RAILWAYS

Introduction

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HUMAN CAPITAL
HUMAN – BEST INVESTMENT!
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My visit card

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- tutorials:

Mondays 13:00 – 15:00

Thuesdays 13:00 – 15:00

Readings

1. Dz. U. nr 151.: Rozporządzenie Ministra Transportu i Gospodarki Morskiej w sprawie warunków technicznych, jakim powinny odpowiadać budowle kolejowe i ich usytuowanie. (PL)
2. Dz. U. nr 33.: Rozporządzenie Ministra Transportu i Gospodarki Morskiej z dnia 26 lutego 1996 r. w sprawie warunków technicznych jakim powinny odpowiadać skrzyżowania linii kolejowych z drogami publicznymi i ich usytuowanie (ze zmianami: Dziennik Ustaw Rzeczpospolitej Polskiej Nr 100 z 9.11.2000, pozycja 1082. (PL)
3. Bonnet, Practical railway engineering, 2008. (EN)
4. Esveld Coenraad, “Modern Railway Track”, 2nd ed. Zaltbommel: MRT-Productions, 2001. (EN)
5. PN-EN 13803-2. Railway applications – Track – Track alignment design parameters, 2007. (EN)
6. Id-1 (D-1) Warunki techniczne utrzymania nawierzchni na liniach kolejowych - PKP Polskie Linie Kolejowe S.A., Warszawa 2005. (PL)
7. Id-3 (D-4) Warunki techniczne utrzymania podtorza kolejowego - PKP Polskie Linie Kolejowe S.A., Warszawa 2005. (PL)
8. http://www.iil.pwr.wroc.pl/makuch/ (PL)
9. http://www.transportszynowy.pl (PL)

History of railways in a pill

- 1825 – Stephenson's „Locomotion" is able to transport Englishmen with a speed of 22 km/h, 27 years later a French locomotive „Crampton" reached the staggering speed of 112 km/h. It was the time of travelling in carts pulled by horses and even oxen.
- 1850 – 1914 - intensive development of railway network.
- World wars proved strategic importance of railways.
- After II World War steam traction was gradually substituted by electric and Diesel engines.
- 60'-70' – slow turn from railways to car transportation.
- Early 80' - increase of interest in rail transportation due to growing fuel costs, especially after the oil crisis started in October 1973 and then in 1979.
- 80' – now – development of high speed railways (over 250 km/h), speed record: 574 km/h, by TGV.

OK., but what about traction?

The success of railways has been settled by the invention of a more efficient traction than the horse – steam traction:

- 1700 - Thomas Newcomen - a steam engine,
- 1767 - James Watt – a improved steam engine,
- 1769 - Nicolas Cugnot – a vehicle with a steam engine,
- 1804 - Richard Trevithick – a locomotive with steam traction,
- 1814 - George Stephenson – „Locomotion" and the first train with steam traction,
- 70' of XX cen. – decline of steam traction.

Nowadays steam traction is used in India and Pakistan.

OK., but what about traction?

History of electric traction development:

- 1879 - Werner von Siemens – prototype of electric traction locomotive,
- 1881 - Magnus Volk – first electric railway line,
- 1895 - General Electric – electric railway,
- 1903 - electric locomotive by Siemens: 205 km/h, AEG: 210 km/h,
- 1955 - locomotive CC7107 French SNCF: 329 km/h,
- 1964 - early multisystem locomotives (for different power supply),
- 2002 - locomotive Eurosprinter by Siemens: 357 km/h,
- 3rd April, 2007 – V150 unit by TGV: 574,8 km/h.

Simultaneously Diesel traction was developed:

- 1897 - Rudolf Diesel – first internal combustion engine,
- to 1930 - America, Italy and Germany – work on traction transfer,
- Before WW II - Fiat, Breda, Bugatti, Maybach - early light Diesel traction trains,
- 50', 60', 70' – intensive development of multitask Diesel locomotives

Train, car or plane?

- Essential delimitation of passenger transportation systems is saturation of communication flows by traffic. Many cities suffer from traffic jams on motorways during rush hours. Similarly, many airports work on the verge of capacity.
- On this background railways, especially High Speed Railways offer the ability to transport many passengers, with higher speed than cars and planes.
- The advantage of railways over car is that on selected lines train speed is much higher than a car speed. Travelling by train is considered more comfortable and more productive for passengers, who needn't focus their attention on driving.







Train, car or plane?

Nowadays jet planes travel 3 time faster than high speed trains. Nevertheless, on distances 400-800 km travelling by train and by plane takes the same time. It is caused by:

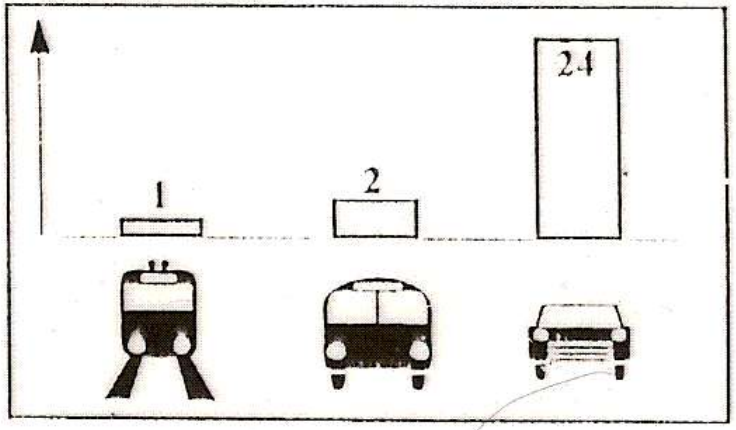
- Airports location (usually far from city centres) what requires a time to get there.
- Getting on and off in the case of trains is much easier, shorter and less stressful than boarding on and off a plane.
- Frequency and capacity of trains is higher than those offered by planes.



