Chapter 2: Railway concepts

1. Historical
2. Algerian railway network
3. Ballasted railway tracks
4. Types of railway lines
5. Constituents of railway tracks

1. History (1/1)

The first railways appeared at the same time as the development of mines and coal exploitation. The first countries to develop this type of work were Germany and England (19th century). Since that time the operating system has been the same except that these tracks have been improved in order to adapt to changes in rail traffic, to the increase in train speed and to the loads which are transmitted to the support structure.

Steam train

High Speed Train (TGV)

2. Algerian railway network (1/4)

➢*Some numbers*

- Total length of lines: 4,573 km

  3,484 km on new roads, 1,089 km on old roads

- Total length of lines in operation: 3,854 km

  3,194 km of line on new tracks, 660 km on old tracks

- Length of double track lines: 450 km
- Length of single track lines: 3,404 km
- Length of electrified lines: 386 km (Suburbs of Algiers, Eastern Mining line)

SNTF today operates this entire network. The program to extend and modernize its lines will allow the SNTF to have a network of ***12,000 km by 2020*** (2,200 km under construction and 7,000 km under study).

The implementation of this program (civil engineering) is carried out by two Algerian companies, namely: ***INFRAFER*** (EPE / SPA) and ***INFRARAIL*** subsidiary SNTF (SPA).

2. Algerian railway network (2/4)

➢ ***Some numbers***

- More than 31 million passengers transported per year (main lines, regional, suburbs)
- Number of trains per day on the entire network is 234.
- More than 6 million tonnes of goods of all kinds are transported annually (18 million tonnes by 2020).
- More than 11,000 very varied wagons carrying:
  - ➢ Mineral products (iron ore, phosphate, pozzolan)
  - ➢ Energy products (Fuel, Lubricant, Special Products)
  - ➢ Cereal products (Wheat, Barley, Semolina, Flour)
  - ➢ Containerized goods (dry ports)
  - ➢ Miscellaneous products (Fertilizers, Cement, Steel Products, Rail, Ballast, Sand, etc.)

2. Algerian railway network (3/4)

➢ *Rail network map*

The railway network consists of three groups:

- the standard gauge northern ring road linking Annaba, Constantine, Algiers, Oran with its extensions to the Eastern (Tunisia) and Western (Morocco) borders. This ring road constitutes the main artery of trade between the currently most developed regions in the country with connections connecting it to ports and various cities.

- the mining line with its branches serving the mining deposits: iron in Ouenza and Boukhadra , phosphate in Djebel Onk.

- penetrating roads towards the high plateaux and the south and a high plateaux ring road connecting the towns of Tébessa → Ain- Mlila → Ain- Touta → M' sila . To which are added the particular branches.

2. Algerian railway network (4/4)

➢*Development and modernization strategy*

(National agency for studies and monitoring of railway investments, 2005)

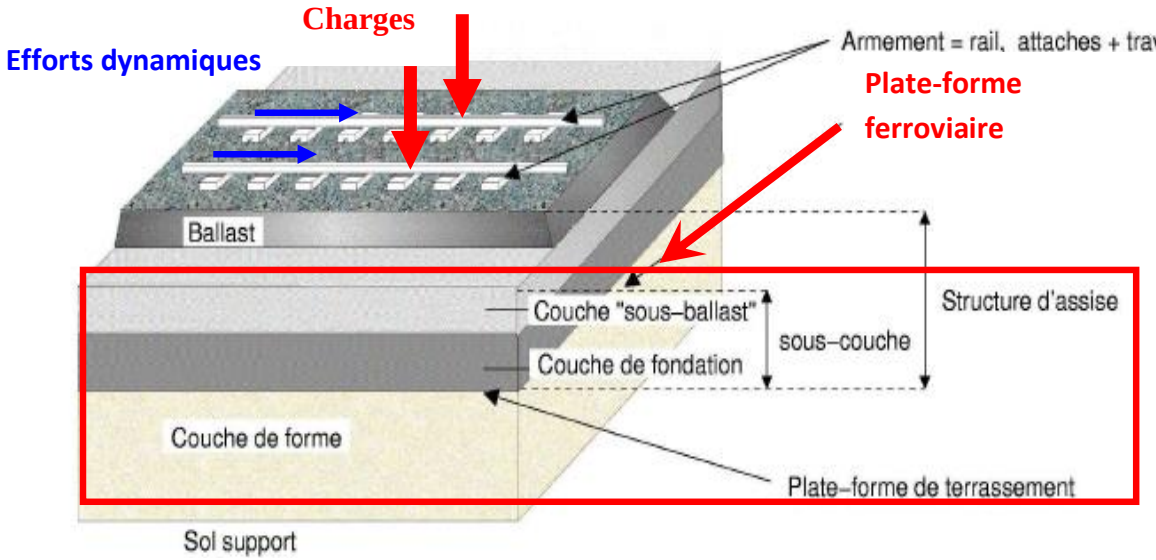
- ❑Electrification of lines and acquisition of new trains electric multiple units for passenger transport from the Algiers suburbs.
- ❑Splitting of the northern Constantine/Algiers/Oran ring road (in progress and study)
- ❑Renovation of old lines and construction of new ones railway lines (M' sila / Boughzoul ; Djelfa/ Laghout ; etc.)
- ❑Acquisition of diesel electric locomotives (USA) for the transport of mainline passengers and goods.
- ❑Acquisition of diesel hydraulic railcars for transport regional travelers (Constantine/Jijel; Constantine/M' sila).

