues. Topsoil is rake off before work and later is thrown back around the building.

Mud is clay soil mixed with a considerable amount of silica sand, mica, calcium, iron and organic matter. If it contains more than 40% sand, it is referred to as skinny mud. At a sand content below 40%, it is a greasy mud. Holding greasy mud in hand, it sticks and holds together, while the skinny mud does not stick and decay. These include brick clay, fireproof mud and kaolin

Clays are siliceous sediments, consisting of 25-30% clayey earth and 65-70% more silicon dioxide. They are always very fine, without sand or mixed with fine sand, very colloidal and water impermeable. The water gets on the volume, shrinking by drying. A special kind of clay is bentonite, which is very fine, so it has properties of colloidal substances. It receives plenty of water - up to seven times its own weight.
Marl or marlstone is clay-mud containing 25-60% calcium carbonate and magnesium carbonate. Marlstone soil have tended to sliding. There are very dangerous.

Fusible mud containing a mixture of alumina or lime clay, sand and mica. Contains 10-40% lime. Water-tight. It is slightly softer than clay, and in nature it has a slate structure. This group also includes shale or claystone, often containing coal.

Loess is a fine, sandy, dusty wind. It consists of a higher content of calcium compounds and up to 50% of dust, mostly silica. It has less ductility than clay and marl. Loess is yellow to light brown, so is often confused with mud. If we put it between our fingers, it is finer than clay, since it contains grains of sand less than 0.1 mm. It draws water and its water permeability is very considerable because it is penetrated by the hair channels. The unpleasant nature of the loess is its great tenderness: up to 5-6 m above the ground water level. However, if it is dried up thoroughly and properly, it is permeability for water is relatively small.

There are 3 classes according to soil exploitation:

- Class I is defined by mining by conventional excavation mechanisms (bulldozers, excavators) or by hand.

- Class II is defined by mining with special mechanisms - rippers, rock spoon, hammers

- Class III is defined by mining by blasting works

6.2. Deep of foundation

Depth of foundation affects the size of the building's settlement. Greater depth reduces the overall settlement construction. The depth of foundation is the difference between the level of the footing bottom and the closest terrain point. The depth of foundation is determined with respect to stability and settlement construction, climatic conditions (freezing, drying out of the soil) and geological and hydrogeological soil profile.

The minimum depth of the foundation is determined by climatic conditions - winter temperature and the type of soil. In the case of freezing of footing bottom under the foundations, there is a real risk of increasing the volume of soil under the foundations (water changes in the state of ice to increase its volume) and thus the formation of stresses and consequently faults. Depending on the soil, we choose the depth of foundation:

- 500 mm for rock and weak rocks soil and under the interior walls
- 800 mm from landscaped terrain (loose soil outside the mountain range)
- 1000 mm from landscaped terrain (cohesive soils outside mountain areas)
- 1200 mm in cohesive soils with ground water depth less than 2 m deep

Depth of foundation in mountain conditions always depends on local climatic conditions. The type of soil is always determined on the basis of the site survey results. In the case of inappropriate soil types, the soil can be improved by replacing with other soil (cushions), compaction, drainage, soil admixtures (grout, lime) or by drying.

On cohesive soils, due to the load, the water is exuded from the pores and thus partially turns into mud and consequently decreases the foundations. That is why rough sand or gravel is used as drainage under the foundation. The height of the embankment must secure the isobar under the foundations so that the stress is less than the bearing capacity of the foundation soil.

6.3. Earthworks

Earthworks in civil engineering are divided into preparatory earthworks, major earthworks and finishing earthworks.

The main types of earthworks are clearances, embankment and backfills. The clearances eliminate terrain inequalities. It also includes rake off the topsoil. The topsoil is surface organic soil with a thickness of 150 to 300 mm. The embankments are poured structures built on the surface of the territory. The embankments are formed over thin layers (150 - 700 mm) which are compacted. The backfills are sprinkled structures that fill the space below the terrain level and around the building structure. The bulk material is frost-free, stable and low compressible materials (e.g. gravel). The backfills need to be compacted. The most important earthworks are excavations.

