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LOGISTICS AND TRANSPORT

Transport constructions 2

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CONTENTS

1. RAILWAY SUBSTRUCTURE

In terms of construction, a railway track is divided into two basic parts, **railway substructure** and **railway superstructure**. The boundary between the substructure and superstructure is a substructure sub-grade.

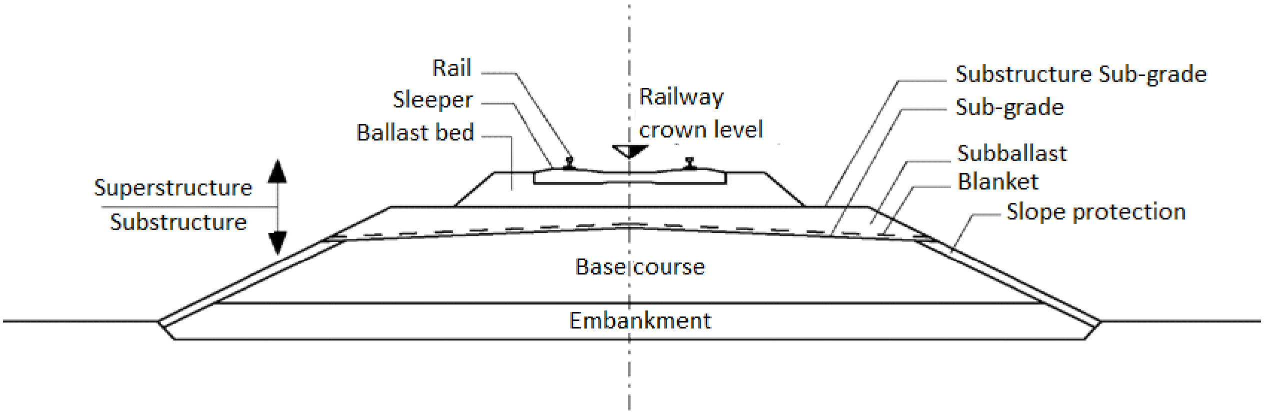


Figure 1 – Cross-section of a railway track
Source: http://www.4-koridor.cz/index.php?t=article&n=clanek-technika-46

1.1. Railway substructure construction

Railway substructure is an engineering structure that consists of a substructure base or a rail substructure construction, adjacent transport areas and communications. In addition, the substructure includes small substructure constructions and equipment (e.g. drainage facilities).

The **substructure base** is formed by a base course or artificial structures. The base course can either be:

- in the noth,
- in the embankment,
- in the cut.

Artificial structures of the railway substructure are structures that either **substitute** or **protect** the substructure:

- bridges and viaducts,
- culverts,
- tunnels,
- walls (protective or retaining),
- other protective structures.

The base course must provide sufficient stability of the rail superstructure even during adverse weather conditions. The shape of the base is designed according to the requirements of railway transport taking into account the properties of the material used, and the bearing capacity of the subsoil on which it will be placed. The substructure base must be sufficiently strong to ensure a permanent geometric position of the track.

Sub-grade = substructure sub-grade is the upper contact surface of the base course with the track structure (the boundary between the rail ballast as a part of the rail superstructure and the upper layer of the substructure). Because it is part of a multi-layered system that carries a railway track, it must be protected from the effects of frost. This is achieved by a sufficient thickness of the structural layer of the rail substructure, possibly using other insulating materials.

Structural layers of substructure sub-grade - material layers between the substructure sub-grade and sub-grade. They improve the water and temperature mode of the rail substructure and increase the load-bearing capacity of the substructure base. They serve to transfer the effects of the operational load and the load of the railway superstructure on the sub-grade.

The width of the substructure sub-grade in a straight track with a normal gauge is 6.0 m for a single-track railway. In a curve with an elevation from 31 mm to 150 mm the sub-grade is widened at the outer side of the curve by up to 0.2 m depending on cant. The width of the sub-grade in a straight double-track railway is 10.0 m.

Sub-balast – a structural layer of substructure base under the rail ballast bed. Its main function is to distribute the effects of the operational load and the load of the railway superstructure on the sub-grade, or to protect the sub-grade against the effects of water and frost.

Sub-grade protection layer - a structural layer that protects the sub-grade from the adverse effects of frost. It must be made of non-frosty, incoherent and permeable materials, or thermal insulation layers. The functions of protection layer are fulfiled by sub-balast.

Drainage of substructure base is provided outside of its base course, either by open drainage devices (track ditches, upland ditches, channels, etc.) or covered drainage devices (drainage piping, intake shafts, geodrens, etc.). From a construction point of view, various trench modifications can be designed, either unsailed or reinforced by trench blocks. If it is necessary to reduce the volume of earthworks at deep cuts in cohesive soils, prefabricated drainage channels are designed instead of trapezoidal trenches.

2. RAILWAY SUPERSTRUCTURE

2.1. Railway superstructure construction

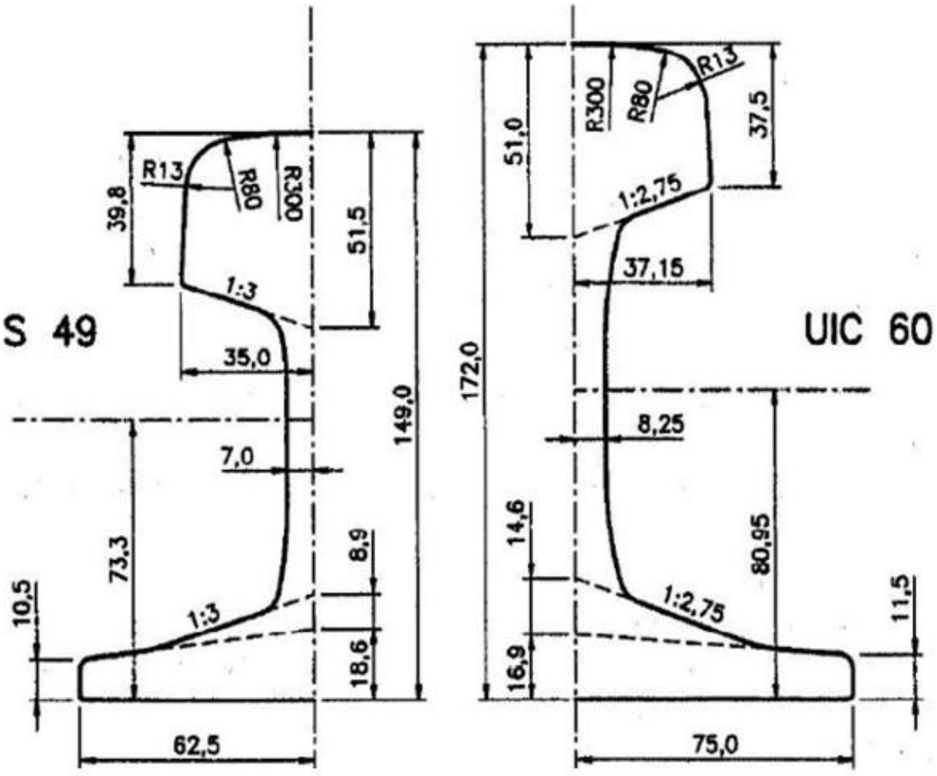
Railway superstructure is a construction that forms the guideway for moving railway vehicles (thus fulfilling a support and guidance function). The railway superstructure has undergone a gradual development during the history of railway, and its construction has now been stabilized in the shape of a **track grating** that is laid in a **rail ballast bed**, which is made of gravel or stone crushed rock of a corresponding grainsize. The track grating consists of:

- railways (rails),
- sleepers (slab, longitudinal, frame, etc.),
- rail fastening system (rail clips, baseplates, rail pads, insulators, nails, coach screws, clamps, fish bolts and clipping bolts etc.).

Rails

Rails are the most important part of railway superstructure, since they directly take over the loads of moving vehicles. Moving vehicles load rails with large static pressures and dynamic shocks, therefore they are made of a massive piece of steel. Railroad tracks in the Czech Republic use flat-bottom rails. Tramway transport use girder guard grooved rails or block grooved rails. In terms of higher loading rates and higher speeds selected national railways and modernized railway corridors make use of rail type UIC 60 and on regional lines smaller rails type S 49 are used (see Figure 2). You can also see the R 65 rail on the national railways (however, it is no longer used on newly built modernized lines). Rails consist of these parts:

- rail head (with running surface);
- rail web;
- rail foot.



Cross sections and dimensions of the S 49 and UIC 60 rail

Figure 2 – Cross sections and dimensions of rail types S49 and UIC 60
Source: http://www.prazsketramvaje.cz/view.php?cisloclanku=2010031701

2.2. Railway superstructure structures

The structures of railway superstructure include railroad crossings, points (switches), turntables, derailers, overhead lines, platform buffers etc.

Points/Switches are structures (or constructions) of rail superstructure which branches the track into two or more tracks and which allow the railway vehicle to pass from one main track to another one into a diverging track without stopping and vice versa. Depending on their structure, switches can be divided into:

- common;
- double (symmetrical or asymmetrical);
- diamond;
- curve, etc.

A **common switch** allows a train to be guided from a straight track to a diverging track (a curve with a radius r). Normal switch consists of three basic parts (see Figure 3):
the switch, in which one track is divided into two, its base is formed by movable **switch rails/point blades**;

- the centre, which consists of crossing rails between the switch and frog part;
- the crossing, whose base is formed by a **cross frog**, in which the outer rail of the diverging track crosses the inner rail of the straight track.

The stationary parts of rails are called stock rails and devices protecting from derailment of a train when passing through the switch are called check rails.

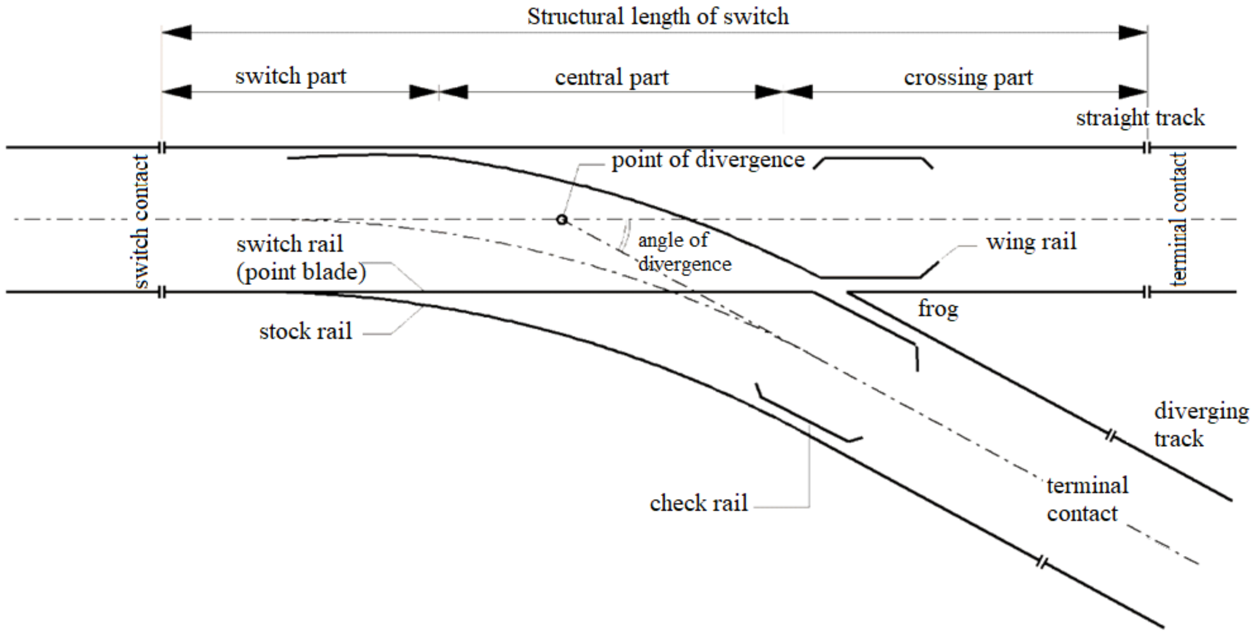


Figure 3 – A diagram of a normal switch with its parts
Source: http://www.4-koridor.cz/index.php?t=article&n=clanek-technika-46

Track crossing is a crossing of two railway tracks adapted to enable rail vehicles to safely travel along their tracks. It is not the **diamond crossing** as rail vehicles are not technically able to cross from one track to the other.

3.WATERWAYS

Transport ways in water transport refer to **maritime shipping routes** or **inland waterways**. In oceans, seas or enclosed water areas they refer to frequently used, recommended, or marked navigation routes. Inland waterways refer either to naturally navigable or artificially navigable rivers and lakes or built channels (canals designed for navigation).

3.1. Types of waterways

According to the technical nature, waterways can be divided into:

- **Waterways with free water surface** – naturally navigable rivers or rivers with artificially modified navigability (regulated rivers). Natural rivers should have sufficient water flow, sufficient depth for navigation and stable water level. However, the seasonality of navigation occurs in many stretches of such rivers allowing passage only in certain time periods. This can be partially avoided by building regulatory structures on natural watercourses.

- **Waterways with elevated water surface** – they are either channelized watercourses, artificially built channels or canals. Channels are usually used only for agricultural and irrigation purposes, while canals are mainly used for navigation. Channalized rivers have sufficient water level in most sections of the watercourse thanks to the so-called lock and dams.

