



WELCOME TO RAILWAY ENGINEERING (CoTM4203)





WOLDIA UNIVERSITY

INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL & WATER RESOURCES ENG.

RAILWAY ENGINEERING (CoTM4203)

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Course Objective…

- To thoroughly introduce the railway system and engineering.

The railway engineering sub-course aims to:

- define the system and distinguish the fixed infrastructure of the system
- tell the story of infrastructure development from historic point of view
- introduce the historic background of rail in Ethiopia and its current status
- introduce and characterize the components of the civil works
- recognize the design considerations and design standards

Course Content…

1. Basics of Railway
2. Railway Line & Sub grade
3. Railway Track Structures
4. Railway Station
5. Switches, Turnouts & Crossings /railway joints/
6. Introduction to Tunnels & Bridges
7. Operation & Transport Management in Railway

Course Delivery

- Block Course by power point presentation
- Supplemented by semester project, assignments, exam...../subject to change/

- Attendance is mandatory!

CHAPTER 1. BASICS OF RAILWAY

Chapter 1. Basics of railway

- Railway Transport system
- Historic development of railway
- Components of railway
- General principle for railway construction and development
- Railway classification and items of Main Technical standards
- Highlight on railway signaling, control, communication and OCS
- Environmental impacts

1.1 Railway transport system

- **Definition :**

Rail transport refers to the land transport of people or goods along guided paths called railways. A railway consists of two parallel rail tracks at a fixed distance (gauge) apart, usually made of steel and mounted upon cross beams called ties or sleepers”

Cont'd

- **Functions:**
  - Important infrastructure of a country
  - Artery of national economy
  - Backbone of traffic and transport system
- **Characteristics:**
  - Great transport capacity/volume
  - Low cost
  - Energy saving and environmentally friend

Railway significance ☺

- It has a high level of passenger or cargo utilization over a limited space
- most efficient energy consumer (1/3 of road transport and 1/7 to 1/5 of air transport)
  - Minimum friction and minimum air resistance/guided movement/
- environmentally friendly
  - Mostly electric powered
- Safest mode of land transport with the lowest accident rate
- It offers comfortable ride options such as meal, sleeping and entertainment

Drawbacks ☹

- Huge initial investment and operation costs
- Cannot support severe alignments such as steep slopes and sharp curves
- Low flexibility in terms of network operations
- Severity of accidents is high (but low frequency)
- Security threat as it is prone to attacks

1.2 Historic development of Railway

600 BC- Ship Track way in Ancient Rome and Greek

1550's - Hand propelled tubs in Germany

1630- Wagon roads for coal mines pulled by horse carts in Beaumont, England

1776- First cast iron rails on timber ties laid in tram ways in England

The 19th century…

1807- first passenger train ran from Swansea to Mumbles and first railway station

1830 - The first railway in the United States opens with mostly hardwood rail topped with iron

1857 - Steel rails first used in Britain

1863 - First underground railway opened in London

20th century and onwards…

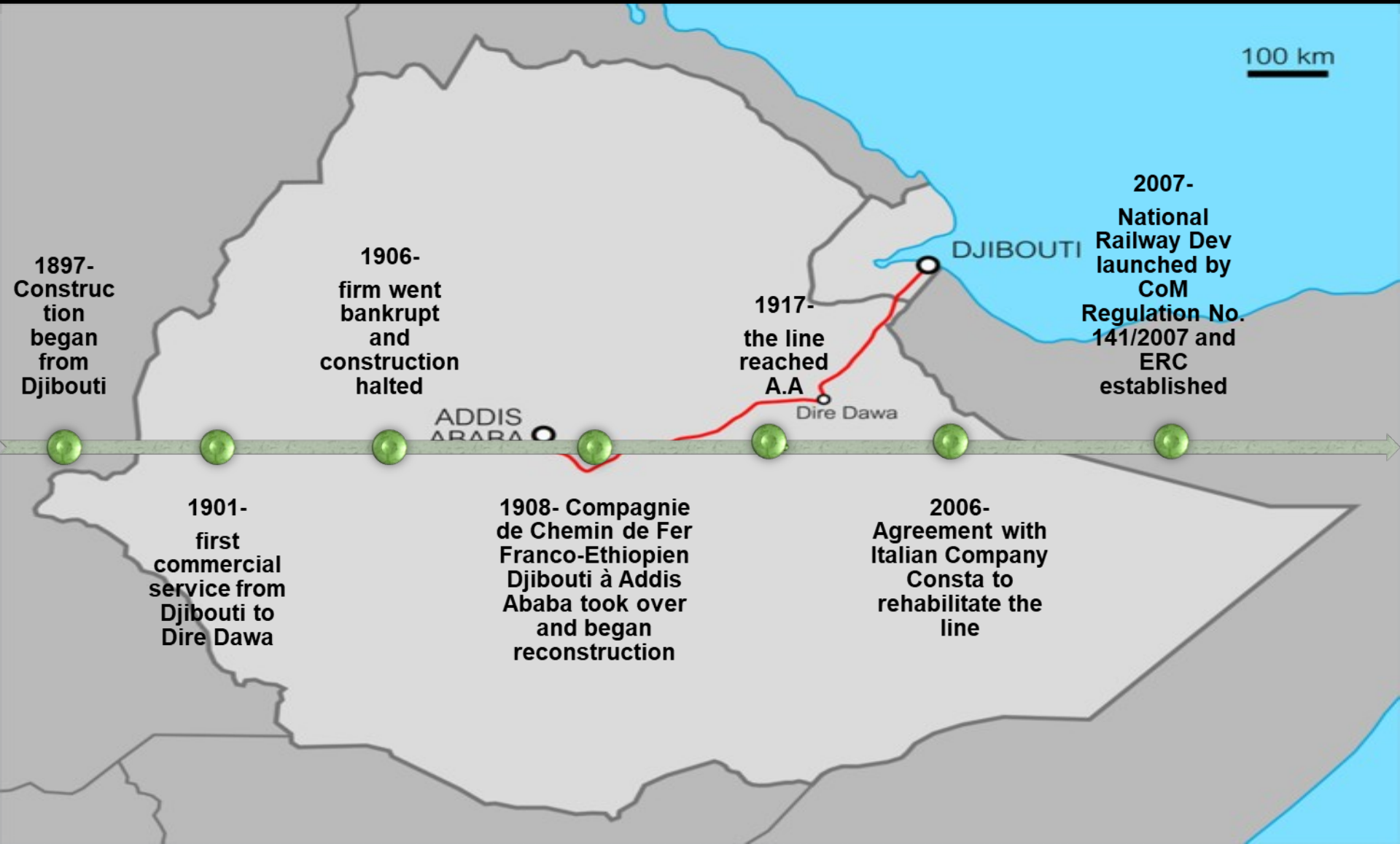
1906- First use of concrete sleepers in Germany

