Lecture 4

University of Anbar

Civil Engineering Department

MSc- Highway Engineering

Railway and Airport Engineering

Railway Track: Components of Substructure

- **Ballast,**
- **Subballast,**
- **Subgrade**

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Track Ballast

- Ballast is layer of broken stone, gravel, or any other suitable material placed under and around the sleeper
- The term ballast comes nautical term for the stones used to
- stabilize a ship .
- Ballast the material to supported a cross ties and rail.
- The quality of ballast material has a direct relationship to the truck support system.
- Good quality ballast, made of well graded gravel, crushed gravel, limestone or igneous rock was necessary if adequate foundation and good drainage is to be achieved for a reasonable period.
- Additionally, it was found that, even with good quality crushed material, the presence of a high proportion of ‘fines’ in track ballast can quickly result in silting up and softening of adjacent and supporting materials, thus causing track settlement and drainage long term problems.

Characteristics of a Good Ballast

To perform the good functions, the ballast should have the following characteristics:

- Ballast must resist the crushing action of superimposed track and dynamic traffic loadings.
- It should have angular and rough surface so that it may give lateral and longitudinal stability to the sleepers.
- It should be non-porous and non-absorbent of water.
- It should be durable and should not get pulverized under the weather conditions such as variation in temperature, moisture and freezing.
- It should have good workability, so that it can be easily laid on formation.
- It should not have any chemical effect on the rails and the sleepers.
- It can be easily packed in position with hand tools.
- It should provide good drainage of water.
- It should be cheap and economical in price.
- It should not make the track dusty or muddy due to powder under dynamic wheel loads but should be capable of being cleaned to provide good drainage.
- Good ventilation and permeability to maintain the bearing capacity of the subsoil.

Advantage of Tradition Ballast Track

- Relatively low construction costs
- High elasticity
- High maintain ability at relatively low cost
- High noise absorption
- High discharge capacity

Ballast Types

- Only a few of the many available ballast materials meet the requirements for today’s heavy-duty, high-speed main line operations.
- Even within the commonly accepted categories there are variations in quality and performance. Selection must be based on a combination of adherence to specifications, tests and, where possible, experience
- Materials which are broken stone, gravel, sand and kankar. The best material for ballast is non-porous, hard and angular stones and therefore the stone ballast is used on all important track.
- In Iraqi railways, broken stone is the most used as ballast material.

The Ballast Component of Track

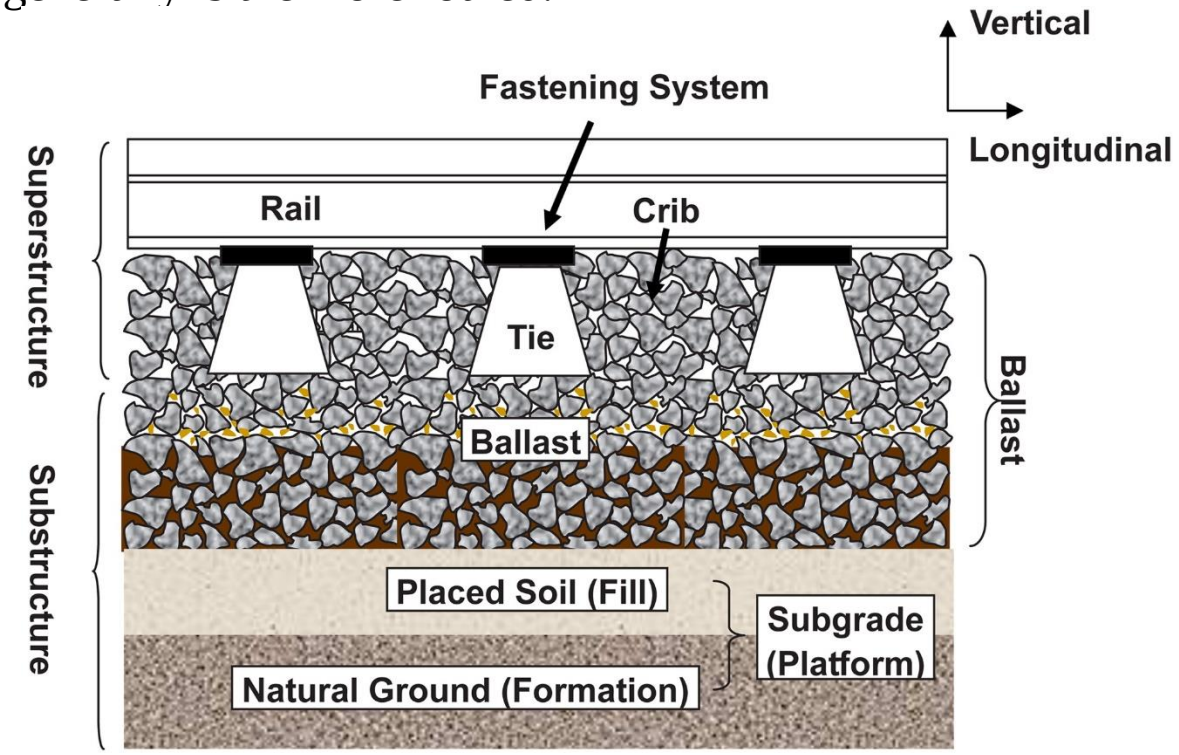
The ballast component of track is subdivided into four zones:

1. Crib—material between the sleepers.

2. Shoulder—material beyond the sleeper ends down to the bottom of the ballast layer

3. Top ballast—upper portion of supporting ballast layer that is disturbed by tamping

4. Bottom ballast—lower portion of supporting ballast layer, which is not disturbed by tamping and generally is the more fouled.

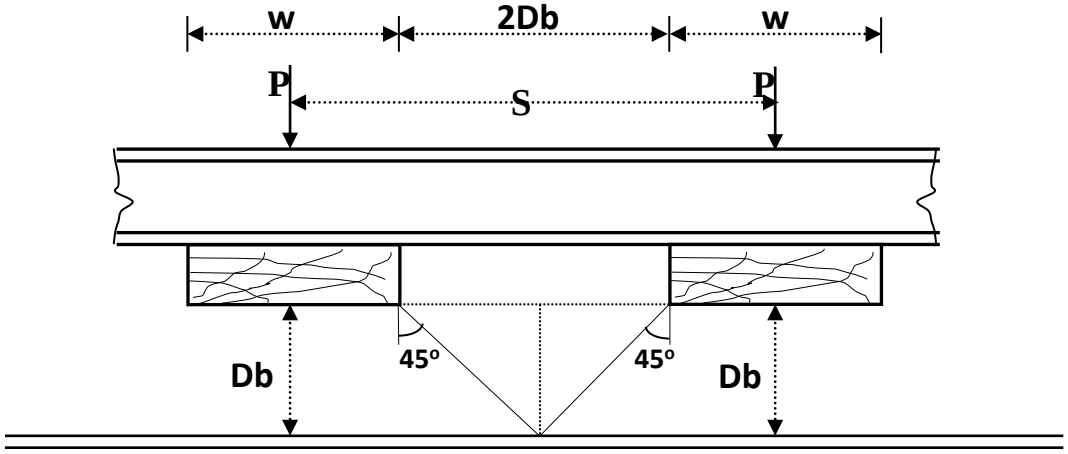


The Required Depth of Ballast

- The required depth of good quality ballast beneath sleepers varies depending upon the maximum speed of trains, the maximum axle loads carried, and the gross annual tonnage expected.
- In general, the absolute minimum depth of ballast needed beneath sleepers for even a lightly loaded railway should never be less than 15 cm and heavily loaded main lines can require as much as 28 cm.
- To ensure both lateral and longitudinal stability of the track, particularly when using continuously welded rail, it is essential that ballast is taken up to the level of the top of the sleepers between the sleepers and given a good ‘shoulder’ at the sleeper ends.
- To achieve maintenance of this condition, regular inspection and periodic tamping is necessary.

Minimum Depth of Ballast Section

- The depth of ballast can be calculated as below:
- $Depth\ of\ ballast\ cushion\ (Db) = \frac{\boldsymbol{spacing\ of\ sleeper\ (s) - Width\ of\ sleeper\ (w)}}{\boldsymbol{2}}$
- Ballast cushion: It is the depth of ballast below the sleepers.
- On curves additional ballast is required to makeup the superelevation. The depth of ballast under the outer rail is increased so as to give the required superelevation.



Minimum depth of ballast

- For example, if wooden sleepers are used in track laying with sleeper density as (n +7), the sleeper spacing is 65 cm and width of sleeper is 25 cm.
- Then, the minimum depth of ballast from above formula works out to be 20 cm which is minimum depth of ballast.

Materials for Track Ballast

- Good quality track ballast is made from crushed natural rock with particles not larger than 50mm nor generally smaller than 28mm.
- Angular stones are preferable to naturally rounded stones, to achieve the best interlock properties and resistance to longitudinal and lateral movement under dynamic loading.
- Too many small stones below 28mm will however clog the ballast and reduce, in the longer term, its drainage properties.
- Samples of track ballast must be checked for grading by sieve analysis.
- Not more than 3% by weight should be retained on the 50mm square mesh sieve and not more than 2% should pass through the 28mm sieve.