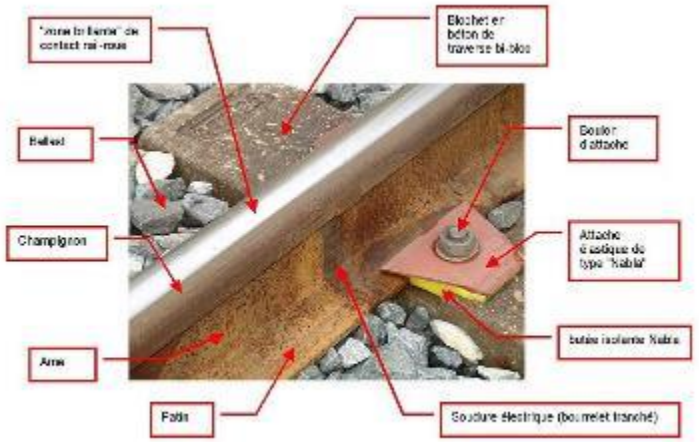
3. The ballasted railway track (1/1)

➢ *Definition*

Railway terminology designates by track all the constituents ensuring the movement of trains and supporting transverse, longitudinal and vertical forces.

Ballasted tracks are very widely used because of their flexibility in construction and maintenance, but also for their ability to meet the mechanical requirements set by the transport of heavy loads over a long distance.





4. Types of railway lines (1/3)

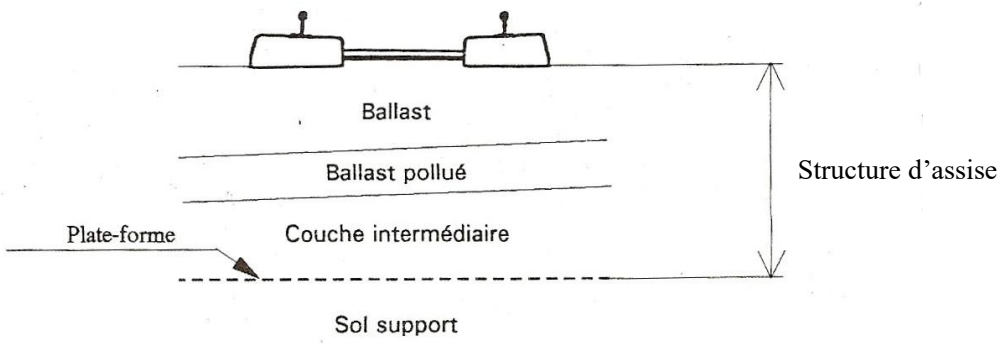
There are two types of main railways, conventional lines and high-speed lines (LGV).

4.1. Classic lines

Classic lines can be divided into two categories:

- ***Existing classic lines***

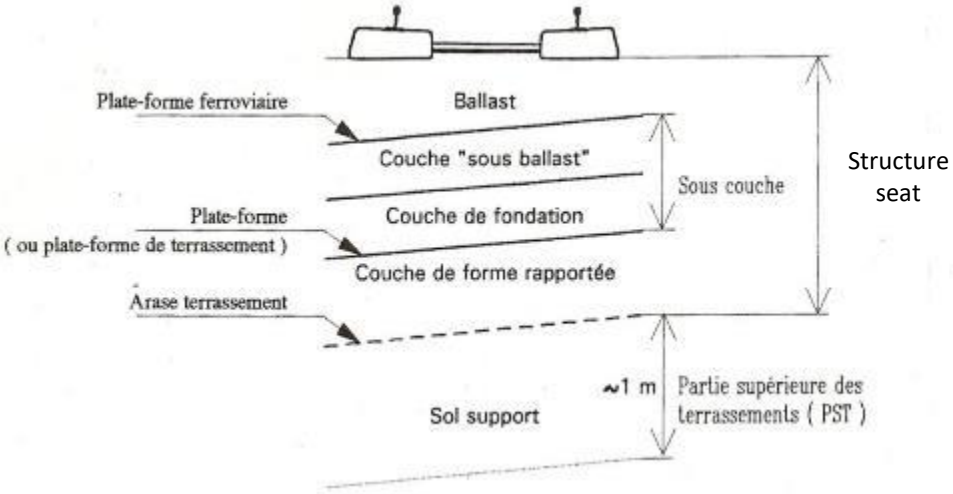
  They are the oldest, the structure is generally composed of ballast placed directly on the support soil, creating an intermediate layer of mixture between the ballast and the support soil.