1937-41 - Magnetic levitation (maglev) train patents awarded in Germany

1959- Construction of the Bullet train in Tokyo, Japan

Post WWII- Welded rail, heavier rail-profiles, slab track, innovative elastic fastenings, mechanization of maintenance

History of Ethiopia railway



The legacy railway…

- 1000 mm gauge and diesel traction
- Owned and administered by the governments of Djibouti and Ethiopia
- 781km – 681 in Ethiopia and 100 in Djibouti)
- Suffers from old-age, lack of spares, high operating cost, worn out track, no Locomotives, very low capacity

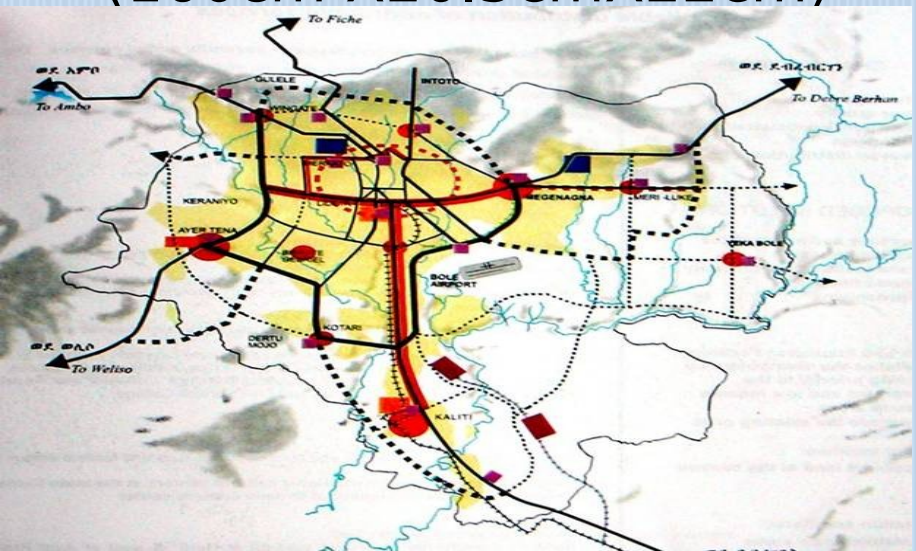


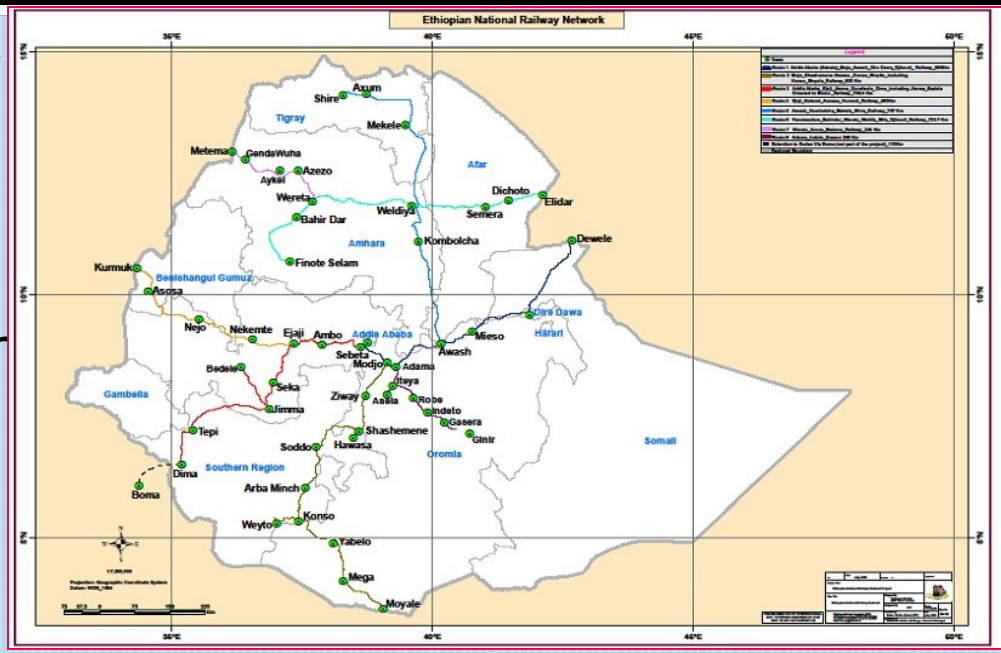




Ethiopian national railway program

- 5000 km of national railway line
- Standard Gauge (1435 mm
- Electric Traction
- High capacity (25 ton/axle)
- High speed (120 -160 km/hr for passenger and 80 -120 km/hr for freight)
- Concrete sleeper (160cm X20.5cmX22cm)

