Lecture 2

University of Anbar

Civil Engineering Department

MSc- Highway Engineering

Railway and Airport Engineering

Railway Track

- Railway Track Components
- Definitions
- Functions Of Track Components
- Track Forces

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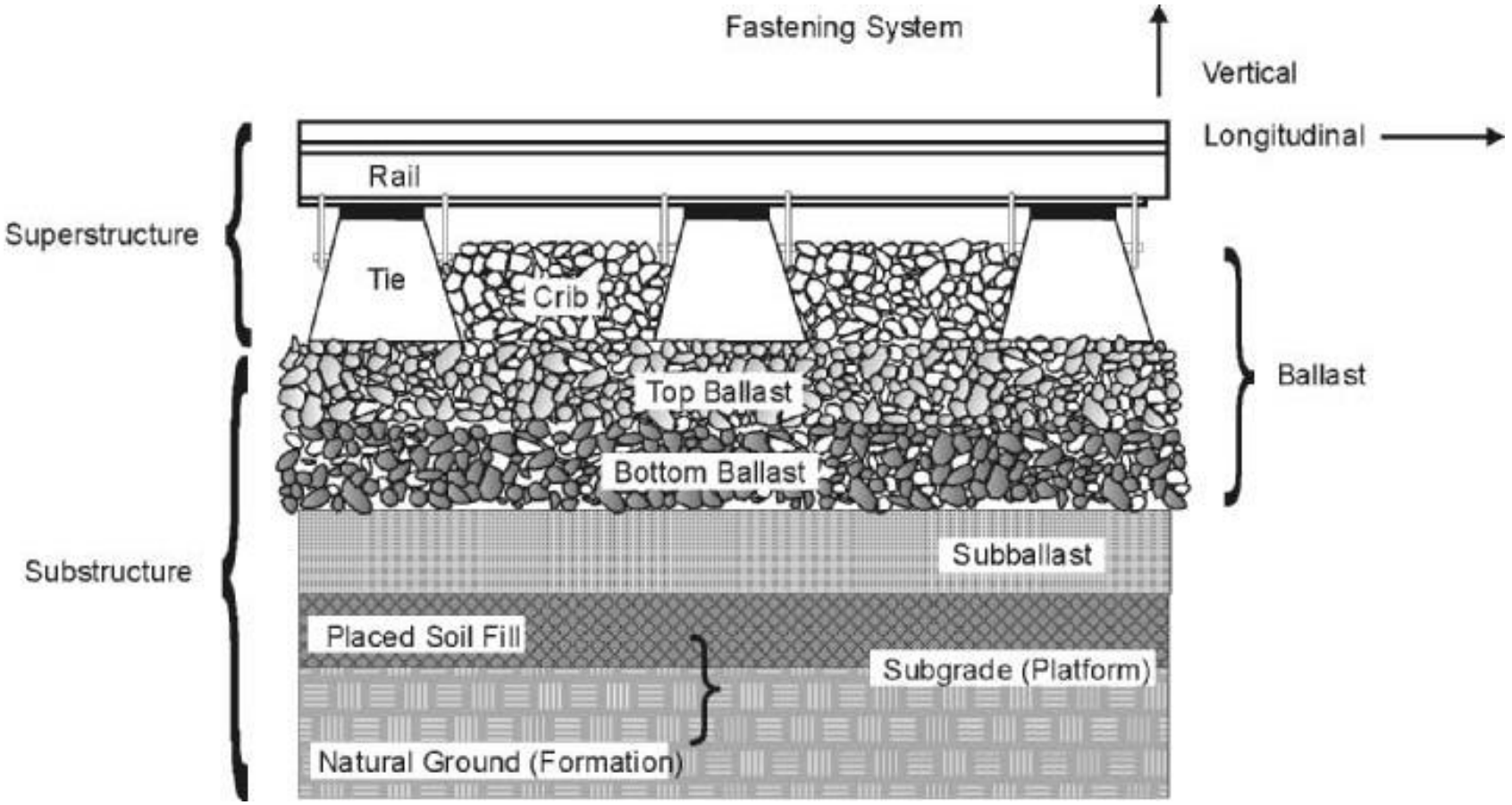
Railway Track Components

- Railway track consists of a superstructure and a substructure.
  - The superstructure is composed of steel rails fastened to crossties (sleepers). The rails are designed to support and guide flanged steel wheels through their prescribed position in space.
  - The superstructure is placed on a substructure.
  - The substructure is composed of a layered system of materials known as ballast, subballast and subgrade.
- The track design needs to consider soil and rock conditions, weather conditions (precipitation, temperature), traffic requirements (wheel loads, total annual tonnage), and maintenance costs for the designed track.