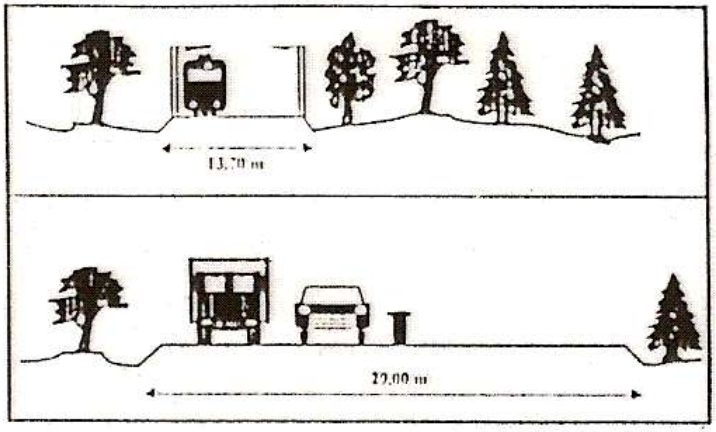




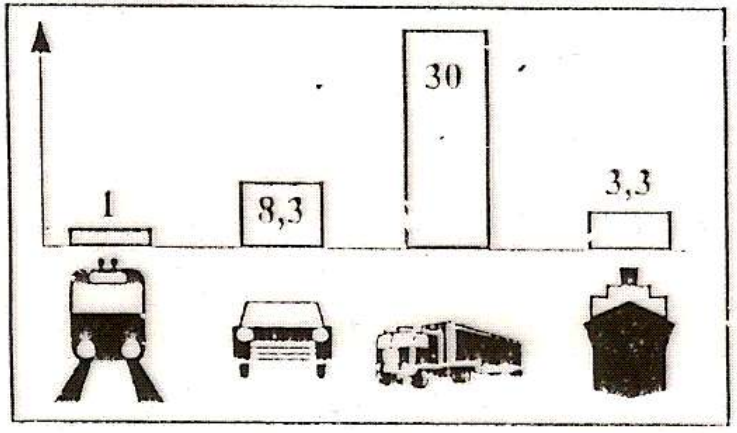
Railways vs rivals



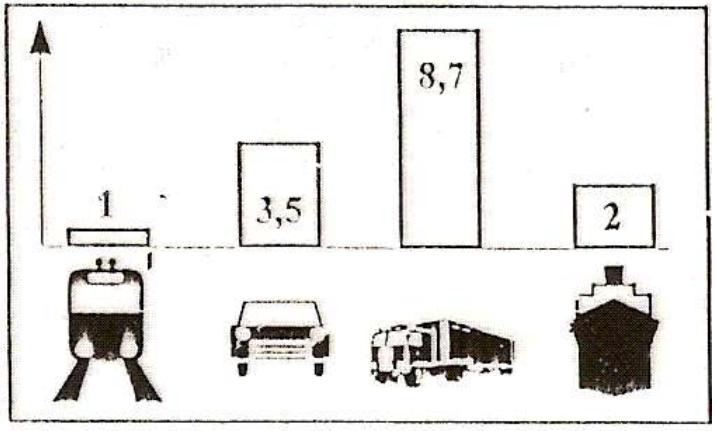
travel hazard



consumption of land area



pollution emission



energy consumption

Railways vs rivals

Means of transportation	Brutto weight/ 1 transportation unit	Mean transport distance	Mean speed	Efficiency coeficient
	[T]	[km]	[km/h]	[Tkm/HP/h]
Horse	4	6	6	-
Passenger car	1	14	50	3.1
Lorry	25	100	90	6
Tramway	4	5	20	?
Passenger railways	750	36	100	30
Freight railways	2300	237	80	52.2
Inland water	3500	281	15	69
Sea shipping	8500	3173	28	40
Airlines	100	331	800	3.3

Efficiency coeficient – transportation work (brutto weight of the transportation unit [T] times the distance [km]) done in 1 hour divided by the engine power [HP].

Basic notions

Railway network

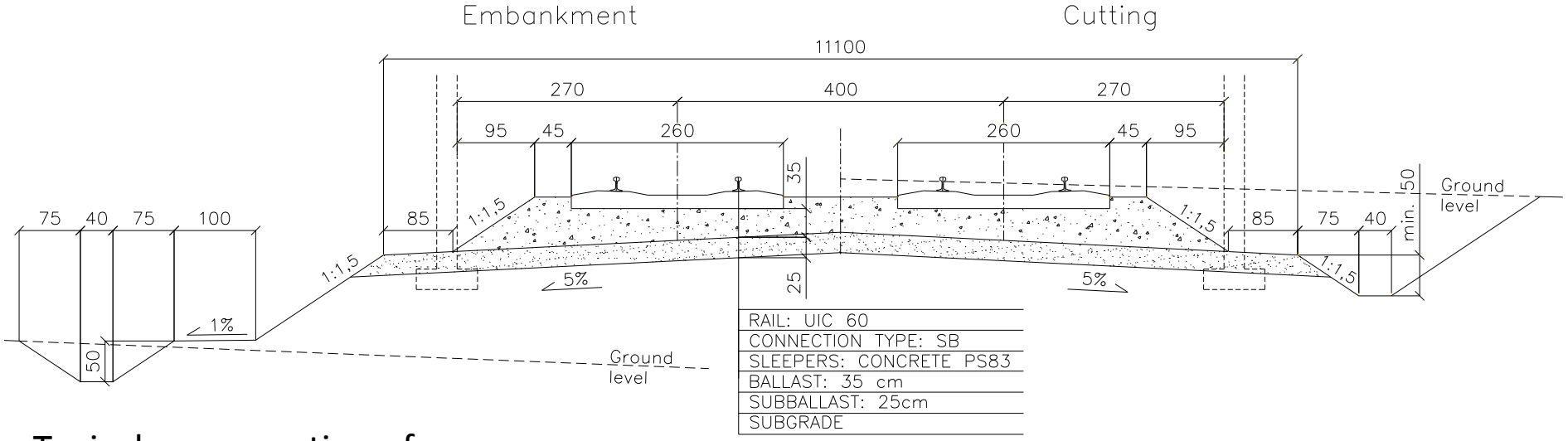
The railway network consists of railroads, stations and other infrastructure required for the safe and efficient transport of passengers and goods by trains.