Inland waterways are generally multipurpose waterworks. They are not only used for water transport; they also serve in various other fields such as (Krajčovič 2006):

- water management, for improved drainage, improved flow, flood protection, improved purity of streams;

- power engineering, power generation in hydropower plants, providing cooling water for thermal and nuclear power plants;

- industry to provide technological and cooling water supplies for drainage and wastewater treatment;

- agriculture, irrigation water and drainage of drained areas;

- sports, recreation and landscape enhancement;

3.2. Classification of waterways

It is based on the parametres of typical vessels that should move safely on a given waterway. The length, breadth, draught (draft) and load bearing capacity of a motor cargo ship are considered to be the standard ship parameters, as well as the length, width, draught and load bearing capacity of a pushed convoy, the minimum bridge clearance value, or the graphical resolution method on maps.

- **Waterways of regional importance** are small waterways enabling smaller vessels to pass. Their individual classes technically correspond to the gradual historical development of the size of vessels in Europe over the past 200 years. Regional waterways usually refer to historical canals or stretches of smaller rivers or the upper river flows of larger rivers. They are no longer considered promising for freight transport and further development of their network is not assumed. However, their use is now increasing for recreational cruises. Their classification is derived from the older classification of waterways adopted by the CEMT in 1954 - Seiler's Classification of Waterways (cs.wikipedia.org).

- **Waterways of international importance** (with the exception of historic class IV) allow passing of larger vessels or convoys with a length of 95 to 110 meters and a width of 11.4 meters. Unlike in the classification of regional waterways, a modular principle is consistently applied whereby the pushed convoys are assumed to consist of one or more standard units (craft) and one pusher, while the design vessel for one unit was represented at that time by the most widespread Rhine lighter Europe II, with dimensions of 76.5 x 11.4 meters with a draught from 2.5 to 4.5 meters, the parameters of which are suitable for the transport of standard containers. For classes V to VII, therefore, a higher-class waterway is able at one time to let pass a formation containing **two or more units** corresponding to a lower waterway category, including one pusher pushing a formation.

At present, the issue of waterways of international significance is also covered by the European Agreement on Main Waterways of International Importance (AGN), which established the basic classification of waterways into individual classes (see Table 1):

Trieda vodnej cesty	Motorové nákladné lode a člny					Ťlačné supravy					Minimálna výška pod mostami	Grafické znázornenie na mape
	Názov	Dĺžka	Šírka	Ponor	Nosnosť	Schéma	Dĺžka	Šírka	Ponor	Nosnosť		
		m	m	m (2)	t		m	m	m (2)	t (3)	m (4)	
IV	Mot.loď Johann Welker	80-85	9,50	2,5	1000-1500		85	9,5	2,5 2,8	1250-1450	5,25 alebo 7,0 (6)	
Va	Veľká motor. loď	95-110	11,40	2,5-2,8	1500-3000		95-110 (7)	11,4	2,5-4,5	1600-3000	5,25 alebo 7,0 alebo 9,1	
Vb							172-185 (7)	11,4	2,5-4,5	3200-6000	7,0 alebo 9,1 (6)	
VIa							95-110 (7)	22,8	2,5-4,5	3200-6000	7,0 alebo 9,1 (6)	
VIb	(8)	140	15,0	3,9			185-195 (7)	22,8	2,5-4,5	6400-12000	7,0 alebo 9,1 (6)	
VIc							270-280 (7)	22,8	2,5-4,5	9600-18000	9,1 (6)	
							193 200 (7)	33-34,2 (7)	2,5-4,5	9600-18000		
VII (9)							285-295 (7)	33 34,2 (7)	2,5 4,5	14500-27000	9,1	

Table 1 – Classification of waterways of international and regional importance
Source:
http://fast10.vsb.cz/krajcovic/!kombinovane/!dopravni_a_vodni_stavby/pomucky_k_reseni/pdf/VODNI_DOPRAVA_KOMBI.pdf

Explanation: **třída vodní cesty**- class of waterway, **motorové nákladní lodě a čluny** – motor cargo ships and barges, **tlačná souprava** – pushed convoy, **minimální výška pod mostem** – minimum bridge clearance, **grafické znázornění na mapě** – graphical representation on a map.

4. PARAMETRES OF INLAND WATERWAYS

4.1. Watercourse improvement

The first method that involves a minimum change into the character of the river is to achieve sufficient depth, especially in critical sections, by systematic deepening of the bottom of the river bed by regular **dredging** of ditches and shallows in a designated fairway. In cases where this method does not guarantee a sufficient navigational depth, i.e. the distance between the river bed and the bottom of a vessel at the required draught of the vessel, the second method of making a river navigable called **river regulation** is considered. We try to achieve the following goals when making a river navigable:

- to ensure a minimum depth that is 30 cm greater than the draught of a vessel and the minimum width of fairway, even at the minimum flow rate,
- the speed of water should not exceed 2 m/s during the maximum flow rate,
- to allow ice and flood deposits transport through the entire stretch,
- there must be no deformation of fairway during the flow of large water.

If neither cyclic dredging nor the regulation do not bring the desired effect for river navigation, river **channelization** is considered. It refers to the method in which, by means of damming the river and the construction of successive navigation-energy levels, the water level is elevated so that the shipping depth is sufficient even at the lowest water flow rate.

The benefits of channelization are:

- permanently ensured depth for navigation,
- deceleration of the flow rate in the weir pool,
- time savings when going upstream,
- safer shipping traffic.

Disadvantages of channelization:

- a great time loss when passing through a lock chamber,
- deposits of flood sediments in the weir pool,
- faster freezing of the water surface at lower flows, i.e. shortening the navigation season.

4.2. Parametres of waterways

The type of used vessel or barge based on the classification of waterways is important for dimensions of a waterway. A smooth navigation requires ensuring and designing the following:

- the smallest depth of fairway;
- sufficient radius of waterway curves;
- the width of the fairway;
- sufficient cross-sectional area of canals;
- maximum current speed;
- vessel speed;
- bridges, or minimum bridge clearance.

It is also important to avoid waves, which could disturb the structure of the shore by their effects. Where necessary, longitudinal dams or reinforced shores are built. From the point of view of the cross section of artificial channels we distinguish:

- Rectangular shape;
- Bowl shape;
- Trapezoidal (most common)
- Transient shape (transition between trapezoidal and rectangular shape)

5. PORTS ON INLAND WATERWAYS

5.1. River ports

Ports represent the places in navigation network where passengers board or get off, or where goods are loaded or unloaded (**commercial public ports** or **industrial non-public ports**), there are other modes of transport and some can also be specially designated. Special ports include **protective harbors.**

Ports should be designed so that the following requirements are fulfilled:

- fast and safe entry and exit of ships into and out of ports
- smooth and safe maneuvering of the ships in the port, anchoring of ships and assembling and dismantling of ship formations
- fast loading and unloading of ships
- direct connection to other modes of transport

As far as port location is concerned, there are either ports situated directly on the waterway (the marginal edge along the watercourse) and ones lying outside the waterway and are formed by:

- Water areas, collectively referred to as **pools**, including entrance to port, access channels, roadsteads, turning areas and sufficient area for maneuvering the ship.