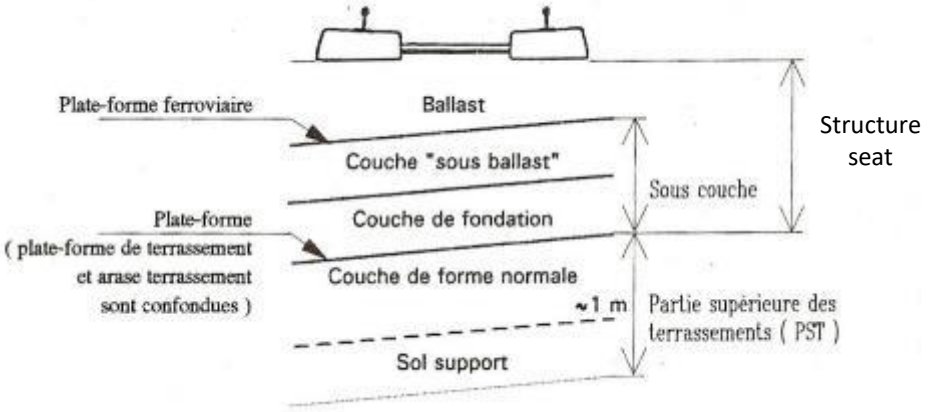


4. Types of railway lines (2/3)

❑***New classic lines***

They can have two different configurations depending on the type of shape layer used, either added or normal.





4. Types of railway lines (3/3)

4.2. High-speed lines (LGV)

- Rail lines built specially to allow the circulation of high-speed trains (initially > 200 km/h, today > 250 km/h),

- The first LGV was put into service in Japan in 1964,

- In Europe, the first LGV was put into service in 1977 in Italy (Rome to Florence),

- The structure of LGVs is similar to the structure of new classic lines, but the level of lift is higher, especially for the platform.

5. Constituents of railway tracks (1/10)

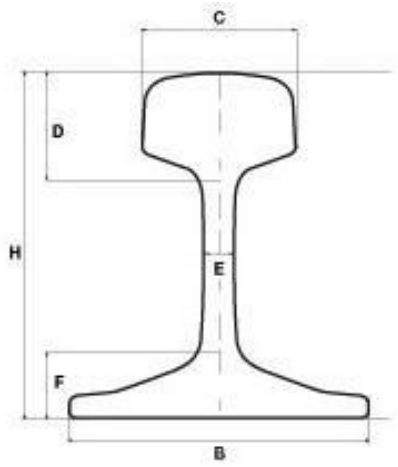
A railway track is a complex mechanical system composed of:

- two rail wires,
- the ribs with their fasteners,
- a base layer of ballast and an underlayer of grainy materials (sand or gravel) with possibly a geotextile.

5.1. Rails

After several developments in the past, ***the Vignole rail*** has today completely replaced the different types of rails. This type of rail includes three parts:

- the mushroom characterized by its width, its height, the bulging of its tread and the inclination of its lateral faces,
- the web and joint spans. Their layout is characterized by the thickness of the core, the shape of the connection fillets with the mushroom and the shoe, and the inclination of the joint surfaces,
- the skate characterized by its width as well as the thickness and shape of its wings.



5. Constituents of railway tracks (2/10)

- The basic length of normal rails is set at 18m, 24m or 36m, and long welded rails (LRS) are most often made up of 18 or 36m rails.
- The main characteristics of the three ***unified rail profiles (UIC 54, U 33, U 50)*** used in practice are shown in the table below:

Kind	Dimensions (mm)				Metric weight (kg)
	H	VS	B	E	
UIC 54	159	70	140	16	54,430
U 33	145	62	134	15	46,303
U 50	153	65	140	15.5	50,900

- Commonly used rail steels have a grade (tensile strength) between 685 and 835 N/mm². Currently, we are increasingly using hard rails with a minimum tensile strength of 885 N/mm² and up to 950 or even 970 N/mm².