Railroads

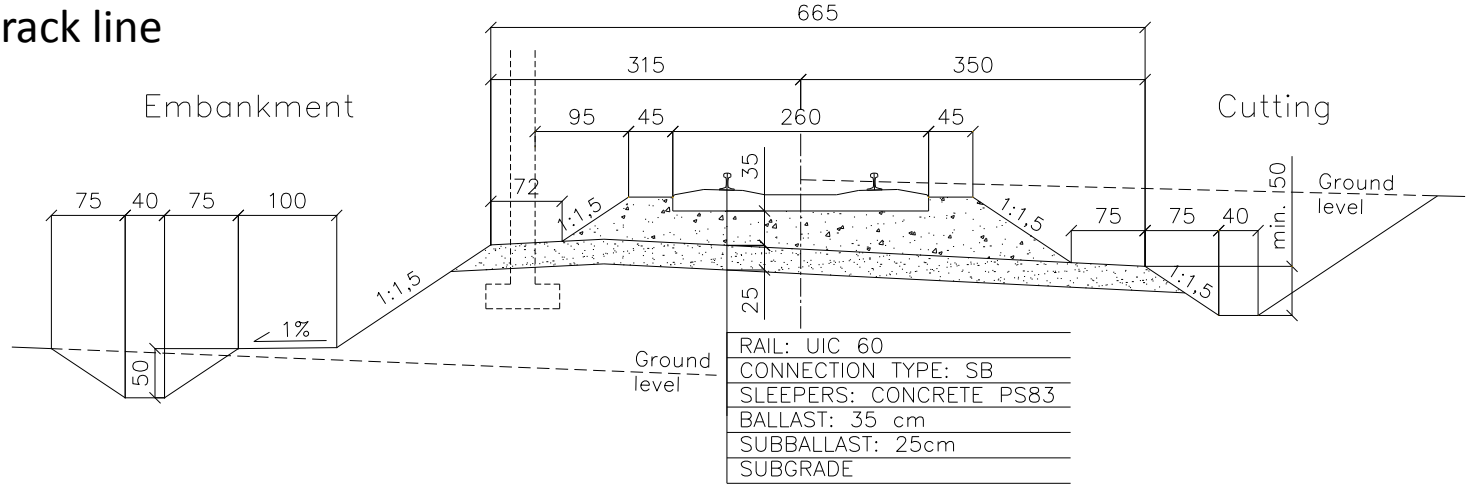
A railroad consists of railway track, turnouts and crossings.

A classical railway track is made of two parallel rails with a constant gauge, supported by sleepers buried in ballast. Under the ballast layer there is the subballast layer and the formation. Depending upon the situation of the local terrain it can be embankment or cutting.

Typical cross-section of a double track line

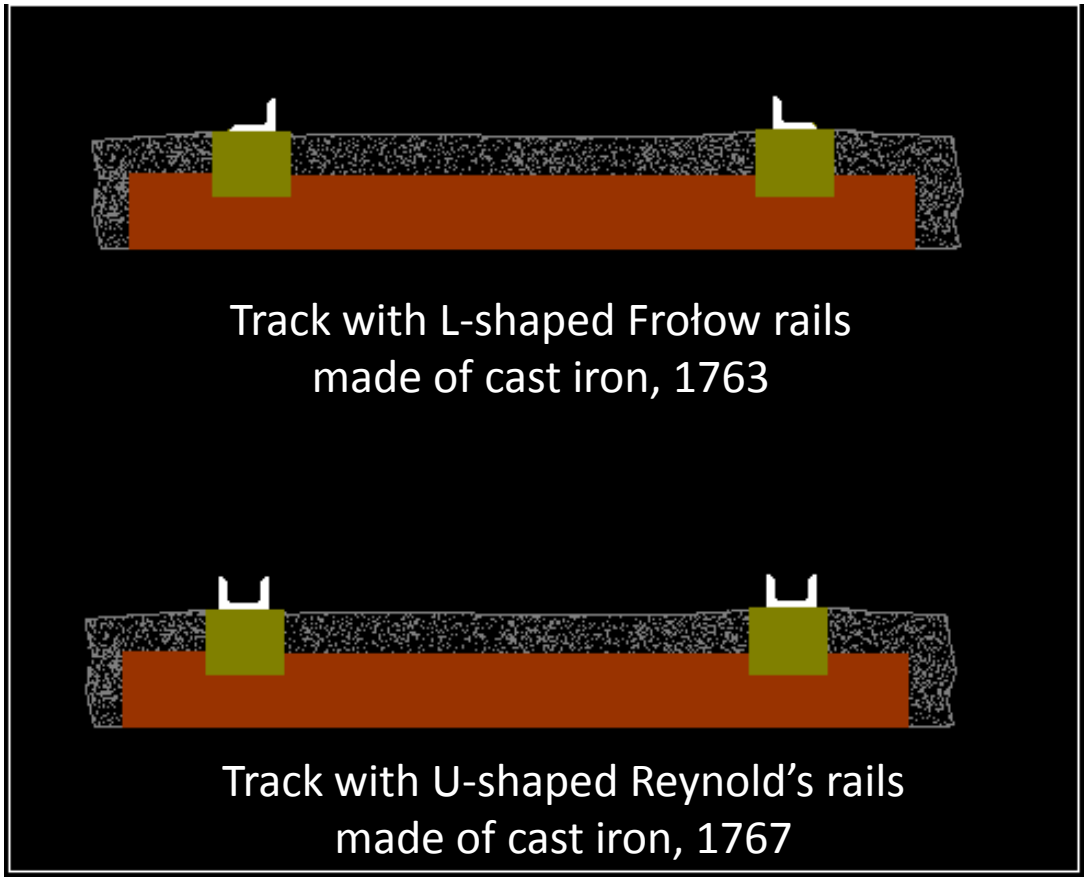


Typical cross-section of a single track line

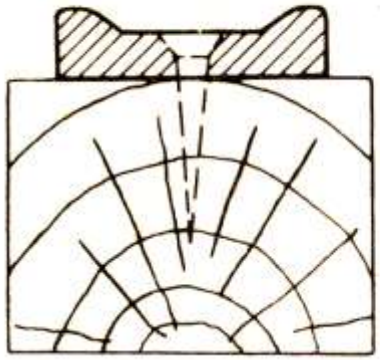


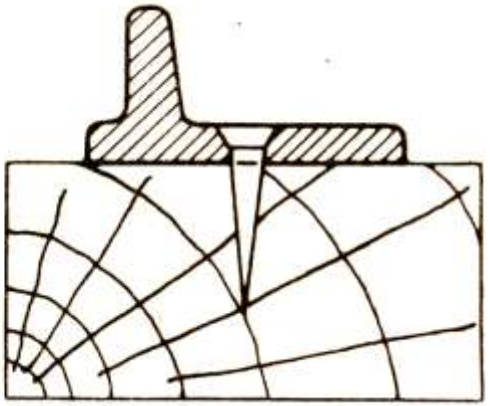
What is going on with the rails?