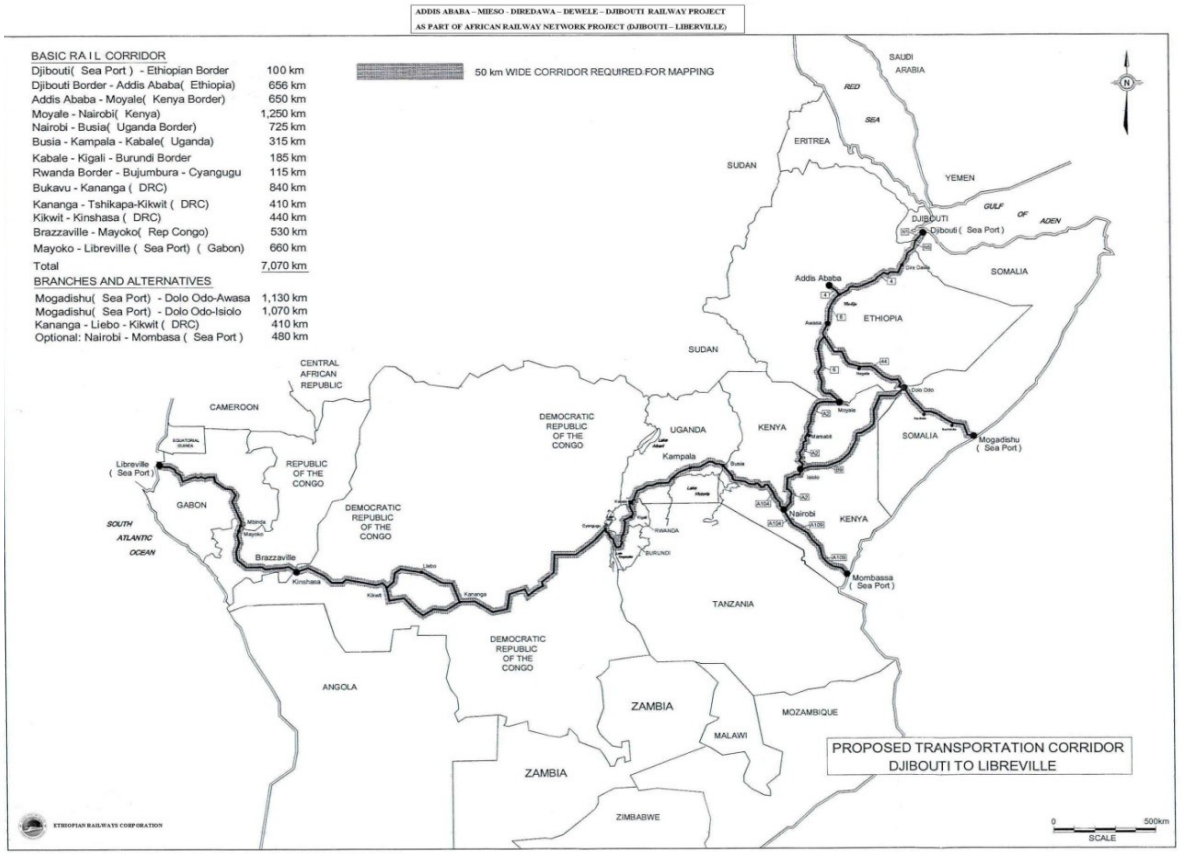




- 34km of Fully electrified LRT for Addis Ababa
- Standard Gauge (1.435 meters) and double track for the whole route
- Capacity: 80,000 PPH (Passenger/hr)
- Headway: 6min with a potential of reducing to 90secs

Regional integration in Africa…





Progress to date…



1.3 Components of Railway



Rolling Stock

Permanent Infrastructure



Power Supply



Signal and Communication



Components…

- Railway is a ***permanent way*** composed of subway, bridge ,culvert, tunnel ,track, station, switches etc.
- In order to provide smooth and stable geometry state, earth structures shall be built by cutting and filling the ground. For spanning rivers or gorges, bridges or culverts shall be built. For pass through mountains, mountains shall be excavated to construct tunnels.

Cont'd

- For trains passing and overtaking, stations shall be built. As for unfavorable geologic body which is difficult to detour, engineering improvement measures shall be taken in order to ensure operation safety.