Ballast Characteristics to Perform Its Intended Functions

For ballast to perform its intended functions, it should consist of the following characteristics:

1. Most particles in the 0.8- to 2.5-inch (19- to 64-millimeter) size range

2. Produced by crushing hard, durable rock

3. Planar fractured faces intersecting at sharp corners (to give angularity)

4. Particles with a maximum ratio of 3:1 for largest to smallest dimensions

5. Rough surface texture preferred

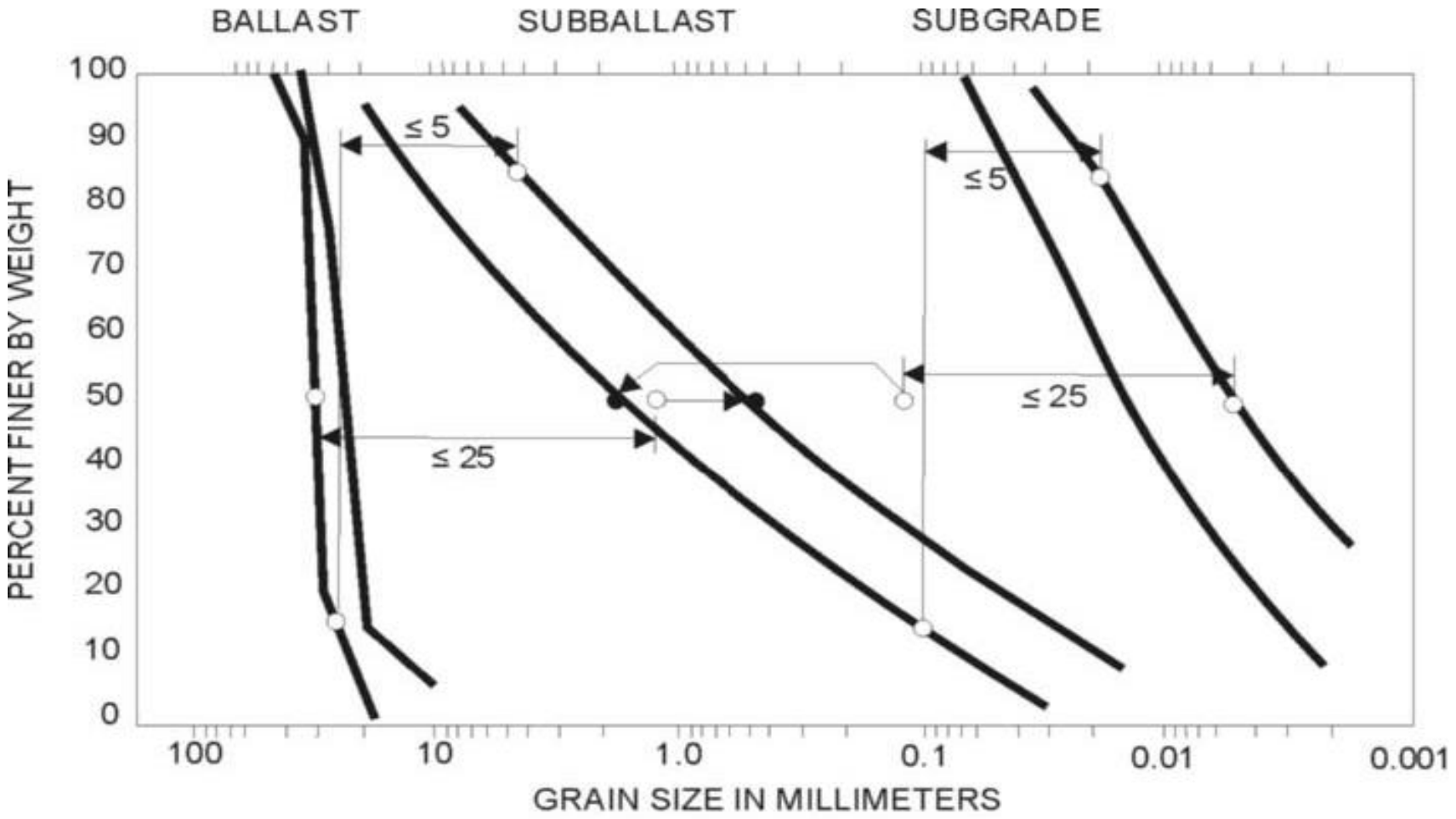
6. Low water absorption

Subballast

- Filtering below the ballast a layer of sub-ballast is placed.
- The sub-ballast is material chosen as a transition layer between the upper layer of large-particle good quality ballast and the lower layer fine-graded.
- It used to prevent mutual penetration or intermixing of the sub grade and ballast and reduced frost penetration.
- Any sand or gravel material may serve as sub ballast material as long as they meet proper requirement