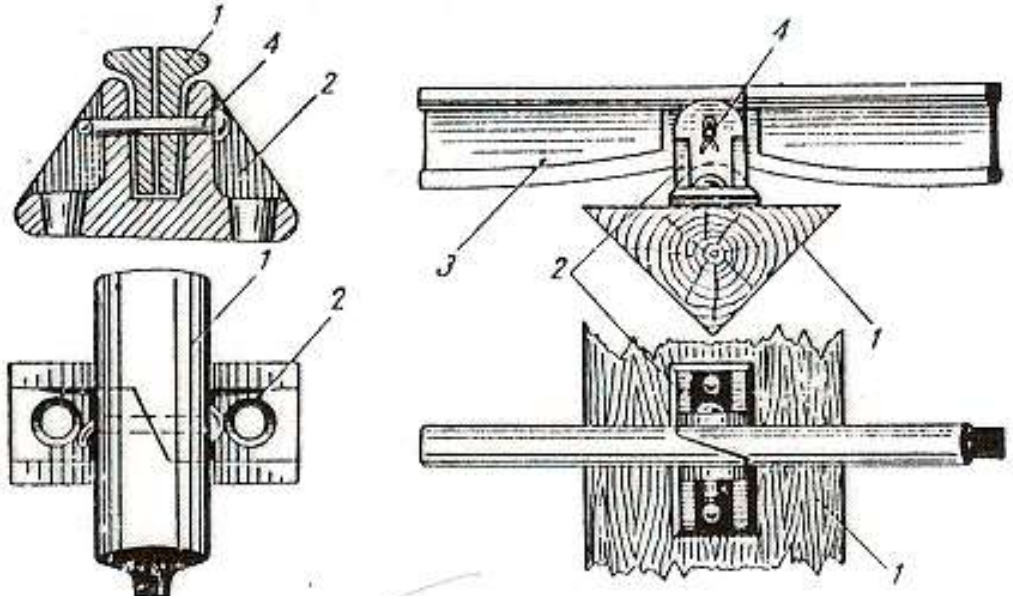
- Since ancient times people have been conscious that wheels move much easier on a hard, flat and smooth surface. The less friction between the wheel and the rail, the smaller force is needed to move the vehicle.
- Due to this fact ancient Romans built paved roads laying plates in two parallel rows with the distance of chariot wheels. The distance between the ruts cut by chariot wheels in Pompea is half a centimeter less than the nowadays used standard track gauge: 1435 mm.
- In XVII century miners from Alzatia used carts with wheels protected by a wooden ring moving on wooden rails for transport of crushed rock. One horse was able to pull a few carts with coal weighing around 1 tonne.