Track Structure Components



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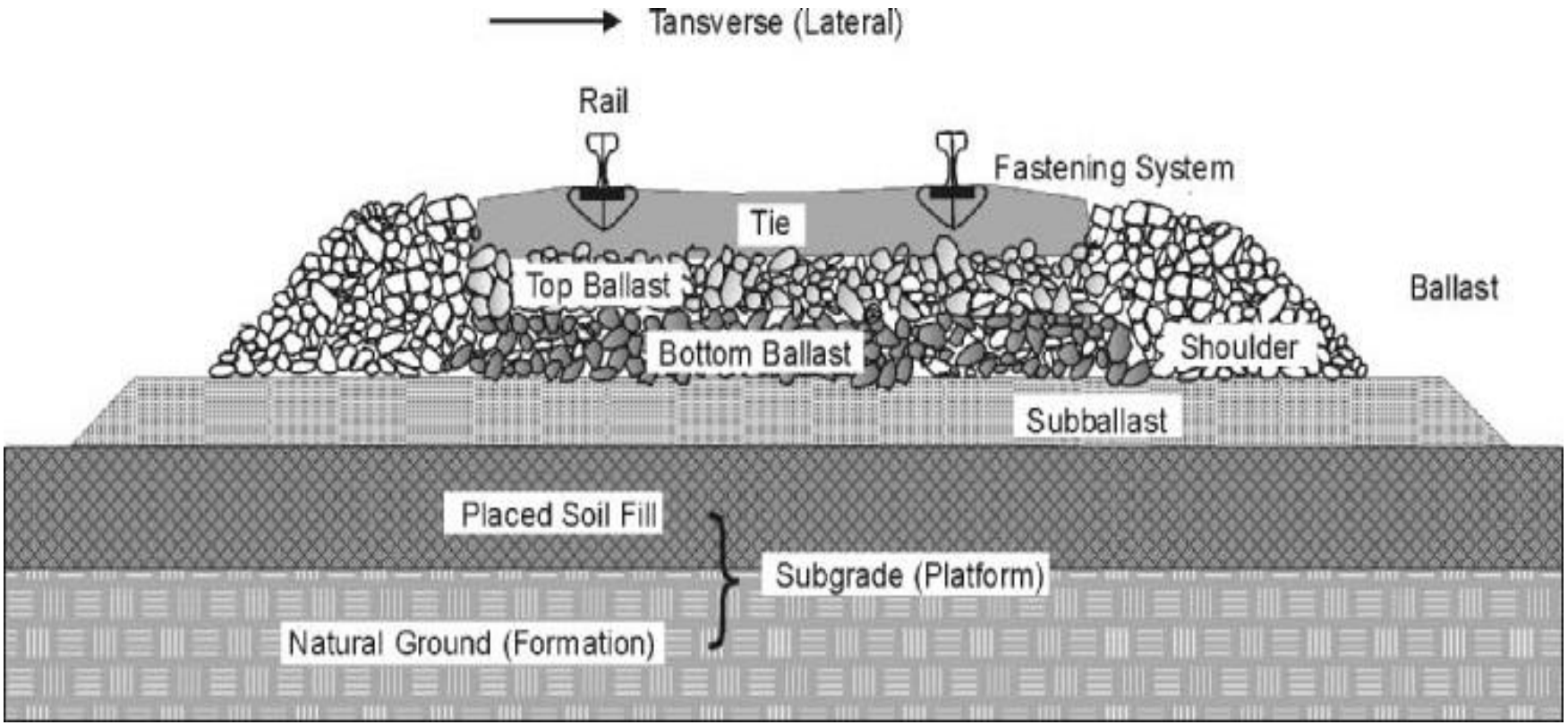