- Land areas called **territory**. They consist primarily of transfer areas, handling areas, warehouses and storage areas, transport infrastructure, etc. The transport infrastructure is particularly important for connection to a public road network, but it is equally important to connect to the railway infrastructure. The rail link to the port consists of a harbor rail network and a siding or access track that connects them to the nearest freight train station. We can also find there less important administrative buildings, and some ports can also be equipped with equipment for ship repair or docking.

- **A port edge** that separates the territory from the pool and where the goods are transhipped or the passengers board or get off. For the transhipment of goods there are built cranes (portal, rail, etc.) and other handling equipment which load the goods to the means of transport provided by other modes of transport (railway or road freight vehicles).

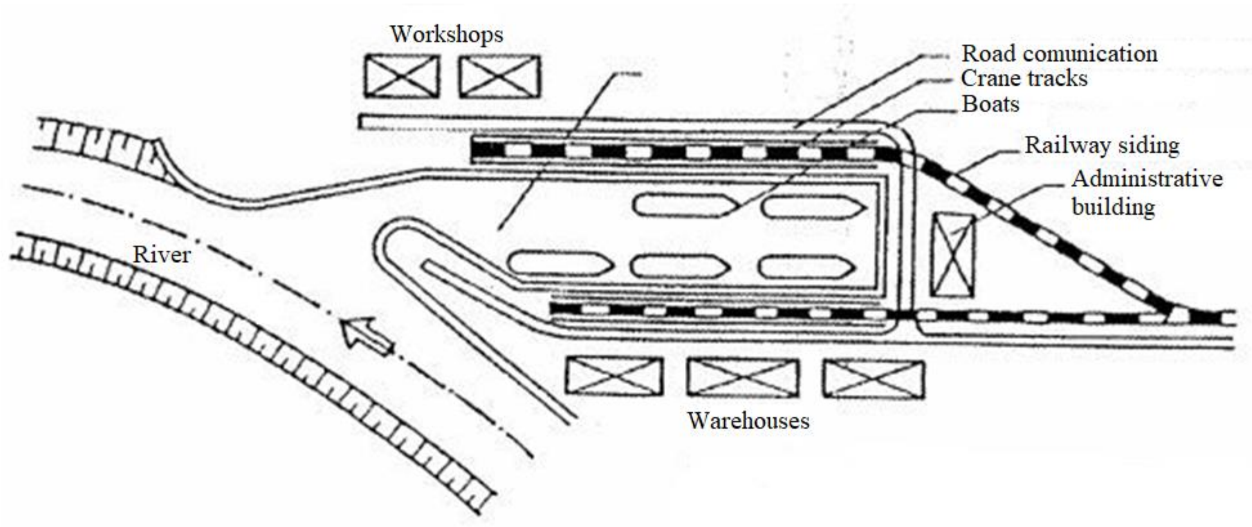


Figure 4 – A scheme of a port with one pool
Source:http://fast10.vsb.cz/krajcovic/!kombinovane/!dopravni_a_vodni_stavby/pomucky_k_reseni/pdf/VODNI_DOPRAVA_KOMBI.pdf

6.OTHER BUILDINGS ON WATERWAYS

6.1. Buildings on waterways

The most important buildings on channelized rivers and artificial canals are **lock and dams**. These are constructions that consist of several functional parts and can be formed by:

- elevating equipment - a weir or dam that provides sufficient water level and divides the waterway into into the upper and lower weir pool (reservoir);
- devices for enabling navigation of vessels - e.g. lock chambers or ship lifts;
- hydroelectric power plant so that the lock and dam can also perform an energy function;
- auxilliary equipment such as fishways, residential buildings, workshops, etc.

Passage from one weir pool (or reservoir) to another is provided by a navigation equipment for covering the height difference. It is most often a **lock chamber (lock)** in the shape of a rectangular reservoir of certain parameters, which will allow the passage of ships and barges. At both ends of the lock chamber there are upper and lower heads formed, inter alia, by lock gates serving for closing the chamber. The required height of water level in the lock chamber is provided by a filling and emptying mechanism operating on the principle of Archimedes law. Lock chamber also includes various devices, for example, bollards, which serve for tying up the vessels in order to level the water surface to the level of the lower or upper water (the lower and the upper roadstead).

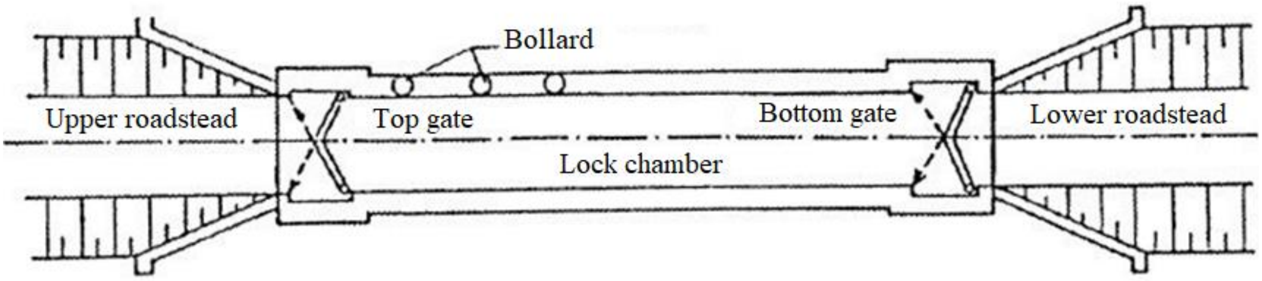


Figure 5 – A scheme of a lock chamber
Source:
http://fast10.vsb.cz/krajcovic/!kombinovane/!dopravni_a_vodni_stavby/pomucky_k_reseni/pdf/VODNI_DOPRAVA_KOMBI.pdf

Depending on the way of water inflow into the chamber and its outflow from the lock chamber, we distinguish these filling and emptying systems of lock chambers:

rect filling and emptying of the lock chamber - filling with the help of top gate is, however, slower than the one of indirect filling;

- **indirect filling** and emptying of the lock chamber - a more even distribution of the water flow into the chamber by means of several inlets or bypasses along the entire length of the lock chamber. From the point of view of the layout, we divide the bypasses into short,
medium and long.