source: www.transportszynowy.pl



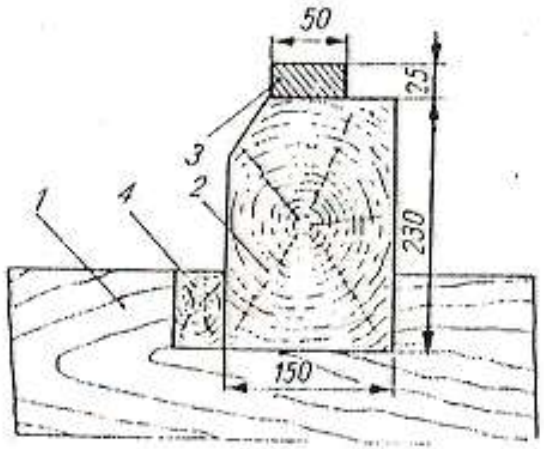




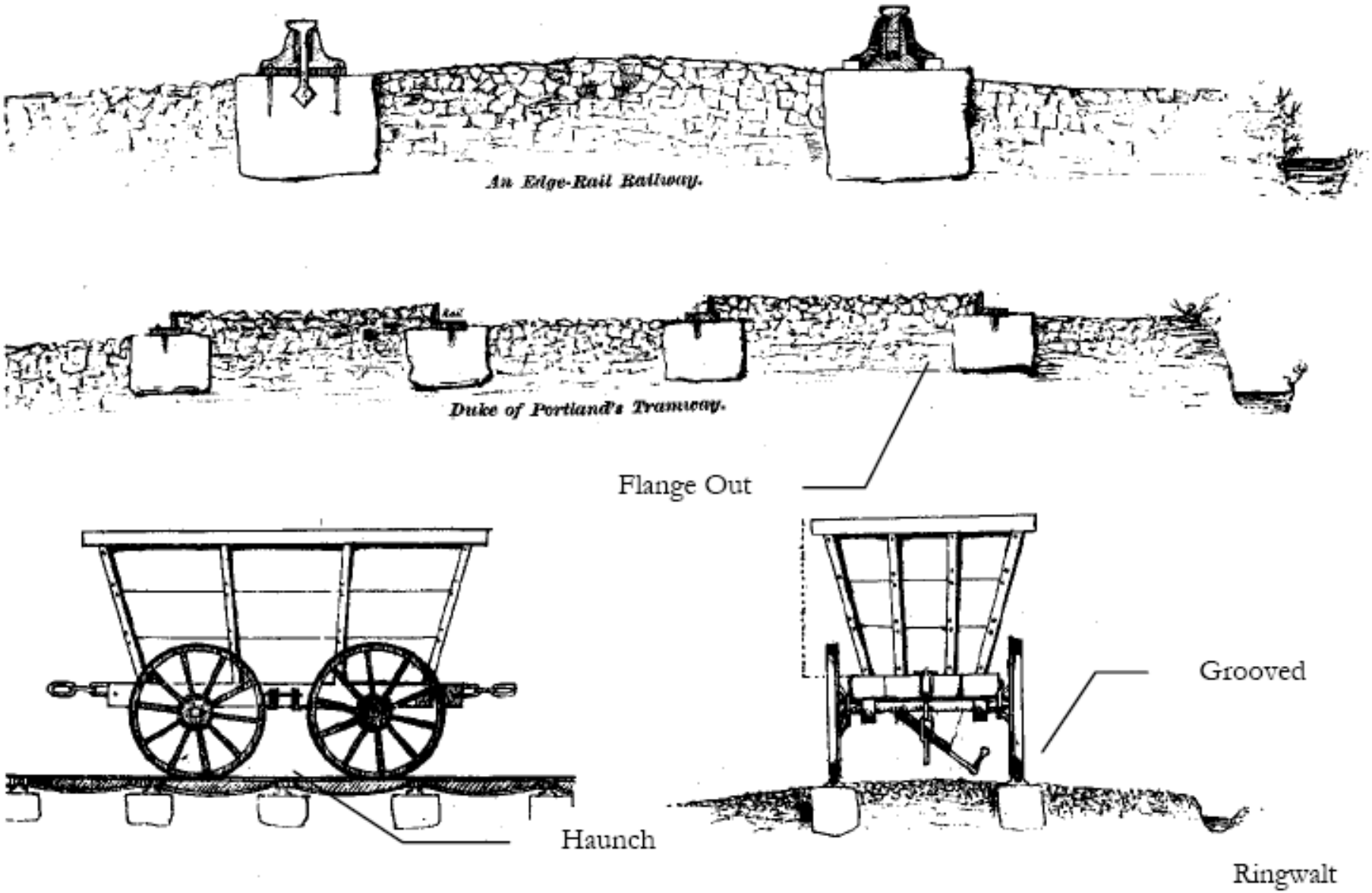
Lougborough, Anglia, 1789

Jessop rail (cast iron): 1 – wooden sleeper, 2 – iron stool, 3 – piece-wise rail with non-equal height, 4 - pivot

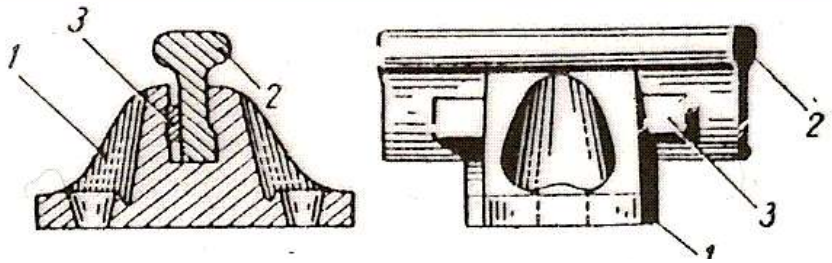




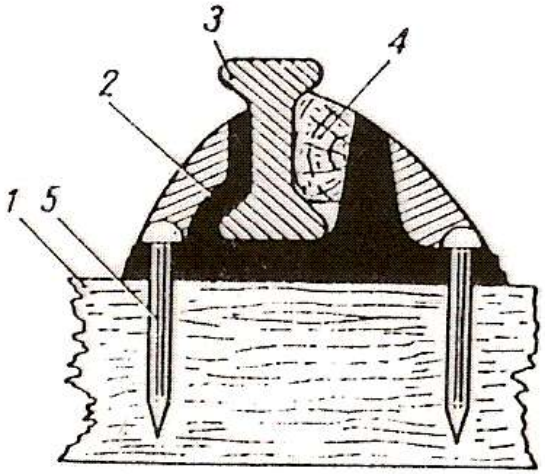
Wooden beam reinforced by steel flat rail: 1 – wooden sleeper, 2 – wooden beam, 3 – flat-shaped rail, 4 – wooden wedge

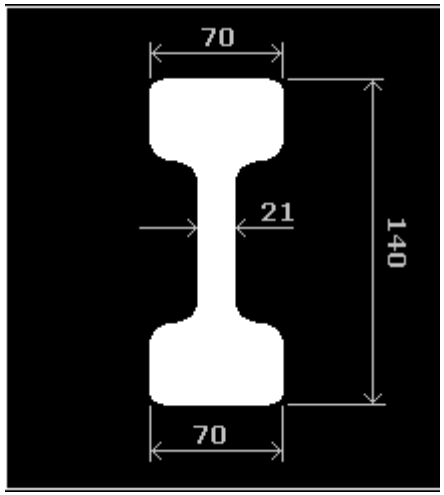


English Railways and Freight Cars, as Illustrated in Strickland's Report, 1826



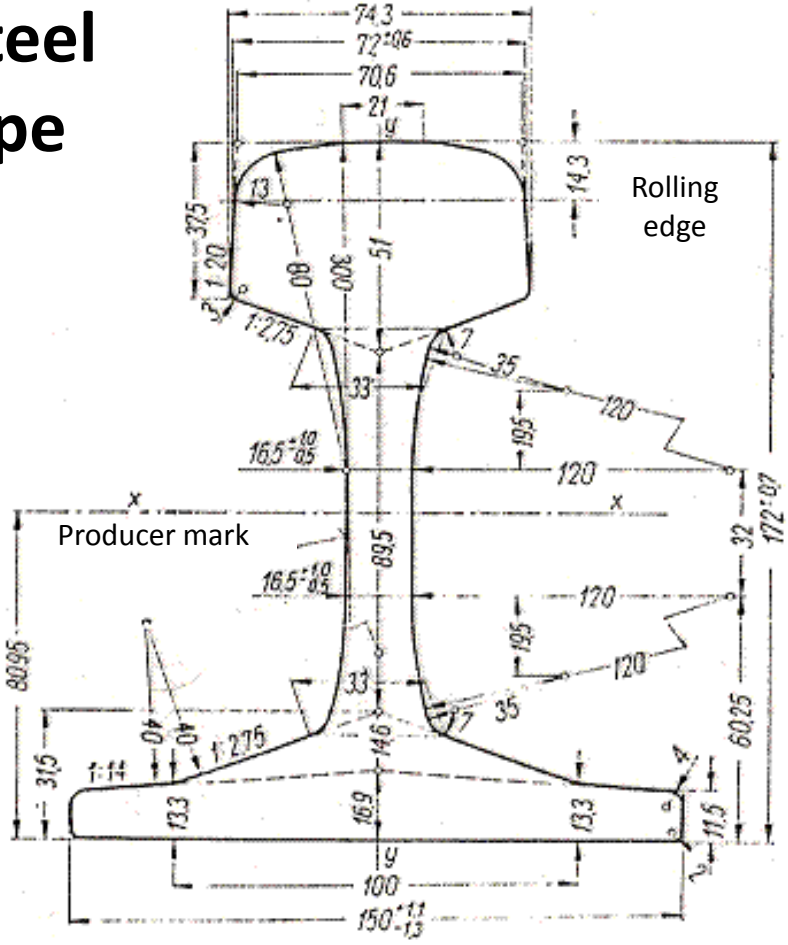
Steel rail with constant height: 1 – iron stool, 2 – steel rail, 3 – steel wedge