- Subballast is a very important but not adequately recognized track substructure component.
- It serves some of the same functions as ballast, but it also has some unique functions.
- One unique function of subballast is to prevent the fine subgrade particles from migrating into the ballast voids, whether from repeated train loading or from flow of water.
- The fine soil particles produced then mix with water and form mud that squeezes into the ballast voids.
- Inserting a 6- inch (150-millimeter) layer of properly graded and durable subballast between the ballast and the subgrade solves the problem.

Subballast Satisfying Filter Criteria

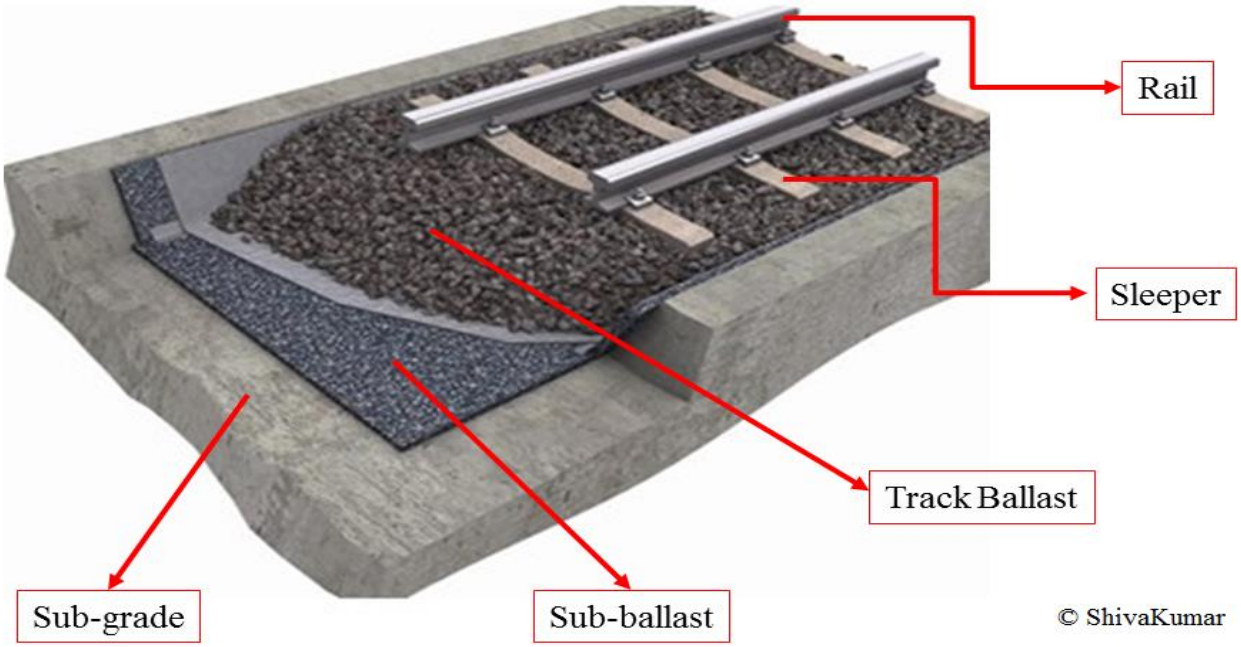


Subgrade

- The subgrade is the platform upon which the track structure is constructed.
- Its main function is to provide a stable foundation for the subballast and ballast layers.
- The influence of the traffic-induced stresses extends downward as much as 5 meters below the bottom of the ties.
- This is considerably beyond the depth of the ballast and subballast. Hence, the subgrade is a very important substructure component that has a significant influence on track performance and maintenance.
- The subgrade may be divided into two categories : (1) natural ground (formation) and (2) placed soil (fill).
- The design method must consider the type and strength of the subgrade soil, the distribution of dynamic wheel loads and number of repetitions, and the substructure layer resilient moduli.

Subgrade

- Sub grade is the layer of material on which the ballast and sub ballast rest .
- It is the main part of the base of railway including all the earthworks which including filling of depressing or highlands.
- High quality soil is placed in the top and bottom layers while least quality is placed in the middle.



Characters of Subgrade

1.High bearing capacity

2.Low compression at loading.

3.With little poetic properties.

4.High water permeability .

5.Low flexibility.

6.The proportion of soluble salts is less then 8%