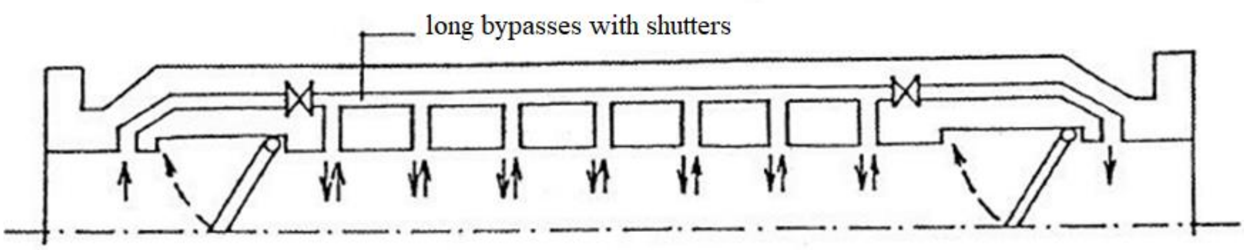


Figure 6 – Layout of long bypasses of lock chamber
Source:
http://fast10.vsb.cz/krajcovic/!kombinovane/!dopravni_a_vodni_stavby/pomucky_k_reseni/pdf/VODNI_DOPRAVA_KOMBI.pdf

Lock gates are movable and fulfil a damming function, they retain the water in the lock chamber from the water in the upper or lower weir pool (upper and lower water). The water area adjacent to the gates where the vessels enter or exit is referred to as the **upper and lower roadstead**. There are several gate types, for example:

- supporting, plate gate;
- sluice gate;
- buckling gates (most common);
- segmented gate;
- sliding gate etc.

At higher gradients, covering of the greater elevation differences on a channelized river is enabled by a **ship lift** (**lift lock**) instead of lock chamber. In contrast to the lock chamber, it is a device operating on a mechanical principle, when the whole chamber with the vessel (channel) is mechanically driven to a higher weir pool, for example by means of rails. We distinguish the following types of ship lifts:

- **vertical ship lifts**, which can be broken down according to the used mechanical principle:
  - piston ship lifts;
  - ship lifts with counterweight;
  - float ship lifts;

- other various special types.

- **Sloping ship lifts** with a longitudinally or transversely mounted channel, the channel is driven at a certain angle e.g. on the rails.

  - In addition to lock and dams, other artificial objects can be found along waterway routes:
  - Road bridges crossing the waterway, or underpasses, which are very rarely designed;
  - Objects for leading watercourses under the waterway, i.e. culverts etc.;
  - Security gates on channelized stretches that, in the event of dam damage, separate the section from the remaining parts of the weir pool and prevent leakage of water from the entire wair pool;
  - Passing points on longer single-ship sections;
  - Canal bridges (for leading canals through watercourses or valleys) and canal tunnels, etc.

7. AIRPORTS – AVIATION INFRASTRUCTURE

Within the aviation infrastructure we can include buildings, facilities and equipment that have a direct impact on the organization and management of air traffic in the airspace or on the ground, or allow the movement or servicing of aircraft on land. It is possible to **divide the infrastructure into three parts**:

- **Airspace** is controlled or uncontrolled airspace above the territory of the state into a height that can be used for air traffic. Airspace is for flying of the airplanes under the conditions laid down by the laws of that State, by international treaties, by ensuring the rules of flying that lay down procedures for flying in the airspace.

- **Airport** consisting of a territorially defined and suitably adjusted area, including buildings and facilities permanently destined for take-off and landing of aircrafts and aircraft movements related thereto.

- **Air services** to ensure the safety and fluency of air transport in the airspace of a given state (territory).

7.1. Aviation infrastructure in the Czech Republic

There are 90 civil airports in the Czech Republic. The list of all the airports and their technical parameters is published by the Ministry of Transport in the Aeronautical Information Publication (AIP), which lists Instrument Flight Airports (IFR) in Part I and Part II, and Visual Flight Rules (VFR) in Part III. **Act No. 49/1997 Coll., On Civil Aviation**, as amended, further defines the classification of airports according to several aspects, two of which are mentioned bellow:

- **according to technical conditions, operating conditions and basic designation:**
  - **Domestic aiports** - they are designed and equipped to carry out domestic (national) flights;
  - **International airports** - a customs airport, designed and equipped not only for domestic flights, but also for flights crossing the state border of the Czech Republic, ie they are equipped with passport, customs, health and other controls. These services may be provided on a permanent basis or on request for each non-scheduled flight;

- **by user group:**
  - **Public airports** - an airport that can accept all aircraft by its operational capability. They are owned by private legal entities;
  - **Non-public airports** - airports where the user range is designated by its operator,
  - **Military airports** - airports, which serve only the needs of the Army of the Czech Republic.

7.2. Airport codes

Airport code serves to determine the individual characteristics of an airport so that it matches the parameters of the aircraft for which the airport is designated. Airport codes consist of two elements - the number from 1 to 4 and the letter A-E (see Table 2).

- **The code number is based on the operational characteristics of the aircraft and is based on the nominal runway length**. It sets out the parameters for runways and obstacle limitation planes and surfaces.

- **The code letter** is based on the geometric dimensions of the aircraft determined by the span of wings and the distance between the outer wheels of the undercarriage. They set parameters relating to the widths of the movement areas (areas intended for the movement of airplanes at the airport).

Kódový prvek 1		Kódový prvek 2		
Kódové číslo	Jmenovitá délka dráhy vzletu	Kódové písmeno	Rozpětí křídla	Vnější rozchod kol hlavního podvozku[a]
(1)	(2)	(3)	(4)	(5)
1	Méně než 800 m	A	Až do, ale ne včetně 15 m	Až do, ale ne včetně 4,5 m
2	Od 800 m až do, ale ne včetně 1 200 m	B	Od 15 m až do, ale ne včetně 24 m	Od 4,5 m až do, ale ne včetně 6 m
3	Od 1 200 m až do, ale ne včetně 1 800 m	C	Od 24 m až do, ale ne včetně 36 m	Od 6 m až do, ale ne včetně 9 m
4	1 800 m a více	D	Od 36 m až do, ale ne včetně 52 m	Od 9 m až do, ale ne včetně 14 m
		E	Od 52 m až do, ale ne včetně 65 m	Od 9 m až do, ale ne včetně 14 m
		F	Od 65 m až do, ale ne včetně 80 m	Od 14 m až do, ale ne včetně 16 m

[a] Vzdálenost mezi vnějšími okraji kol hlavního podvozku

Poznámka: *Informace o projektování letišť pro letadla s rozpětím křídel větším než 80 m jsou uvedeny v Aerodrome Design Manual, Part 1 a 2.*

Table 2 – Airport codes
Source: http://d2051.fsv.cvut.cz/predmety/ylet/3.pdf

8.AIRPORT TERMINAL

8.1. Terminal

Layout solutions of terminals must correspond to the smooth and safe clearance of passengers at arrivals and departures. The terminal building is strictly divided into arrivals and departures. The layout solutions (i.e. the size and parameters of individual halls) depend to a large extent on these factors:

- The type of airport in terms of the ratio of transit and direct flights:
    - **Hub and spoke -** a transit airport with a large number of transfer flights. It requires a sufficient dimensioning of transit space in the non-public area of the airport due to the large number of changing passengers;
    - **Point to point -** an airport with a high proportion of arriving and departing passengers who do not (or rarely) change to other flights at a given airport. It requires balancing of departures and arrivals;

- **Fast and as short as possible transfer** from public transport through a **quick check-in** in the public area of the terminal to **board** the aircraft;

- **A good information system** for good passenger orientation at the airport terminal;

- **Conflict-free movement** of passengers on departures and arrivals;

- **Schengen security requirement** - separation of the flow of passengers into and out of the Schengen area vertically or horizontally, etc.;

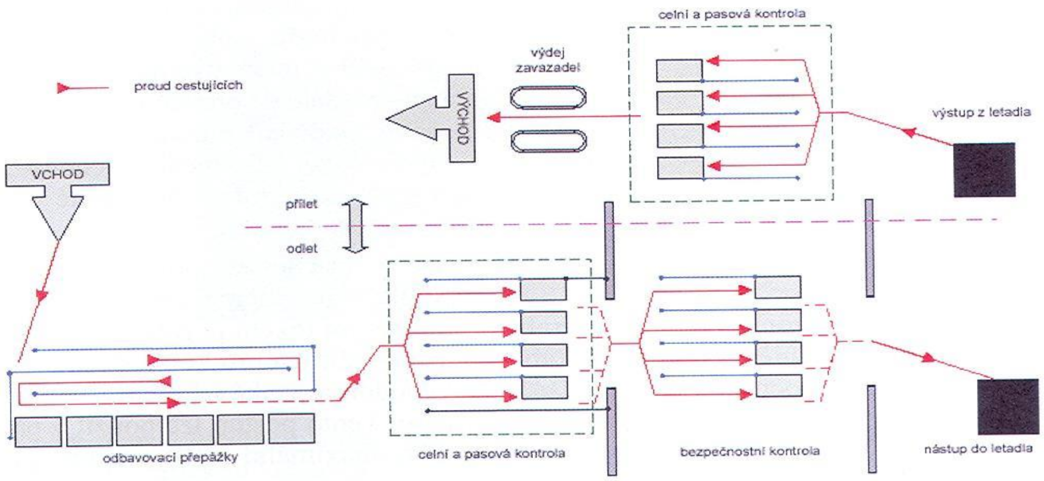


Figure 7 - The process of passenger clearance at arrivals and departures at the airport terminal.
Source: The author

8.2. Platform arrangement

Airport platforms are designed as non-public parts of the terminal (the non-public part of the terminal can be accessed only with a valid boarding pass), where passengers can board or exit mostly horizontally using the so-called "Airbridge". It forms the boundary between the airplane and the check-in area of the terminal. It is closely related to the apron, where the airplanes are placed on stands. The arrangement of the individual stands along the terminals can be designed in several ways:

- **Developed arrangement -** Airplanes placed alongside the terminal building or around it;
- Airplane arrangement on an **open area -** Airplanes are placed in several rows on the apron. Passenger access to airplanes is basically possible with the help of buses, the access to the nearest airplanes is possible on foot under certain conditions;
- **Island platforms -** individual platforms are linked with the terminal by underground tunnels or overpass corridors. Airplanes are deployed around island (satellite) platforms;
- **Finger platforms** - The most appropriate way of arranging, where platform corridors (fingers), along which the airplanes stand, run out of the terminal;

8.3. Space around the airport

It refers to the space in front of the terminal building in the public area. It is predominantly a traffic hub and the location area of public transport stops, taxi stands, long-term and short-term car parks, etc. Parking areas should be designed separately for passengers, staff and airport visitors.

The number of passengers checking in at peak hours is crucial for transport between the airport and the city or agglomeration. The traffic rush hour between the airport and the city is directly dependent on the peak hour of air traffic at the airport. Mostly, the airport is connected to a quality higher-capacity road network. At large airports, rail connections are designed to provide sufficient capacity of traffic (such as high-speed trains at London Heathrow Airport) or connections of airports to the cities or agglomerations by unconventional modes of transport (e.g. Pudong airport is connected to Shanghai by Transrapid technology, a transport network based on magnetic levitation).

9. RUNWAY SYSTEM OF THE AIRPORT

9.1. Runway system

Runway system and complementary movement areas are a system of runways to ensure the movement of aircraft. Runway (RWY) is a defined rectangular area on a land of an aerodrome adapted for the take-off and landing of aircraft.

One of the basic parameters of an airport is **operational usability**. The factors that affect the operational usability of an airport and the determination of the required directions, number and location of runways are:

- **type of operation** - procedures for making approaches to land and take-off, and time (day or night) for airport use;
- **climatic conditions** - wind direction and wind speed, low visibility, and cloud base;
- **airport topography** - compliance with obstacle limitation surfaces;
- **air traffic around the airport** - proximity to other airports and flight routes.

The number and direction of runways must ensure at least 95% of airport operational usability per year depending on aircraft type and direction and speed of wind. Based on this assessment, **airports with single or more runways** are designed.

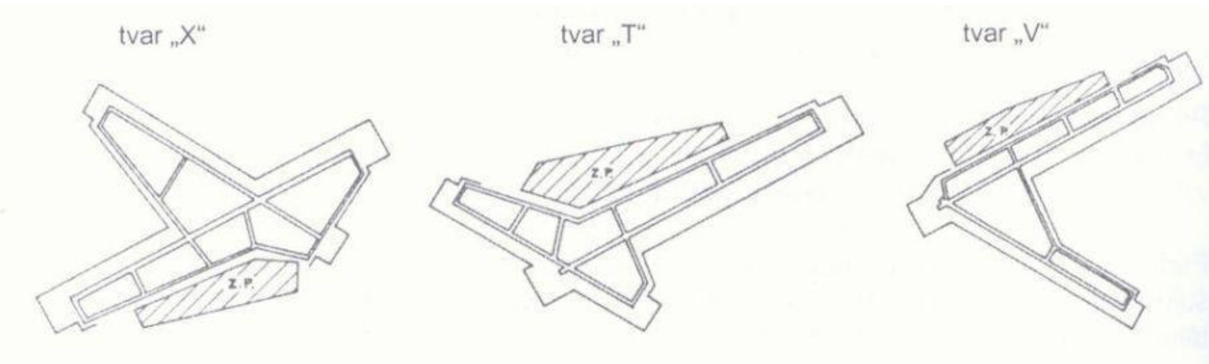


Figure 8 – An example of some types of airports with two runways
Source: Bartošová, 2010

Runway capacity is the number of possible take-offs and landings on a given runway for a certain time and under specified conditions. Runway capacity depends on the minimum intervals between flight operations, flight management (instrument and non-instrument), the length of individual taxiways and the organization of movements along them and the applicable procedures and regulations. All the movement of aircraft along the movement areas is controlled by the **control tower**. A design of a parallel runway results from the assessment of the runway capacity. Thanks to the construction of the parallel runway, the runway capacity of an airport will be increased.