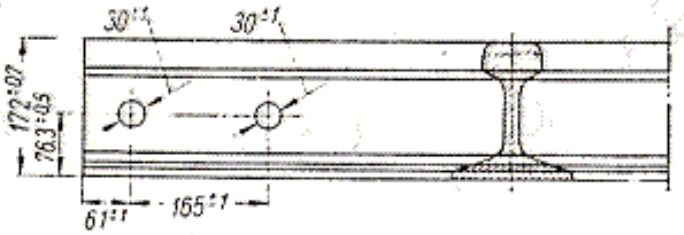


Stephenson two-headed rail (1830) : 1 – wooden sleeper, 2 – iron stool, 3 – two-headed rail, 4 – wooden wedge, 5 - nail

Standard steel rail S60 type



Holes for bolts – side view



Prototype of S60 rail was the Vignoles rail (1830)

Railway rail S49



Railway rail UIC60



Tramway rail Ri-60N



Block rail LK-1



Classification of railways

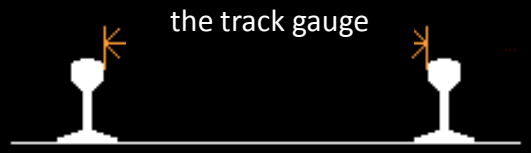
Depending on service field:

- Commercial railways – obliged to transport all goods accordingly to transport regulation and table of fares – open for public service,
- Industrial railways – are the property of industrial companies and serve for internal transportation.

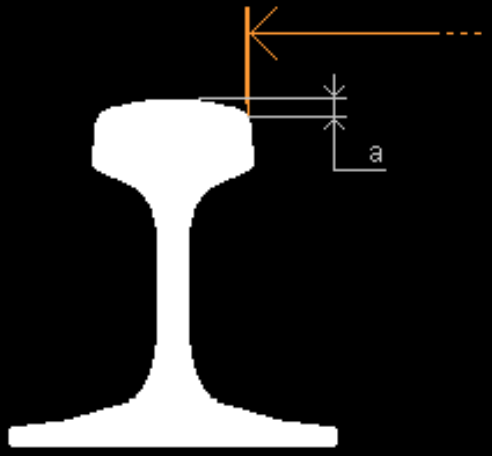
Depending on gauge:

- standard gauge – distance 1435 mm between rails,
- wide gauge – distance more than 1435 mm (e.g.: Russia: 1524 mm, 1676 mm - Spain, 1600 mm - Ireland),
- narrow gauge – distance smaller than 1435 mm (e.g.: 1000 mm, 750 mm, 600 mm – widely used as local, industrial or tourist railways).

The gauge



The track gauge is a distance between inner edges of rail heads



a – for standard gauge = 14 mm, for the gauge more narrow than 900 mm = 10 mm

Allowable deviation from the nominal gauge on straight sections are:
+ 10 mm and
– 3 mm.