Major components…



Tunnel



Bridge

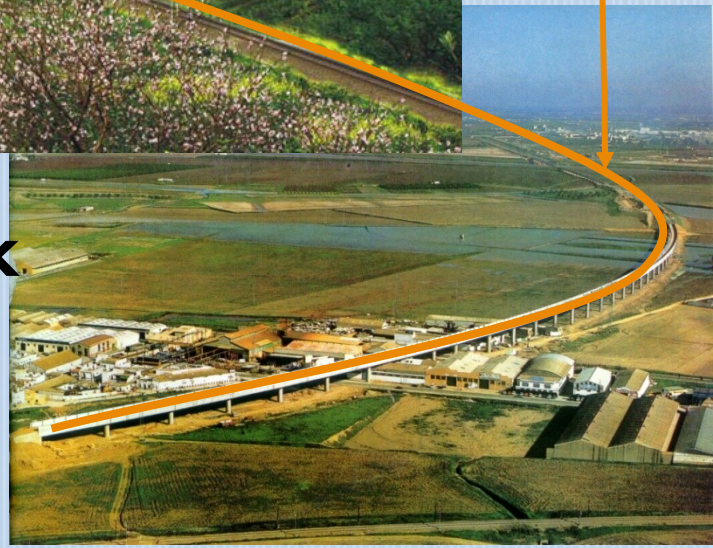


Earth Work

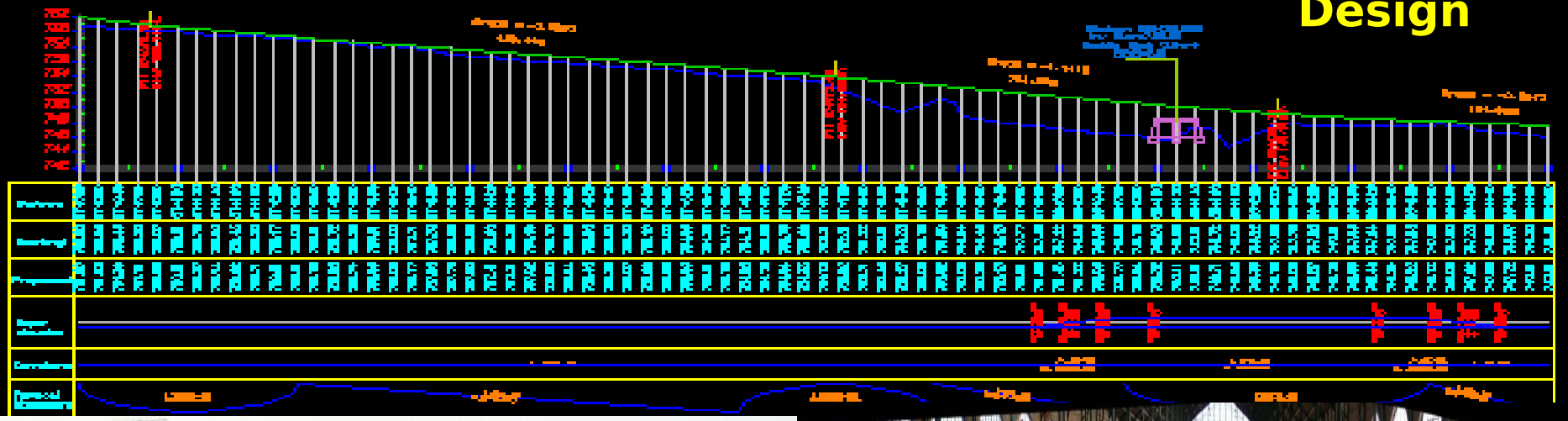
Track Alignment

Station





What types of Civil Works?



Design



Constructi
on



Operation
and

1.4 General principle for railway construction and development

- Based on the strategies of national economy and social development and the demands of territorial development,
- national defense
- transport market
- highlighting key points and strengthening weak links,
- coordinated development with other traffic and transport modes and relevant industries such as energy industry.

General principles…

- Directed by national development strategies
- Oriented by market, centered with benefit and on the premise of transport safety
- Actively adopting mature, advanced, economic, practical & reliable technologies and emphasizing comprehensive integration of technologies
- Insisting on the principle of using optimized system to maximize comprehensive benefit

Design year of railway construction

- Short term: The tenth year after delivery for operation
- Long term: The twentieth year after delivery for operation

N.B:- Traffic volumes in short term and long term are both forecasted.

1.5 Railway Classification & Main Technical Standards

1.5.1 Railway Classification:

- is the class grade of a railway classified according to its role in railway network, properties, volume of passenger traffic, goods traffic volume, maximum allowable axle load, design speed, etc.
- is the basic standard of a railway system, which is the basis to determine the technical standards and equipment types.

Classification…cont'd

- When railway is designed, railway classification should be determined
- Due to the reasons of
  - ✓ vast territory,
  - ✓ complicated topography,
  - ✓ unbalanced population and resources distribution and
  - ✓ the different economic conditions

Classification….cont'd

- railway's role in network, properties, volume of passenger & goods traffic, maximum allowable axle load and speed are different. Hence, railways should be classed in to different grades

Basis of railway classification

- Basses for railway classification include
  - axle load of rolling stock,
  - maximum running speed,
  - volume of passenger and goods traffic,
  - designed speed, and
  - significance of railway construction.

Basis…

1. ***Axle load of rolling stock***

- Axle load is one of major basis to determine the design load standard.
- Axle load of locomotives affect the power of locomotive, and car’s axle load affect the train’s load per meter. The bridge load and track type is controlled by car’s axle loads.

Cont'd

2. maximum speed

- The maximum speed is one of the most important marker of railway transportation quality.
- It affects the travelling time of passenger and freight trains, traffic capacity and the using condition of rolling stock.
- It also affect construction cost, expenditure for buying rolling stock, locomotive energy consumption transportation cost, etc.

Cont'd

The running speed is limited by the power of locomotive, the standards of alignment and track, level of signal facilities, method of traffic control, traffic organization, etc.

The Maximum speed is the major technical parameter to determine the

- ✓ radius of horizontal & vertical curves
- ✓ length of transition curve
- ✓ the type of track.

Cont'd

3. ***Annual Volume of Passenger and Goods traffic***

- it is the main base for
  - designing transport capacity
  - evaluation of economic effectiveness
  - determination of route alternatives
- The annual volume of passenger and goods traffic affect the track-train interaction track deformation, residual life of structures.

Cont'd

- In general, railway investment cost, cost of railway traffic and traffic revenue shall be decided by annual volume of passenger and goods traffic.
- For these reasons, under the same service life, equipment with high standards should be used in the railway with heavy traffic volume.