There are two types of runways: **instrument** and **non-instrument** (for a visual or instrumental approach of aircraft to the runway). There are various parts and areas on runways or in their vicinity (see Fig. 9):

- **Shoulder** – provides the transition between runway surface and the other surfaces;
- **Strip** – defined safety area including runway and stopway;
- **Stopway** – the area adjoining the end of the usable length of starting;
- **Clearway** – the area over which the aircraft can safely carry out a part of the initial ascending;
- **Runway and safety area** (RESA);
- **Treshold**.

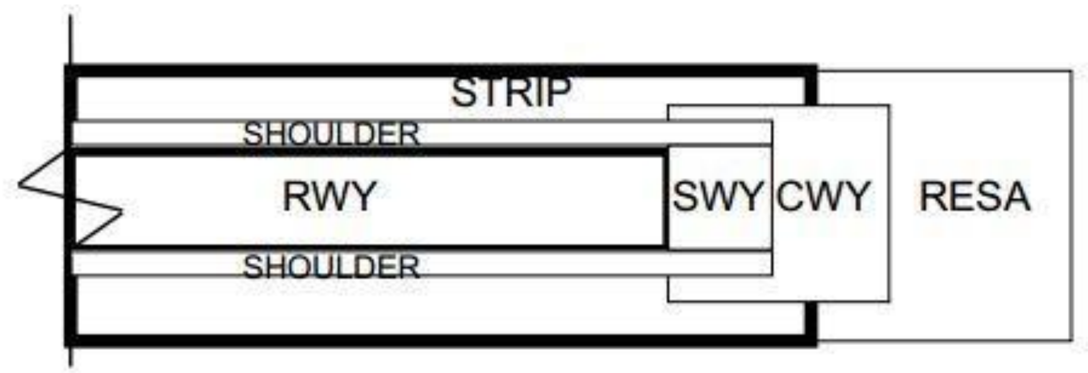


Figure 9 – Defined areas of runway and its vicinity
Source: http://d2051.fsv.cvut.cz/predmety/ylet/3.pdf

10. OTHER MOVEMENT AREAS AND AIRPORT EQUIPMENT

10.1. Airport movement areas

Movement areas, as part of an airport, are designed for take-offs, landings and ground movements of aircraft. The movement areas of an airport are formed by:

- **Runway (RWY);**
- **Taxiway (TWY);**
- **Apron (APN).**

Airplanes are preparing for take-off at the **apron**, which is an area near the terminal and the platforms and where are the stands for aircraft. The apron is a place where passengers board and get off, luggage and goods are loaded and unloaded. It also serves for refueling and other activities related to technical clearance of airplanes. Individual **taxiways** then connect the aprons and **runways**.

Taxiways refer to defined strips of an airport designated for movement of aircraft and for the connection between different parts of the airport. Apart from taxiways, there are also:

Taxiway strip and taxiway on the apron;
Taxiway for a fast turning (a taxiway linked to runway at a sufficiently acute angle for a fast escape of aircraft from the runway).

10.2. Obstacle limitation surfaces

Airspace around an airport must provide security for all aircraft movements. This is a space where movements are made when an aircraft approaches the landing, or the spaces in which aircraft are rising after take-off, etc. Therefore, the airspace around an airport is defined by a system of obstacle levels and surfaces beyond which neither artificial nor natural obstacles can occur.

In addition to obstacle limitation surfaces, so-called **protection zones** are being developed in the vicinity of airports, such as a banning zone for buildings or ornithological protection zone, etc.

10.3. Navigational aids at airports

Among the navigational aids at airports belong:

Visual navigation aids:

- **Indicators and signals** (eg wind direction indicators, landing direction indicators, signal lights, etc.);
  - Marking (Horizontal - this is meant by marking on RWY, on taxiways, etc.);
  - Marks and signs (vertical);

Lighting equipment:

- **Approach lighting systems** – align the aircraft with the runway (RWY);
- **Lighting approach systems** indicating the altitude of the aircraft;
- **Other light signs and devices** (e.g. runway end lights, runway centreline lights, side lights of runway or taxiway etc.).

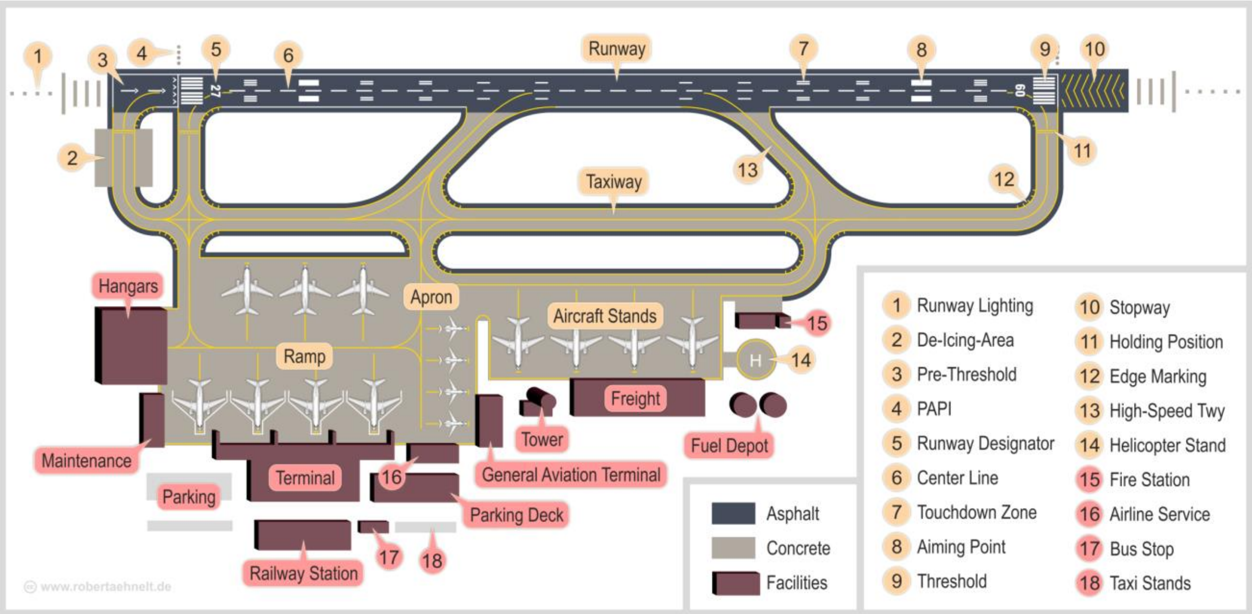


Figure 10 – Civil airport traffic infrastructure
Source: CellarDoor85 (Robert Aehnelt). - Own work., CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=16561926

11. METHODS OF FINANCING TRANSPORT INFRASTRUCTURE CONSTRUCTION

Projects in the field of transport infrastructure are characterized by a relatively high investment intensity. The main source of funding for most of these projects in the European Union are national budgets.