source: www.transportszynowy.pl



Standard gauge 1435 mm

Narrow gauge 760 mm

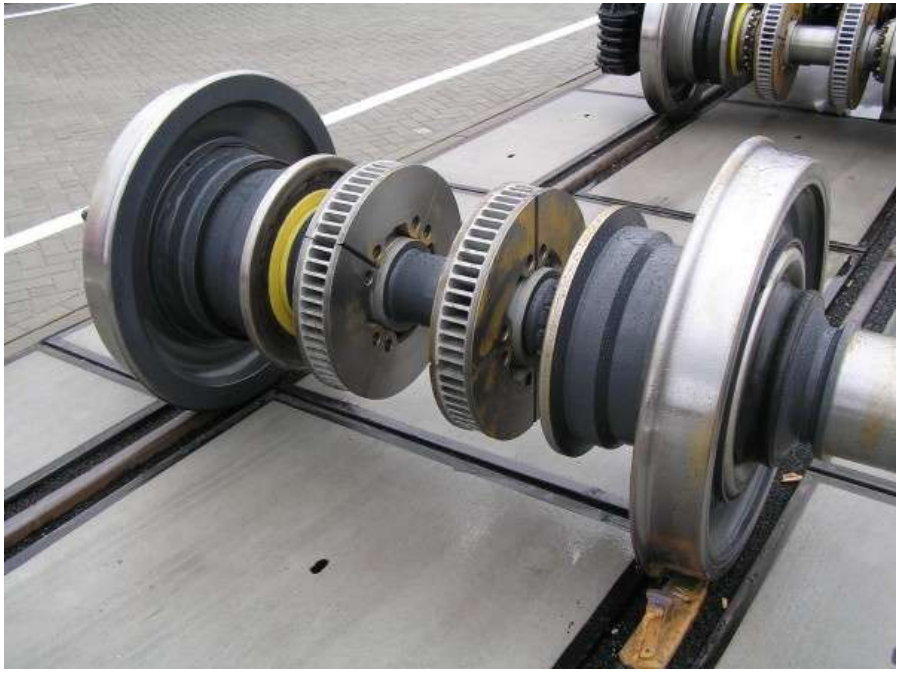


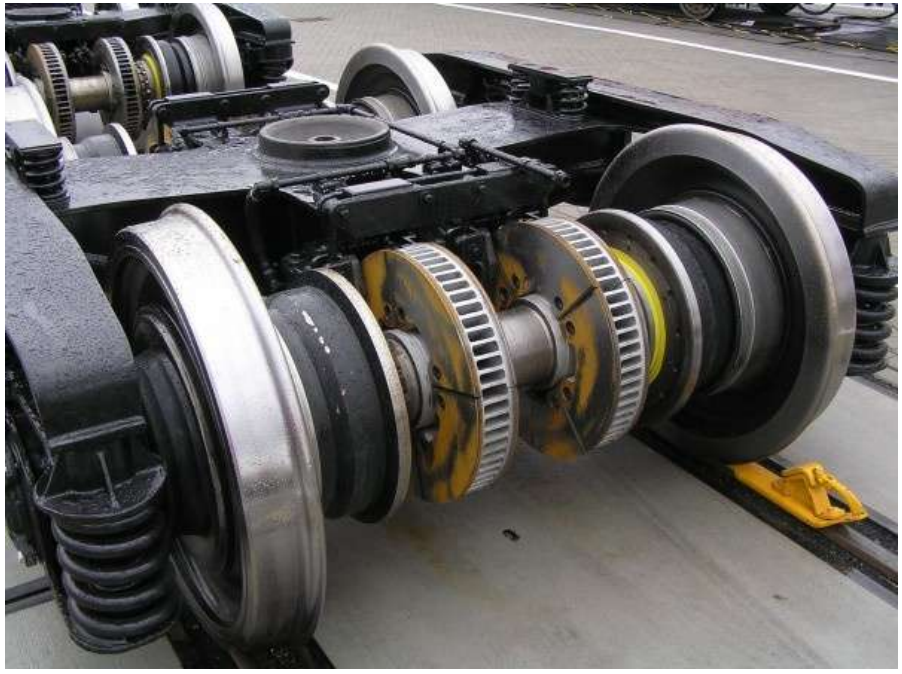
Wide gauge 1524 mm



Change of wheels distance

On the beginning of 90’ in XX century Polish designers lead by eng. Suwalski constructed boogies with wheelsets enabling the lengthening of axles. This makes the exchange of boogies at the change of the track gauge unnecessary. This procedure is carried out automatically without unloading the wagons. The SUW 2000 system is used in passenger as well as in freight railway transport.





source: www.transportszynowy.pl

Classification of railways

Depending on importance:

- main lines – the most important in the national network,
- first category lines – for fast passenger and distant freight traffic,
- second category lines – for traffic of medium intensity and speed,
- local importance lines – for local service with low intensity and speed.

Parameters of Polish railway lines

Category	Intensity of traffic	Maximal speed		Axle load
	T	V_{max}	V_f	P
	[Tg/year]	[km/h]	[km/h]	[kN]
main lines (0)	$T \geq 25$	$120 < V_{max} \leq 200$	$80 < V_f \leq 120$	$P \leq 221$
first category (1)	$10 \leq T < 25$	$80 < V_{max} \leq 120$	$60 < V_f \leq 80$	$210 \leq P < 221$
second category (2)	$3 \leq T < 10$	$60 < V_{max} \leq 80$	$50 < V_f \leq 60$	$200 \leq P < 210$
local importance (3)	$T < 3$	$V_{max} \leq 60$	$V_f \leq 50$	$P < 200$

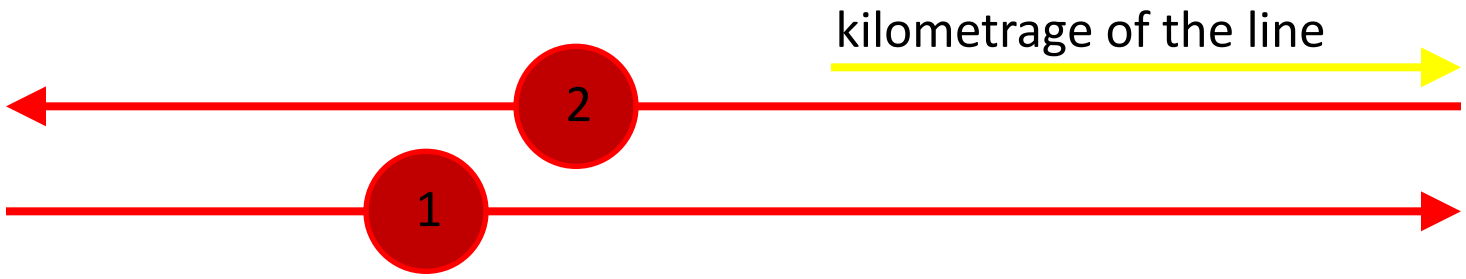
Classification of railways

Depending on number of tracks:

- single track,
- double track,
- multiple track.

In Poland on double track lines the traffic runs on the right hand side, which means: on the right hand track looking in the direction of the motion. The run on the left hand track is treated as „run on the improper track".

Principle of track numbering



Classification of railways

Depending on terrain characteristic:

- lowland lines – the steepest slopes reach 5-10 permil,
- sub-mountain lines - the steepest slopes reach 10-15 permil,
- mountain lines - the steepest slopes reach 15-25 permil.
  (Natural adhesion of the wheel to the rail enables running on the slope of 35 – 38 permil without slippage),
- special mountain lines - A rack-and-pinion railway (a railway with a toothed rack rail, usually between the running rails, which ensures traction). The steepest slope of the rack railway is 250 permil.



Track of a rack railway with Abt system

Profile of a rack railway track Montreux-Glion: maximal slope 130 permil.



Abb. 53. Zahnbahn Montreux-Glion.

Classification of railways

Depending on location in relation to the ground :

- surface lines – tracks on the level of the terrain (conventional railways, tramway, funicular),
- overhead lines – tracks run on long viaducts over the terrain (conventional railways, cableways),
- underground lines – tracks in tunnels under the ground (conventional railways, tube).



Conventional surface railway

Cableway surface railway - Zakopane







Overhead railway on a viaduct - Kuala Lumpur, Malesia

Cableway overhead railway – a support of the traction line and a cabine







Underground in a tunnel - Berlin



Railway line runs in tunnels and on viaducts - Landwasser Viaduct – Switzerland

Classification of railways

Depending on traction:

- steam,
- electric,
- diesel,
- magnetic,
- cable.











Classification of railways

Depending on function:

- Long distance passenger train,
- Regional train,
- Suburban train,
- Tramway,
- Underground.











Elements of infrastructure

- railway lines,
- railway sidings,
- railroad yards,
- classification yards
- railway stations, railway stops, halts, terminus
- civil engineering structures:
  bridges, viaducts, culverts, tunnels, footbridges, underpasses, retaining walls,
- grade crossings,
- other auxiliary buildings.