5. Constituents of railway tracks (3/10)

5.2. Crossbars and fasteners

The rails rest on a floor made up of:

- either by sleepers on ballast,
- either by stringers or a concrete slab crossing engineering structures.

Laying on sleepers is the most frequently used. The sleepers ensure:

- the gauge of the rails at a value compatible with the imposed limits,
- the ballast distribution of loads transmitted on the rails by the rolling stock.

The sleepers usually used are:

- metal sleepers,
- wooden sleepers,
- ordinary reinforced concrete sleepers or concrete sleeper prestressed.

5. Constituents of railway tracks (4/10)

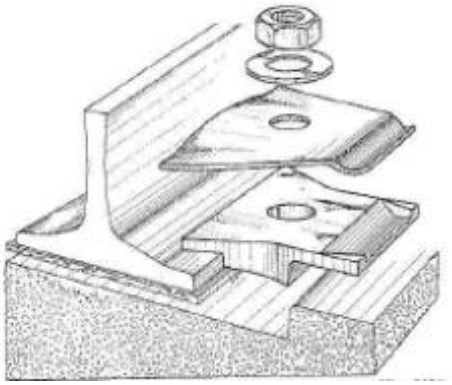
- Metal sleepers are widely used in tropical countries due to their immunity to termites. This type of sleepers presents a high cost and difficulties in maintaining the leveling and straightening of the track.
- The wooden sleepers are made of oak or beech (length of 2.6m; thickness varies from 12 to 15cm).
- Concrete sleepers are of several types:
  - the one-piece prestressed concrete sleeper,
  - the mixed biblock sleeper made up of two reinforced concrete blocks connected by a metal spacer,
  - the articulated crosspiece made up of three independent concrete elements: two blocks and a spacer.

Currently, the mixed crosspiece with a length of 2.24m and its weight is 190kg is most often used.

5. Constituents of railway tracks (5/10)

- Concrete sleepers have the following advantages:
  - great longevity
  - the high weight of the sleeper ensures better track stability,
  - maintenance of tightening and fasteners practically zero,
  - non-combustible,
  - economical compared to the other two types of sleepers.
- Concrete sleepers also have some disadvantages:
  - handling difficulties due to weight,
  - less good retention of leveling on mediocre platforms,
  - fragility of concrete upon impact,
  - during a derailment, they are more vulnerable than wood.
- Regarding the fasteners generally encountered in concrete sleepers are:
  - the NABLA attachment
  - the PANDROL attachment
  - the rigid toad with spring washer
  - the elastic toad RN

5. Constituents of railway tracks (6/10)



NABLA
attachment

PANDROL
attachment

Elastic toad

5. Constituents of railway tracks (7/10)

5.3. Ballast and seating structures

The base layers of a railway track include from bottom to top:

- the capping layer possibly topped with a geosynthetic (geotextile and/or geomembrane),
- the sub-layer composed of grainy materials (sand or gravel),
- the ballast layer composed of crushed stone.

5.3.1. The shape layer

The platform may include a subgrade layer of the same nature as that of the base soil or an added layer of better quality than that of the base soil. This layer can also be treated with hydraulic binders and covered with a geosynthetic (geotextile and/or geomembrane).

5.3.2. The underlay

The underlay includes:

- a layer called sub-ballast in clean gravel, well graded 0/31.5mm, comprising at least 30% crushed stone and compacted to 100% OPN.,
- a well-graded clean gravel foundation layer compacted at 100% OPN,
- depending on necessity, a layer called anti-contaminant in clean sand.

5. Constituents of railway tracks (8/10)

This underlay ensures:

- the protection of the upper part of the platform against erosion which results, on the one hand from the punching carried out by the ballast elements, on the other hand, from the action of runoff water,
- protection of the platform against the effects of freezing,
- a better distribution of the transmitted loads, which makes it possible to obtain admissible stress values at the level of the upper part of the platform.

5.3.3. The ballast layer

The ballast for a railway track must be composed of hard crushed stone (porphyry, sandstone, quartzite, limestone, etc.) with a grain size of 25/50. 10/25 aggregate is used for manual correction of railway track leveling.

- ensures the transmission and distribution on the platform of the loads exerted by the trains,
- ensures the anchoring of the sleepers in the longitudinal and transverse direction,
- contributes to the damping capacity of dynamic loads transmitted to the track thanks to the dissipation of energy by friction of the ballast grains between them.
- ensures drainage and rapid evacuation of runoff water,
- allows, by means of mechanized tamping-straightening, the rapid rectification of the leveling and layout of the track.

