**Ordinary Steel Girder**

- For length of span up to 25m.
- Main support construction is longitudinal girder that installed each spacing of 45cm – 100cm.
- Upper bridge deck.
- Bridge deck can be made from wood or steel plus concrete covering by asphalt.
- Transversal bridge as load distributor.
- Wind bracing and brake bracing are located below the deck (no upper wind bracing).
- Sub structures consists of abutment and pier that function as foundation as if the soil condition is good enough, and it can be designed as direct foundation (footplate).
Introduction (cont’d)

Composite Steel Girder

- For length of span up to 30m.
- Its components same as an ordinary steel girder bridge.
- Bridge deck made from RC that monolith with longitudinal girder and united by using a shear connector.
- No need of brake bracing.
- Only below wind bracing is exist.
- Wind bracing is applied only in construction stage, but often installed permanent.
- If bridge deck made from timber, so that wind and brake barcing must be installed.

Figure 1. Cross View
Introduction (cont’d)

Figure 2. Plan View

Introduction (cont’d)

Figure 3. Brake Bracing (can be installed on one of the edge, both or in the middle)
Advantages:

- The weight of steel can be reduced.
- The height of profile can be reduced.
- Bridge deck stiffness can be increased.
- The longer of span can be afforded.
- The strength for supporting bridge load can be increased.

Disadvantages:

- Stiffness is not constant, RC slab is neglected for negative moment zone.
- For long term, the excessive deflection will occur.

Analysis of Composite Beam

✓ Composite bridge deck structure can be assumed as a T beam, with tension force is resisted by a timber, compression force is resisted by RC slab. While shear force on contact area of Timber-Concrete is resisted by a number of shear connectors. Its dimension, types, and total are determined match with the value of working shear stress on contact area.

✓ Due to a sustained load that suffered by a composite beam, so that beam will resist a flexure caused by a flexural moment. This beam flexure is the result from strain that occurs due to external load.
Analysis of Composite Beam
(cont’d)

✓ As the loading increases, the beams experience additional deformation and strain that may result in the presence of flexural cracks along the span. In this case includes the strength of RC slab and the interaction capacity of shear interface will decreases.

✓ Component of Timber-Concrete composite structure is calculated as one-way slab.

Analysis of Composite Beam
(cont’d)

Composite cross section as shown in Figure 4, where:

- \( b_e \) = effective width
- \( h \) = total height
- \( t \) = slab thickness
- \( h_w \) = timber height
- \( b_w \) = timber width

Figure 4. Cross Section Timber-Concrete
Analysis of Composite Beam (cont’d)

Effective Width ($b_{eff}$)
Based on SNI 03-1729-2002, article of 12.4.1, the limitation of effective width for T beam is taken from the smallest value of:

a. $\frac{1}{8}$ from the length of span.
b. $\frac{1}{2}$ from a clean distance between the axes of adjacent beams.
c. The distance from the axis of beam to the slab edge (only for the edge beam).

Modular Ratio ($n$)
Ratio modular is a ratio value between the timber elastic modulus ($E_w$) and the concrete elastic modulus ($E_c$) as shown in Eq. 1.

$$n = \frac{E_w}{E_c} \quad \text{(Eq. 1)}$$

Equivalent Width ($b_{eq}$)
The equivalent width of concrete material into timber material is obtained by divided its effective width to Eq. 1, so that:

$$b_{eq} = \frac{b_{eff}}{n} \quad \text{(Eq. 2)}$$
Analysis of Composite Beam (cont’d)

Neutral Axis
The material is considered homogeneous, so it can be directly calculated static moments, neutral axis, and inertia moment. The neutral axis of cross section can be obtained by calculating the static moment (see Figure 5).

![Neutral Axis of Cross Section](image)

Figure 5. Neutral Axis of Cross Section

Analysis of Composite Beam (cont’d)

Stress Diagram
The sample of stress diagram from composite cross section analysis as shown in Figure 6.

![Sample of analysis results](image)

Figure 6. Sample of analysis results
Shear Connector

- Shear connector is a mechanical joining device that function to support a shear load that occurs on the contact plane of composite material. Its also to guarantee that both material will working together as an unity.

- There are various shear connector including nails, bolts and rivets. In the case of the strength of the connection is not distinguished whether it is a compression or tension connection, which determines the strength of connection not tensile and shear strength but rather the force of hole and the strength of shear interface.

- Usually in stress-strain analysis in the direction of the joints or on the shear connecting section is considered flat.

Shear Connector (cont’d)

- Basically, shear connector is applied according to the working shear force, thus in areas with large shear will have more shear connector than other areas. The detailed of shear connector as shown in Figure 7.
Shear Connector (cont’d)

The sample of loading case on simple beam as shown in Figure 8.

Figure 8. (a) Loading case  
(b) Shear Force Diagram

Shear Connector (cont’d)

- Figure 8(b) shows a shear force diagram on simple beam that burdened by point load as shown in Figure 8(a).
- Shear stress $\tau$ on composite flexure beam can be calculated as:

$$\tau = \frac{D \cdot S}{I \cdot bw}$$

where:
- $D$ = shear force on reviewed location  
- $S$ = static moment on reviewed location  
- $I$ = inertia moment on reviewed location  
- $bw$ = width of beam on reviewed location
Shear Connector (cont’d)

The shear stress distribution of composite beam for half span as shown in Figure 9.

Figure 9. (a) Distribution of shear stress
(b) Shear force value on zone 1 and zone 2

Shear Connector (cont’d)

✓ Shear stress distribution of beam that burdened load as shown in Figure 8(a) is expressed for a half span as shown in Figure 9(a).
✓ Shear force each zone ($V_i$) is represented by a volume as shown in Figure 9(b) as:

\[ V_i = \tau_i \cdot L_i \cdot bw \]

where:
- $L_i$ = length of zone $i$
- $\tau_i$ = shear stress of zone $i$
- $bw$ = width of beam of zone $i$
Shear Connector (cont’d)

✓ Figure 9 shows that value of shear stress or shear force is equal as long as $L_1$ and $L_2$.
✓ If the value of point load increase, so that value of shear stress or shear force will leads to a straight line along the span.
✓ From the support to the mid-span, the shear stress and shear force are smaller, so the required number of shear connector is also smaller.

Thanks for your attention and success with your study!