In less developed countries, European funds (European Regional Development Fund - ERDF and Cohesion Fund) and international financial institutions (European Bank for Reconstruction and Development - EBRD and European Investment Bank - EIB) are also involved in financial flows. The European Commission also supports innovative financing methods in transport projects, in particular various forms of Public-Private Partnerships (PPPs).

A significant part of the funds for transport infrastructure in the countries of Central and Eastern Europe focuses mainly on the development of the railway network, which constitutes a part of the pan-European transport infrastructure. The main sources of transport infrastructure financing in these countries are national budgets and loans from international financial institutions and other banks, while the EU has so far contributed by only a small part.

The main source of funding for transport infrastructure development in the Czech Republic is the state budget and the State Fund for Transport Infrastructure (SFDI). Following the accession of the Czech Republic to the European Union, the way for increased use of EU funds was opened. After initial structural problems with the implementation of PPP projects, the Government of the Czech Republic adopted a new resolution on the promotion of Public-Private Partnerships at the beginning of 2004.

11.1. Forms and sources of funding

- public budgets - mainly the state budget will continue to be the main source of funding through the SFDI; in the case of local networks, the budgets of the higher territorial units with the support of the state budget,
- state funds,
- bank loans of different beneficiaries with documented effectiveness of their subsequent allocation,
- EU funds - to support the implementation of transport infrastructure projects and

transport services. This mainly includes:

- Cohesion Fund,
- The European Regional Development Fund (ERDF), which belongs to the category of structural funds, through the Joint Regional Operational Programme,
- financial instrument of the Trans-European Transport Network (TEN).

The state budget of the Czech Republic (or territorial budgets)

State budget expenditure is governed by Act No. 218/2000 Coll. of 27 June 2000 on budgetary rules and on the amendment of certain related laws (budgetary rules). Under this Act, State budget expenditures also include subsidies and repayable financial assistance to territorial self-governing units for non-business activities and subsidies for financing specific programs and events. Participation of
the state budget in the financing of the property reproduction program is governed by Decree of the Ministry of Finance No. 40/2001 of 19 January 2001 on the participation of the state budget in the financing of asset reproduction programs.

State transport infrastructure funds

The source of financing from the state budget is primarily the State Fund of Transport Infrastructure, which is a legal entity established with effect from July 1, 2000 by Act No. 104/2000 Coll. on the State Fund for Transport Infrastructure and on Amendment of Act No. 171/1991 Coll. on the competence of the Czech authorities in matters of transfer of state property to other persons and on the National Property Fund of the Czech Republic, as amended, and in accordance with the SFDI Statute to ensure the purpose of SFDI, as set out in §2 of the Act.

SFDI was set up as an extra-budgetary fund, which is a legal entity. The property it manages is the property of the state. SFDI is the main source of funding for transport infrastructure in the Czech Republic.

State Environmental Fund

The State Environmental Fund of the Czech Republic (SEF) was established on 4 October 1991 by Act No. 388/91 Coll. SEF supports measures to improve the environment in all its components, including water, air, nature and landscape protection.

12. METHODS OF FINANCING TRANSPORT INFRASTRUCTURE CONSTRUCTION

12.1. Structural funds of the European Union

Cohesion Fund

The Cohesion Fund provides funding for large investment projects in the environment and transport sectors in EU Member States whose GDP is below 90% of the EU average. Decisions on the use of the Cohesion Fund are taken jointly by the Member State and the European Commission. The managing authority is the Ministry for Regional Development (MRD), the unit of management of the Cohesion Fund. The highest decision-making body of the Cohesion Fund is the Inter-Ministerial Steering Committee, whose powers are defined by the Statute approved by the Government of the Czech Republic.

European Regional Development fund (ERDF)

The European Regional Development Fund (ERDF) was established in 1974 as a basic instrument of regional policy to finance structural assistance through regional development programs targeting the most affected areas and reducing interregional inequalities. It is currently one of the most important structural funds.

By its participation in the development and structural changes of lagging regions and the transformation of declining industrial areas, the Fund is aimed to help to overcome major regional disparities in the European Community, to promote economic and social cohesion, and to contribute to the development and transformation of regions. The Fund also contributes to the promotion of sustainable development and creating sustainable jobs.

In the sphere of transport infrastructure, the ERDF funds the following:

- productive investment to create and maintain sustainable jobs,
- investment in infrastructure,
- creating infrastructure for local development and employment development,
- research and technological development,
- development of information companies,
- international, cross-border and interregional cooperation

12.2. International financial institutions

European Bank for Reconstruction and Development

The European Bank for Reconstruction and Development supports investments in transport

infrastructure provided that it is linked to the necessary commercialization and restructuring.

As far as the field of public transport is concerned, the EBRD supports projects where services will be provided on a commercial basis (by a private entity or a municipality). Carrier costs should be fully covered by fare, price compensations and other revenue. The Bank's priority in the field of regional transport is to contribute to the development of non-state operations through loans to private entities or territorial administrations where they can prove their creditworthiness or obtain reliable guarantees.

European Investment Bank

The European Investment Bank (EIB) finances capital investment projects that support the balanced development of the EU. EIB loans are tied to specific projects and are focused on financing the long-term investment component. The Bank mainly finances promising public and private transport projects.

The EIB's financial resources are available under the same conditions to the State, public authorities at central or regional level, cities, municipalities and private and public companies with or without foreign capital participation. The EIB is an additional source of funding and can pay up to 50% of the project costs within a reasonable budget plan. Therefore, the Bank's financial activities are always conditioned by synergy with the project's own resources and other long-term financial resources.

12.3. Public-Private Partnerships

Public-Private Partnerships in the field of public infrastructure and public services are currently being used in a number of countries, partly due to a lack of public sector funding. These are cases where a private entity provides a public service or other public means, which may include the financing, construction or modernization of the transport infrastructure.

The benefits of PPP funding lie in:

- accelerating the process of building transport infrastructure,
- faster implementation of projects,
- reduction of financial costs,
- better risk allocation,
- higher motivation to increase transport performance,
- improved quality of services,
- generating additional revenues,
- highlighting public management.

13. LITERATURE

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