6.4. Excavations

Excavations are carried out by excavating below ground level. The area in which excavations are made is called the excavation site. Exhausted soil is called a borrow material.

According to the shape and dimensions of the excavation, there is a pit, trench and shaft. The pit is an excavation whose length and width is greater than 2 meters. The furrow has a predominant length dimension and a maximum width of 2 meters. The shaft has a predominant depth dimension and a maximum floor area of 36 square meters.

The lifting of the soil is carried out by various types of earthmoving machines. Hand excavations are limited to clearing work. The method of excavation is chosen according to the volume and type of rock.

The footing bottom must not be broken during excavations. It must also be protected from climatic effects (rain, flooding, drying and freezing). The soil layer (approx. 200 - 500 mm) is retained at the bottom of the excavation as a protection layer, which is removed just before the realization of the foundations.

6.5. Ensuring structural stability of excavations

Excavation walls must be secured against landslides. The choice of method depends on the excavation depth, physical-mechanical properties of the soil, the loading of the edges of excavations and the time the excavation remains open.

Vertical walls can be excavated in cohesive soils with a depth of no more than 1.5 meters. In other cases, excavation walls must be provided with one of the following options:

- Sloping walls of excavations: The slope of the excavation walls should be as steep as possible because the cubes of earthworks and the excavation area are increasing. At the same time, minimal slope, defined primarily by the angle of internal soil friction and the coefficient of soil cohesion, should be respected ((e.g. sandy gravel 1:1, clayey sand 1:0.50, dust 1:0.25). In excavations deeper than 3 meters, slopes are interrupted by field benches with a minimum width of 500 mm.

- Shoring of excavation walls: Shoring is a temporary building structure that protects sloping walls against landslide during excavation work. Timbering must be done directly with the excavations. Timbering consists of sheeting and bracing. Sheeting is flat part of shoring which is in direct contact with the soil. Sheeting consists of wood or steel planks laid vertically, horizontally or obliquely. Soil pressure acting on sheeting is intercepted by horizontal and diagonal struts. Depending on the construction and the method of implementation, we distinguish:

    - Shoring with attached sheeting: Attached sheeting is used in cohesive and incoherent soils. According to the coherence of the soil, the struts are laid either at a meeting or with spaces, horizontally or vertically

    - Piles shoring: Piles shoring consists of a piles rammed into the subsoil. Horizontal sheeting is triggered between pilots. Bracing pilot induces high strength sheeting. This method can be used in wide construction pit and up to 20 m depth. Piles shoring cannot be established in boulder soils where the defects cannot be pulled to the required depth or at the necessary distances.

    - Weft shoring: Weft shoring is used in construction pit and grooves. It may be vertical or oblique.

    - Driven shoring: Driven shoring is carried out in cohesive, cohesive and incoherent soils where we can get secure enclosed space in which we can work. It is the costly and hardest way of shoring.

- Triggered shoring: Triggered shoring is used in less cohesive soil at excavation depth of up to 6 m. Carved frame from round logs, columns, vertical shoulder and wedge.

- Underground walls: Underground walls are used to secure the walls of deep excavations, in blank space or at a great load on the edges of excavations. Depending on the building material used, we distinguish the underground walls of clay, clay-cement and concrete. Underground walls can fulfil not only the function of armor and sealing, but also the function of construction and foundation for the peripheral load-bearing masonry. Milano's underground walls are made up of a continuous groove with a depth of up to 40 meters, into which prefabricated concrete panels are launched or they are concreted in a width of 0.6 - 1.0 m and at the same time serves as the load-bearing wall of the underground part of the building.

- Pile walls: Pile walls can be used in soils and rocks with low strength. The individual piles overlap each other below the groundwater level. Piles simply touching above the water level and the axial distance is less than 2 m. Non-anchored piles are used up to 6 m if the span is larger, they are anchored or bracing.

- Sheet pile walls: Sheet pile walls are used in cohesive to solid and non-cohesive soils (outside the boulders). They can be used below the level of ground water. The locks are connected to each other to ensure water tightness. The best known type is Larssen sheet piling which can be used up to a depth of 20 m. After finishing the work, it is possible pull out and re-use them.

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