Basis of Classification…cont'd

- Example:- In china, railways are classified in to three categories based on the annual volume of passenger and fright traffic, role they played in railways network, and maximum design speed. These are:
  1. Railway line for passenger traffic
  2. Railway line for mixed passenger and freight traffic
  3. Line for goods traffic

Cont'd

- These further classified in to seven grades:
- ✓ High speed line
- ✓ Rapid speed line
- ✓ Classes I~IV
- ✓ Heavy haul railway

1. Railway line for passenger traffic

- Mainly responsible for transportation of passenger with design speed of passenger car not less than 200km/h. Further classified as:

1）High-speed railway :

- Railways for passenger with maximum design speed of 250km/h and over and play trunk parts in railway network
- Generally built in a developing region where is densely populated and has a heavy volume of passenger traffic.

Cont'd

- It links political center and economic center, or economic center and economic center.
- On high-speed line, passenger trains could operate with speed of 250km/h or over in main section, the seating capacity could be up to 1600 persons per train, the maximum traffic-carrying capacity could be 2*32000person or over.

Cont'd

2) Rapid -speed railway

- Railways are classified as rapid-speed railways which play a linking and auxiliary part in railway network for passenger traffic, with designed speed of 250km/h or lower.
- In China, rapid-speed line also classified as rapid-speed trunk line for passenger traffic or inter-city line in terms of the role in rapid railway passenger transport network, transport demand, and service area.

2. Railway line for mixed passenger and freight traffic

- These railway lines are responsible for passenger and fright transportation, with design speed of 160km/h or lower (passenger train) and 120km/h (fright train).
- Railways for mixed passenger and fright traffic can be classified as 4 grades,
  ClassⅠ, ClassⅡ, ClassⅢ, and ClassⅣ.

Cont'd

- The class of a new line or reconstructed railway should be determined in terms of
- the role in railway network
- Properties
- Design speed of passenger train and
- volume of passenger and fright traffic

And Should meet the following requirements

Cont'd

- Class I Railway: Play a trunk part in railway network, and the volume of short-term traffic is no less than 20 million tons.
- ClassIIRailway: Play a linking and auxiliary part in railway network, and the volume of short-term traffic is less than 20 million tons.
- ClassIII Railway: Give service to a local zone, and the volume of short-term traffic is less than 20 million tons and larger than 5 million tons.

Cnt'd

- ClassIV Railway: Give service to a local zone, and the volume of short-term traffic is less than 5 million tons.

1.5.2 Items of Main technical standards

- Main technical standards includes the *basic standards and types of railway facilities*, which shall give obvious influence on the traffic capacity, construction cost, operation quality, and the selection of other equipment standards.

Main technical Standards…cont'd

- The design of railway of mixed service shall include main technical standards of the following:
  - numbers of main lines
  - ruling grade
  - minimum radius of curvature
  - available length of arrival & departure
  - kind of energy supply
  - types of locomotives
  - tonnage rating
  - locomotive routing and
  - type of blocking.

Cont'd

- Main technical standards for railway of passenger traffic include:
  - designed speed
  - distance between centers of main line tracks
  - minimum plane curve radius
  - maximum gradient
  - available length of arrival and departure line
  - EMU type
  - train operation control mode
  - train operation command mode
  - minimum head

1. 5 Railway Signals, Communication and control



1.5.1Railway communication

- From the method of transmission: Cable and wireless communication.
- From the service area: toll communication; area communication, section communication, station communication.
- From the service nature: public communication, private communication and data transmission.

Cont'd

Railway private communication system consists of:

1.Train dispatching telephone

- The train dispatching phone is a kind of wired phone, which is used to communicate between dispatchers and station attendants.

Cont'd

2. train dispatching radio phone

- The train dispatching radio phone can be used as the communication tool between train dispatchers, locomotive dispatchers, station attendants or others and the driver.

Cont'd



Wireless dispatching telephone in a station



train dispatching radio phone

Cont'd

3.Wireless dispatching telephone in a station

- The wireless dispatching telephone in a station is used by dispatchers, hump attendants or other commanders to communicate to the shunting locomotive driver.

Cont'd

4.Other railway private communication equipments

- Private telecom system
- Railway local telephone
- Long distance telephone and telegraph within railway administration and mail lines
- Train out report telegraph and telephone
- Railway station communication system

1.5.2 Railway signaling & control system

Signaling consists of the systems, devices and means by which trains are operated efficiently and tracks are used to maximum extent, maintaining the safety of passengers, the staff and the rolling stock.

It includes the use and working of signals, points, block instruments and other equipments

Signals have **aspects** and **indication**

- Aspect is the visual appearance of the signal
- Indication is the meaning

Objectives of signaling

The various objectives of providing & operating signals are:

- ✓ To provide facilities for the efficient movement of trains
- ✓ To ensure safety between two or more trains
- ✓ To provide facilities for the maximum utility of track
- ✓ To provide facilities for safe and efficient shunting operations
- ✓ To guide the trains movement during maintenance and repair of tracks

Cont'd

- Signals can be placed:
  - At the start of a section of track
  - On the approach to a movable item of infrastructure, such as switches or a swing bridge
  - In advance of other signals
  - On the approach to a level crossing
  - Ahead of platforms or other places that trains are likely to be stopped

Signal equipments introduction

- Railway signal equipments are the key facilities to organize and command train operation, ensure safety, enhance the transport efficiency, transfer information, improve working conditions of driving personnel .
- The foundation of railway signal equipment includes signal machine, switch machine, track circuit, signal relays, etc.