Railway lines: single or double track

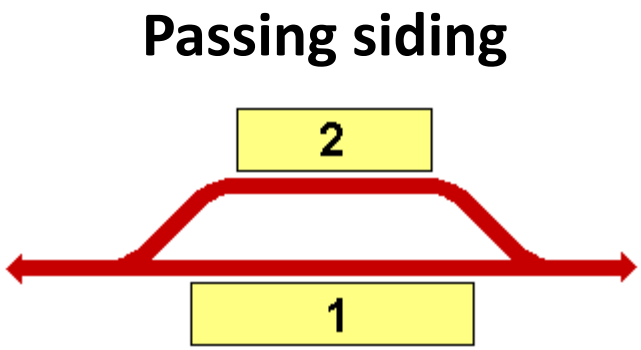




Railway siding

It is a track section distinct from a through route such as a main line or branch line or spur. It may connect to a through track or to other sidings at either end. The distinction between sidings and other types of track is that a "siding" generally denotes an auxiliary or not exactly specified usage. Sidings often have lighter rails, meant for lower speed or less heavy traffic. A particular form of siding is the **passing siding** (called a crossing loop in British usage). This is a section of track parallel to a through line and connected to it at both ends by switches. Passing sidings allow trains travelling in opposite directions to pass, and for fast, high priority trains to pass slower or lower priority trains going the same direction. They are important for efficiency on single track lines, and add to the capacity of other lines.





Source: http://encyclopedia.thefreedictionary.com

Rail yard (railroad yard)

It is a complex series of railroad tracks for storing, sorting, or loading/unloading, railroad cars and/or locomotives. Railroad yards have many parallel tracks for keeping rolling stock stored off the mainline, so that they do not obstruct the flow of traffic. Railroad cars are moved around by specially designed yard switchers, a type of locomotive. Cars in a railroad yard may be sorted by numerous categories, including railroad company, loaded or unloaded, destination, car type, or whether they need repairs. Railroad yards are normally built where there is a need to store cars while they are not being loaded or unloaded, or are waiting to be assembled into trains. Large yards may have a tower to control operations.



A rail yard in Los Angeles

Source: http://encyclopedia.thefreedictionary.com

Classification yard (US) or marshalling yard (UK)

It is a railroad yard found at some freight train stations, used to separate railroad cars on to one of several tracks. First the cars are taken to a track, sometimes called a **lead** or a **drill**. From there the cars are sent through a series of switches called a **ladder** onto the classification tracks. Larger yards tend to put the lead on an artificially built hill called a **hump** to use the force of gravity to propel the cars through the ladder.

Freight trains which consist of isolated cars must be made into trains and divided according to their destinations. Thus the cars must be shunted several times along their route in contrast to a unit train, which carries, for example, automobiles from the plant to a port, or coal from a mine to the power plant. This shunting is done partly at the starting and final destinations and partly (for long-distance-hauling) in classification yards.



Chicago and North Western Railway's Proviso Yard in Chicago, Illinois, 1942.

Railway passenger station







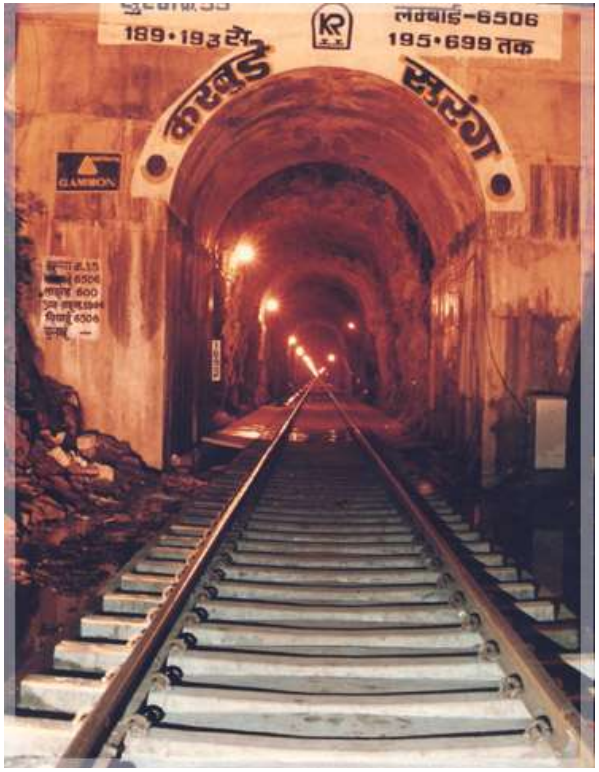


Civil engineering structures

bridge, viaduct, tunnel, culvert, footbridge, retaining wall, underpass











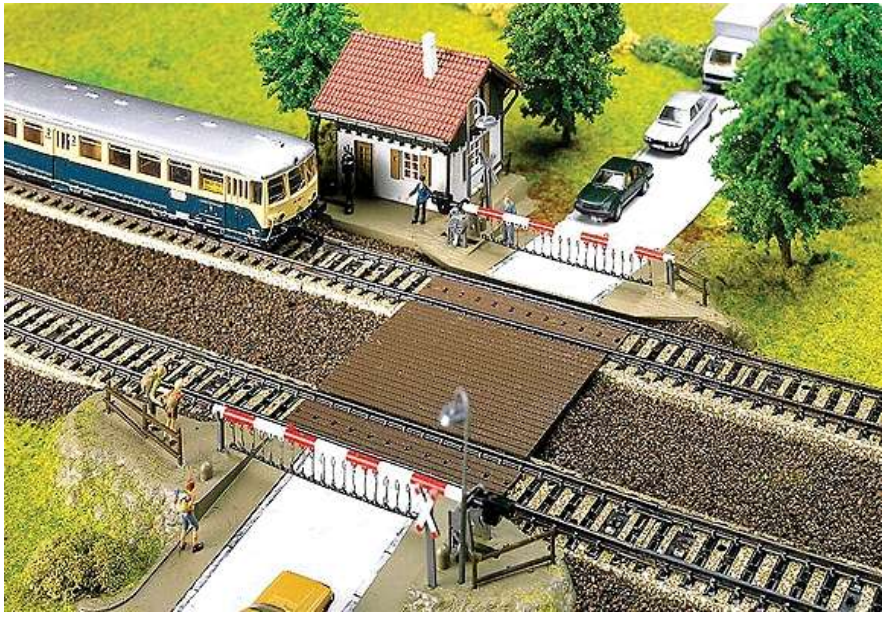




Grade crossing









Auxiliary buildings



Water tower



Locomotive shed



Control tower



Control tower at branch line