Definitions

- **Railway Track:** Railway track is the structure provided by rails fitted on sleepers, resting on ballast and subgrade for passage of wheels.
- **Rails:** Rails are steel girders, which provide the hard and smooth surface for movement of wheels of locomotive and railway vehicles.
- **Sleepers:** These are the members which are laid transversely under the rails, to support the rails and to transfer the load from rails to the ballast.
- **Fish-Plates:** These are plates used for joining the rails at rail-joint. As these resemble in shape to the fish, therefore are named fish-plates.
- **Ballast:** It is the granular material, which is used in packing under and around the sleeper for transferring the load to the formation.
- **Adzing of Sleeper:** The sleepers are cut at the rail seat to provide a slope of 1 in 20 to the rails. The method of cutting the wooden sleepers or casting of concrete sleepers accordingly is known as adzing of sleepers.
- **Bearing Plates:** To reduce the pressure intensity on the soft timber sleepers, steel plates are provided between the rails and the sleepers, which is known as bearing plates. With the bearing plate no adzing of sleepers is required, as the cant of 1 in 20 is directly provided through these plates.
- **Gauge:** Is the minimum distance between the running or gauge faces of the two rails.

Definitions

- **Standard Gauge:** The common widest gauge used in railway, which is 1435mm between the inner faces of the top flanges of track.
- **Buckling of Gauge:** If during rise of temperature, the free longitudinal movement of the rails is checked, they will buckle sideway, which is known as buckling of gauge.
- **Bull-Head Rail:** The rail having similar head and bottom shapes is known of bull-headed rail. It is used with rail chairs.
- **Boxing:** It is the process of filling the ballast around the sleepers.
- **Rolling Stock:** Rolling stock consists of locomotives, passenger coaches and goods wagons. The term is used because they roll on the rails.
- **Relaying of Track:** Changing of rails, sleepers and fittings is called relaying of track.
- **Plate Laying:** The process of laying the sleepers and joining the rails on the prepared formation is called plate laying.
- **Creep of Rails:** The longitudinal movement of the rails in a track due to various reasons is known as the creep rails.
- **Guard Rails:** These are additional rails provided over the bridge to prevent the damage and danger in case of derailment over the bridge.
- **Packing:** The process of ramming the ballast underneath the sleeper is known as “packing”.
- **Derailment:** When the wheels of the trains or bogies get out of rails, it is known as derailment.

Functions of Track Components: Rail

1. Guide the flanged wheels in the vertical, lateral, and longitudinal directions.

2. Provide a smooth-running surface.

3. Transfer wheel loads to spaced ties without large deflection.

4. Resist tension failure from longitudinal tensile force caused by rail temperature reduction.

5. Help resist buckling from longitudinal compression force caused by rail temperature increase.

6. Resist fatigue cracking from repeated wheel loads.

7. Provide strong bolted or welded joints.

8. Limit rail impact by maintaining track geometry and truing wheels to limit ‘‘false flange’’ wear on wheel and rail and reduce wheel defects such as engine burns, corrugations, and flat spots.

9. Permit tracks to cross over each other and permit trains to switch from one track to another.

10. The rail material is such that it gives minimum wear to avoid replacement charges and failures of rails due to wear.

Functions of Track Components: Fastening Systems

1. Restrain the rail in the vertical, longitudinal, and transverse directions.

2. Resist overturning of rail from lateral wheel force.

3. Connect sections of rail to permit safe and smooth train operation.

4. Create a canted (inclined) surface to provide proper wheel/ rail contact-wood ties.

5. Spread the rail seat force over a larger part of the tie surface to reduce tie damage-wood ties.

6. Provide resiliency under the vertical wheel load-concrete ties.

7. Reduce tie abrasion at rail seat-concrete ties.

8. Provide damping of the high frequency wheel-induced vibrations-concrete ties.

Functions of Track Components: Sleepers or Ties

1. Transfer the vertical wheel load from the rail through the rail seat to the bottom of the ties to provide an acceptable level or stress for the ties and ballast.

2. Hold the fastening system so that it can restrain the rails at the proper vertical, lateral, and longitudinal position and maintain the required gage.