Signal machine

- Signal and signal reapter say a signal that used to command train operation and shunting homework.



Switch machine

The switch machine plays an important roles on train operation ,which is used to complete the conversion and locking of switch.

ZD6 seriess are used for the existing line



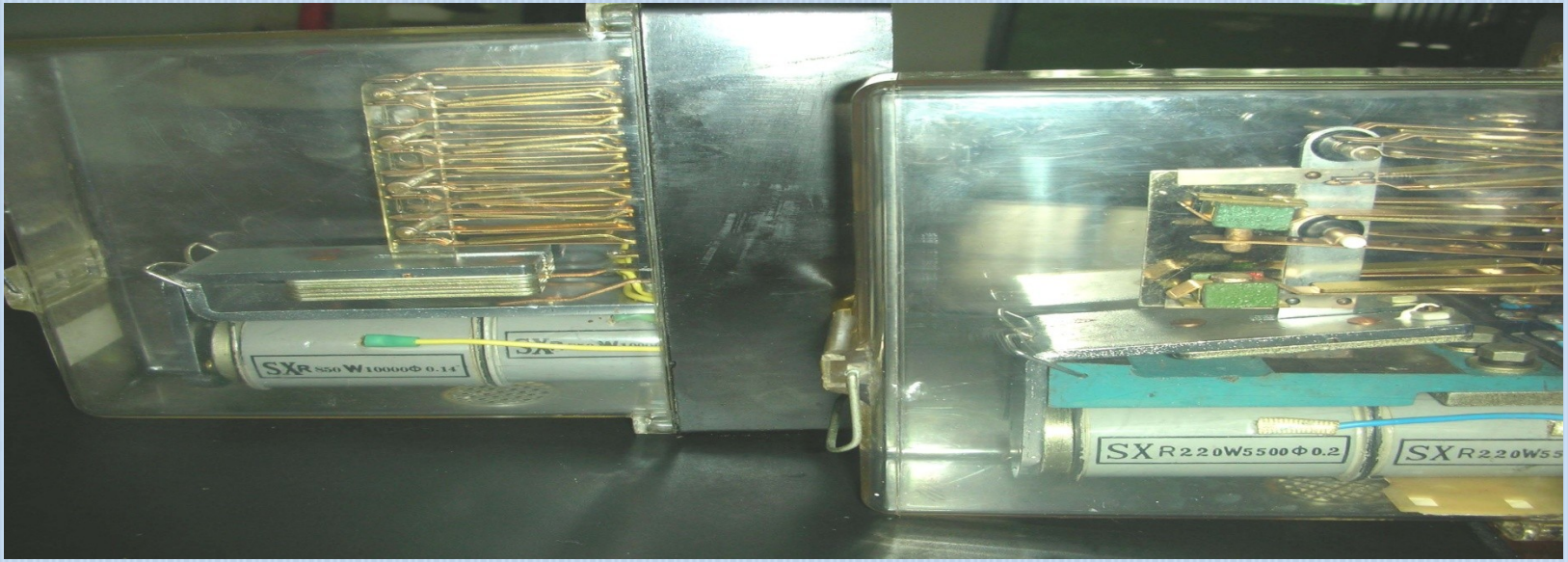
Track circuit

- The track circuit is used to monitor the occupancy of the train and



Signal relay

- Signal relay is not only the key component of various relay control system but also the interface unit of electronic or computer control



The basic color of the visual signal

- Red - stop
- Yellow - Noting and reducing speed
- Green- driving at the required speed
- Bluish-white calling-on signal or permitting shunting signal
- Blue - permissive signal or prohibiting shunting signal

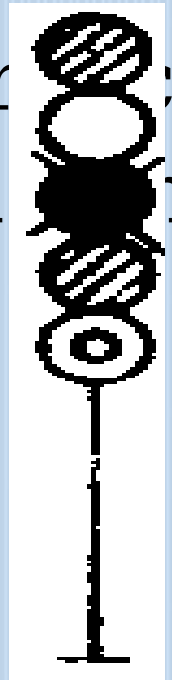
Cont'd

number	symbol	description
1		Green
2		yellow
3		red
4		blue
5		Bluish-white
6		white
7		empty
8		stable
9		flash
10		Pairs of semi-yellow
11		Half yellow half red

Home signal

Function：Protecting stations, indicating the train operating conditions to ensure the receiving route safe and reliable.

The entrance of station must be fitted with home signal.





Cont'd

indication	Meanings	picture
	Banning train through the signal	
	Allowing train through the signal at the limited speed , Being prepared to stop on the main track by switch normal position	
	Allowing train throug the signal at the limited speed , Being prepared to stop on the siding track by switch reverse position	