5. Constituents of railway tracks (9/10)

- To fulfill its role, the ballast must have sufficient hardness to resist the forces received and wear by abrasion. This hardness is expressed by means of a coefficient called ***overall hardness (DRG)*** determined from the ***resistance to attrition (*** Deval test) and the ***resistance to shocks*** (Los Angeles test).

  The ***Deval coefficient*** must be greater than:

  - 14 for hard stones,
  - 12 for limestone.

  Los Angeles coefficient must be less than 25.

  The value of ***DRG*** is min [(LA, DS); (LA, DH)], it is determined from the attached chart.

  The desirable overall hardnesses for the ballast are:

  - classic lines with passengers and $V \leq 200$ km/h $\rightarrow$ DRG ≥ 17
  - lines without passengers $\rightarrow$ DRG ≥ 14
  - high speed lines $V > 200$ km/h $\rightarrow$ DRG ≥ 20

5. Constituents of railway tracks (10/10)

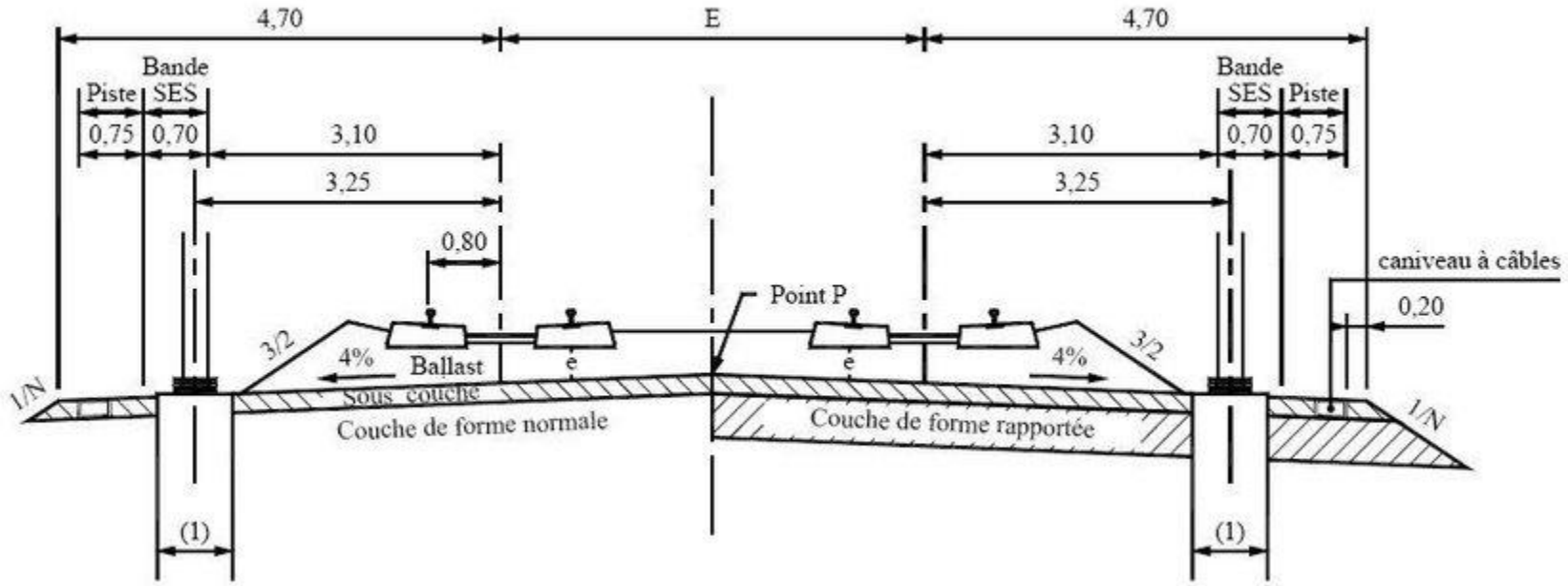
- The limit dimensions of ballast and gravel must be as follows:

	Normal	Fine ballast	Gravel
Circular mesh Square mesh	31.5/63 25/50	20/40 16/31.5	12/31.5 10/25

- The minimum thickness of ballast measured under the sleeper directly above the low rail, differs depending on the intensity of traffic and the type of sleeper:
  - classic lines: 20 cm (wooden sleepers); 25 cm (concrete sleepers),
  - high-speed lines: 30 cm (exceptionally 25 cm in curves).

The following diagram shows the ***typical cross-section*** of railway tracks:

Railway type cross section



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