3. Provide a canted (inclined) surface for proper wheel/ rail contact-concrete ties.

4. Act as an elastic medium between the rails and the ballast to absorb the blows and vibrations of moving loads.

5. Provide longitudinal and lateral stability to permanent way.

6. Hold the rails in proper level or transverse tilt on curves.

7. Support the rails at a proper level in straight tracks and at a proper superelevation on curves.

Functions of Track Components: Ballast

1. Transfer and distribute the load from sleepers to large area of formation.

2. Restrain the ties against vertical, lateral, and longitudinal forces from the rails.

3. Reduce the pressure from the tie-bearing area to a level that is acceptable for the underlying materials.

4. Provide the ability to adjust track geometry by rearranging the ballast particles by tamping and lining.

5. Assist in drainage of water from the track.

6. Provide sufficient voids between particles to allow an efficient migration of unwanted fine particles from the ballast section.

7. Provide some resiliency to the track to decrease rail, rail component, and wheel wear.

8. Protect the sleepers from capillary moisture in formation.

9. Moisture is drained quickly away from the track and not allowed to accumulate around rails and sleepers.

Functions of Track Components: Subballast

1. Maintain separation between the ballast and subgrade particles.

2. Prevent attrition of the hard subgrade surface by the ballast.

3. Reduce pressure from the ballast to values that can be sustained by the subgrade without adverse effects.

4. Intercept water from the ballast and direct it to the track drainage system.

5. Provide drainage of water flowing upward from the subgrade.

6. Provide some insulation to the subgrade to prevent freezing.

7. Provide some resiliency to the track.

Functions of Track Components: Subgrade

1. Provide a stable platform on which to construct the track.
2. Limit progressive settlement from repeated traffic loading.
3. Limit consolidation settlement.
4. Prevent massive slope failure.
5. Restrict swelling or shrinking from water content change.

Functions of Track Components: Drainage

Drainage is the single most important factor governing the performance of track substructure. A properly functioning drainage system provides the following:

1. Intersects the water seeping up from the subgrade
2. Diverts the surface water flowing toward the track
3. Removes water falling onto the track
4. Carry off stone dust, sand, and other debris that otherwise could foul the track.

Track Forces

The forces applied to the track are vertical, lateral (parallel to the ties), and longitudinal (parallel to the rails).

1. Vertical

- The main vertical force is the repetitive downward action of the wheel load.
- In addition, this wheel/ rail interaction produces a corresponding lift-up force on the ties away from the wheel load points.
- The nominal vertical wheel force, also called the static force, is equal to the gross weight of the railway car divided by the number of wheels.
- This force ranges from about 12,000 lb (53 kN) for light rail passenger cars to 39,000 lb (174 kN) for heavy freight cars.

Vertical Impact Dynamic Load

The vertical impact dynamic load has two components, a short-duration larger force and a longer duration smaller force.

The first is expected to be more harmful to the rails and ties, while the second does more damage to the ballast and track geometry.

The major factors affecting the magnitude of the dynamic vertical forces are:

- Nominal wheel load
- Train speed
- Wheel diameter
- Vehicle un sprung mass
- Smoothness of the rail and wheel surfaces
- Track geometry
- Track modulus or vertical track stiffness

The traditional approach for representing the geometry-driven dynamic wheel load is to multiply the nominal wheel load by an impact factor that is greater than 1.

Track Forces: Lateral

- One type of lateral force applied to the rail is the wheel force transmitted through friction between the wheel and top of the rail and by the wheel flange acting against the inside face of the rail head, particularly on curves.
- Another lateral force is the rail buckling resistance force.
- The design lateral wheel force depends upon a number of factors, including:
  - Vehicle speed
  - Track geometry
  - Elevation difference between the two rails at the same cross section
  - Transverse hunting movement due to the train-track dynamics

Track Forces: Longitudinal

- Sources of longitudinal rail forces are:
  - Speed
  - Locomotive traction
  - Locomotive and car braking
  - Expansion and contraction of the rails from temperature change
  - Track grade
  - Special track, i.e., turnouts, at grade crossings, rail crossings.
- The ratio of lateral to vertical force (L/V) is also important because it can cause loss of alignment and even track buckling.