Cont'd

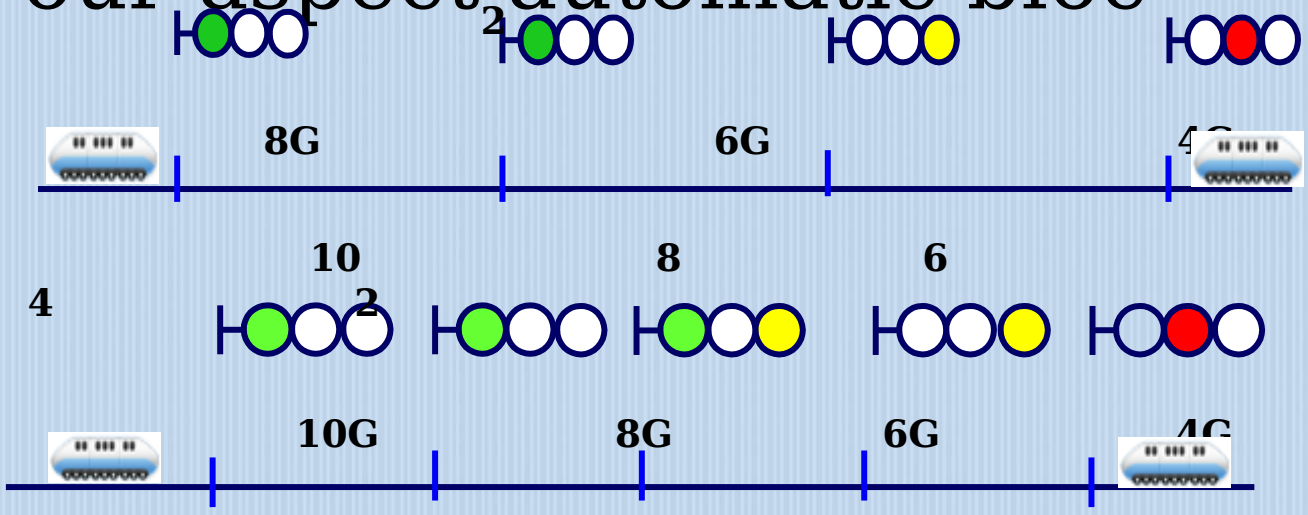
indication	meanings	picture
	allowing train entering or through the station according to the speed required by the switch normal position , which means there are at least three block sections idle in front of the train	
	allowing train entering the station according to the speed required by the switch normal position , which means the next signal has been cleared at yellow light	
	Calling-on signal, entering station at no more than 20 km/h speed and being ready to stop.	

Through signal

Function：**protecting block section,** Indicating the train can enter the next block section.

Three-aspect automatic block

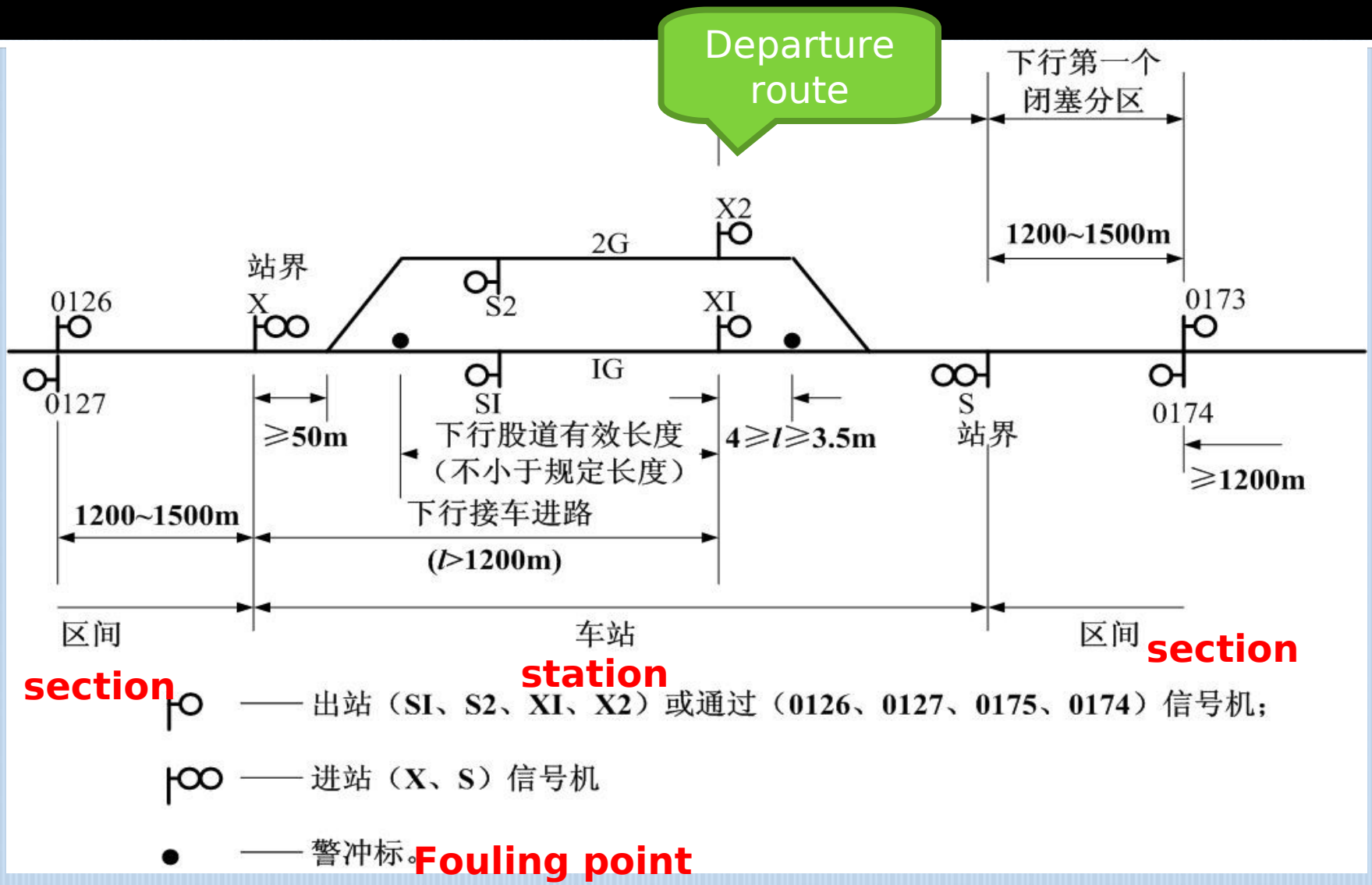
Four-aspect automatic bloc



Departure signal

- **Function** ： indicating the train can enter the section or not, and the parki




Departure route
下行第一个
闭塞分区
1200~1500m
X2
2G
站界
X
S2
XI
0126
0173
0127
SI
IG
S
站界
0174
≥50m
下行股道有效长度
（不小于规定长度）
4≥l≥3.5m
≥1200m
1200~1500m
下行接车进路
(l>1200m)
区间
车站
区间
section
station
section
—— 出站（SI、S2、XI、X2）或通过（0126、0127、0175、0174）信号机；
—— 进站（X、S）信号机
—— 警冲标。
Fouling point

Shunting signal

function：Indicates the various shunting operation, be Installed in interlocking yard with shun

A:single shunting signal

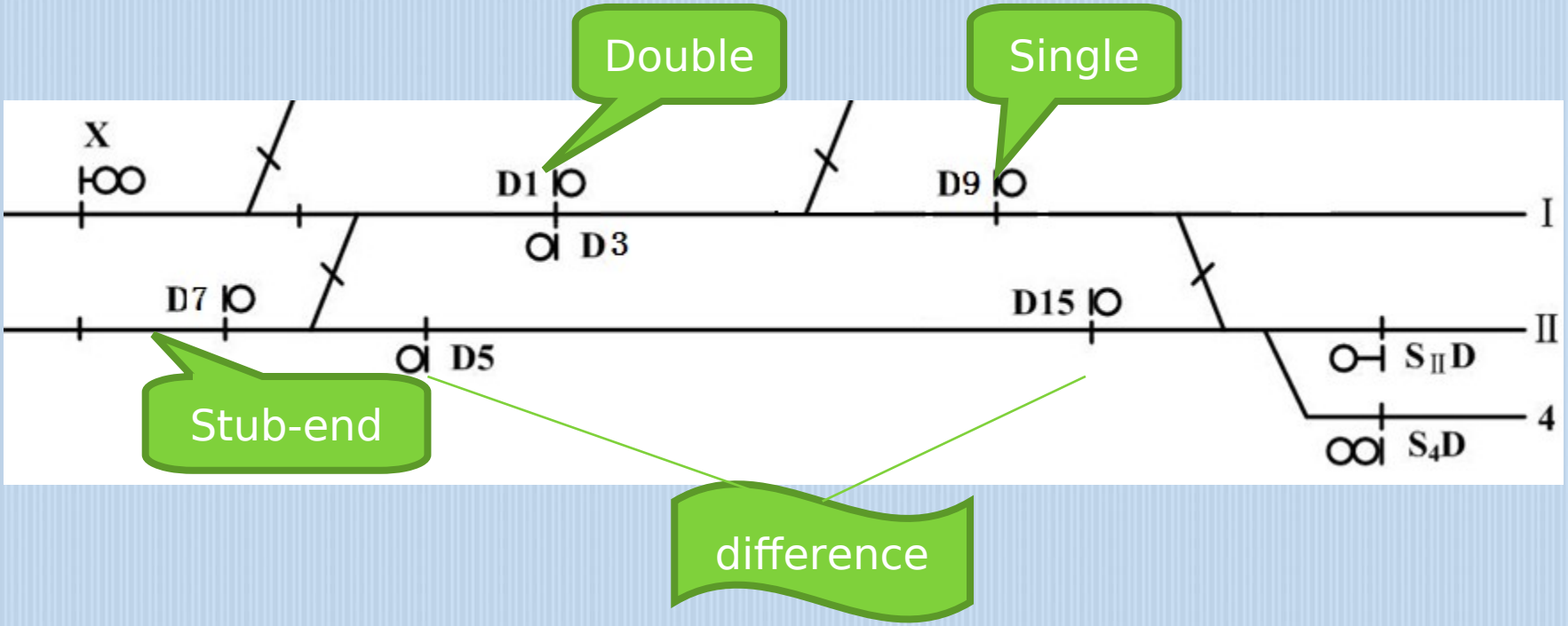
B:double shunting signal

C: difference shunting sig

D:stub-end shunting sign



Cont'd


Double
Single
X
D1
D9
I
D3
D7
D15
II
D5
$S_{II}D$
4
S_4D
Stub-end
difference

Cab signal

Cab signal	description		
	Four-aspect automatic block	Three-aspect automatic block	Semi automatic block
L	run at the required speed		
LU	pay attention to run at the required limit speed	run at the required speed	
U	slow to under the speed level required	pay attention to run	
UU	run at the required limit speed , which means that the signal train approch is at clear and switch is in the reverse		

Cont'd

U2	means that train slows to the required level of speed though the closing ground signal. and indicates the next ground signal showing two yellow lamps	Means train pay attention to run and indicates the next ground signal showing two yellow lamps
USU	Run at required limit speed, which means that the signal train is approching is at clear and the larger switch is in the station of reversation	

Cont'd

HU	Request to take measures to stop
HSU	Home signal which train is approching opens calling-on signal
H	Train has been overd the red signal
B	Not Repeat the ground signal, train runs according to the ground signal showing
null	Cab signal Stops working

Control of movement of trains

- One of the basic objectives of signaling is to control the movement of trains with a view to ensure safety by preventing accidents
- To achieve this goal, a particular system of working should be adopted keeping in view three important aspects i.e safety, speed and traffic density of operation

System types…

- The Various systems of controlling the movement of trains are:

1) one –engine only system
2) Following train/time interval system
3) Pilot guard system
4) Train staff & ticket system
5) Absolute block system
6) Automatic block system
7) C.T.C system
8) A.T.C system

Thank You