Outline of the lecture

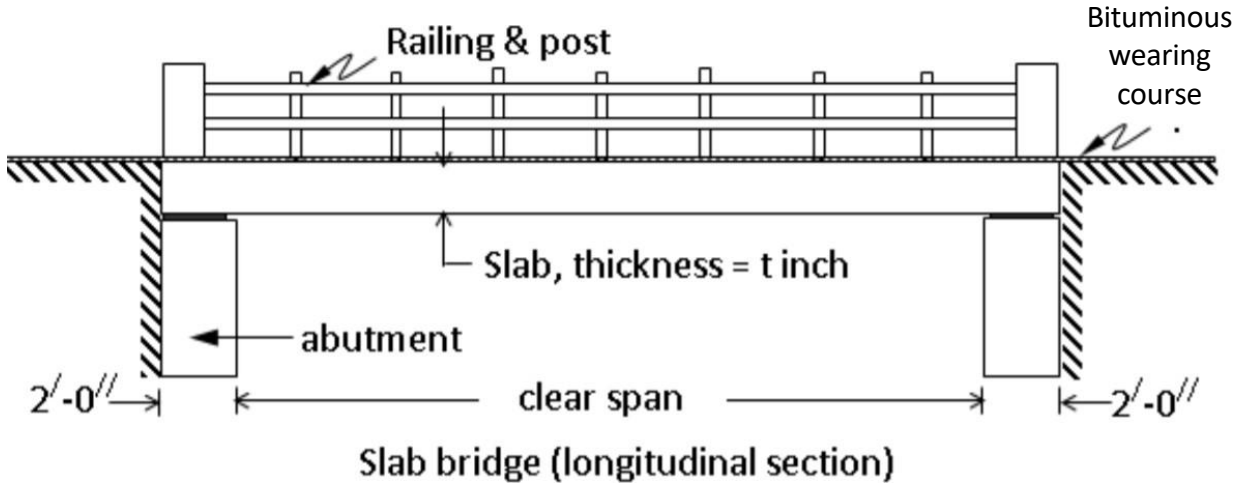
Design of a slab bridge

- We will design superstructure:
  - Deck Slab and
  - Curb (Edge Beam)

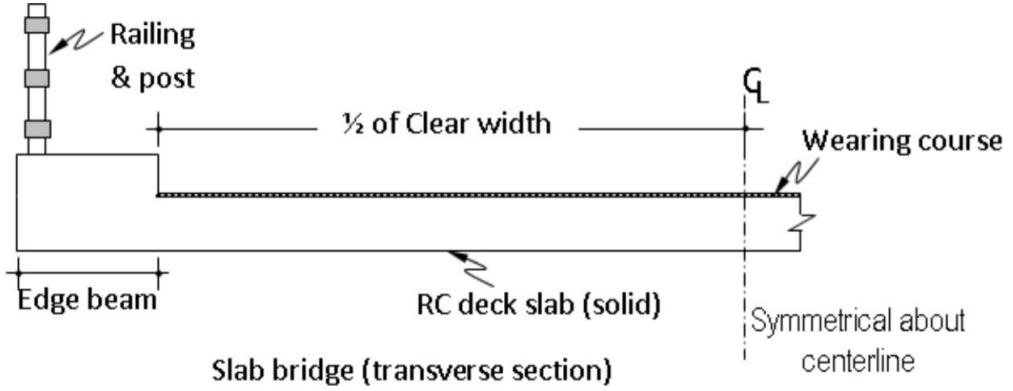


Slab Bridge





Slab bridge (longitudinal section)



Slab bridge (transverse section)

Slab Bridge:

- Small Span (20-25 ft)
- No navigation (ships/boats)
- Only water flows

Deck Girder Bridge: 50'<L<100'

Box Girder Bridge: L>100'

Design of DECK SLAB

a) Dead Load

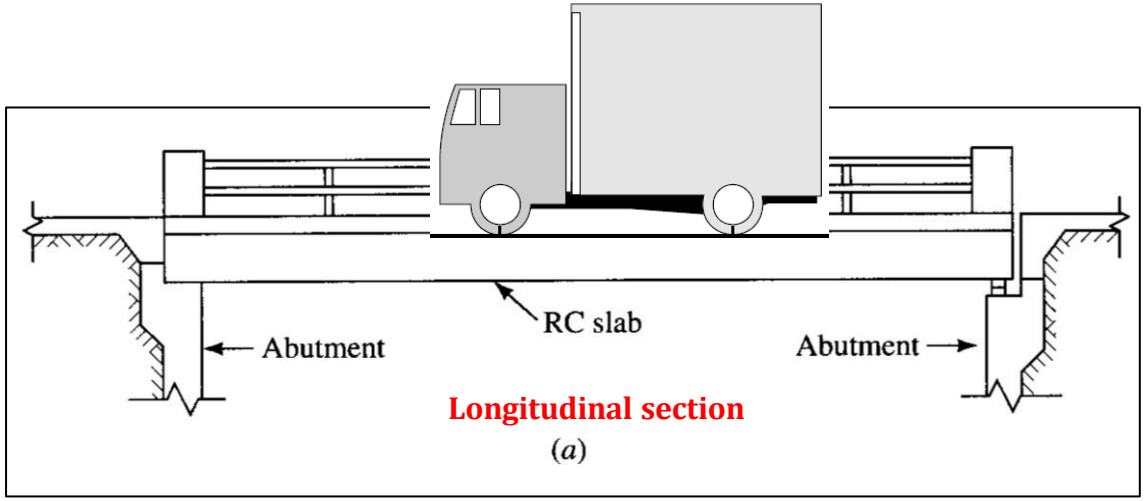
- From self weight of Slab
- From wearing course

b) Live load

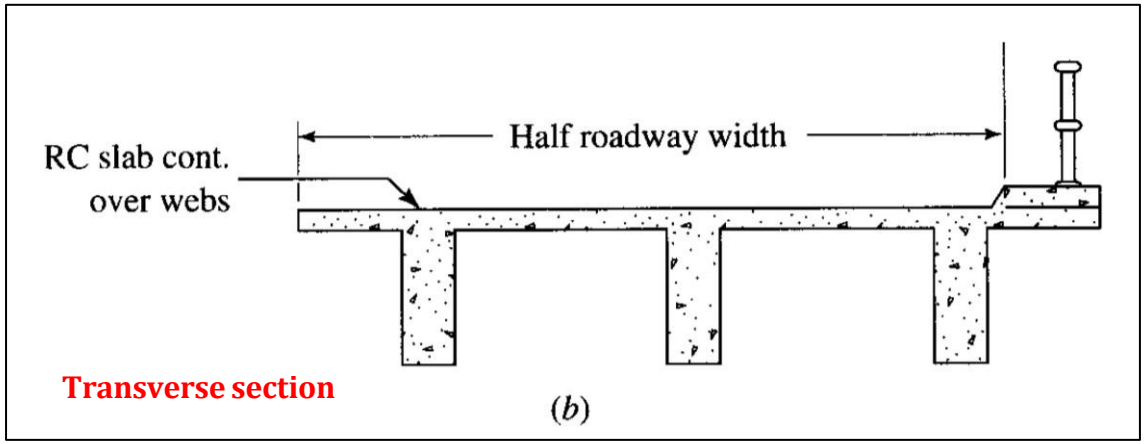
From vehicular loading

a) Truck Load

b) Lane Load



Traffic Parallel to the span



Traffic Perpendicular to the span

Vehicular Loading

Types of vehicle vary from simple two-axle vehicle to multi-axle trucks with trailer, tractor/semitrailer combinations and longer combinations

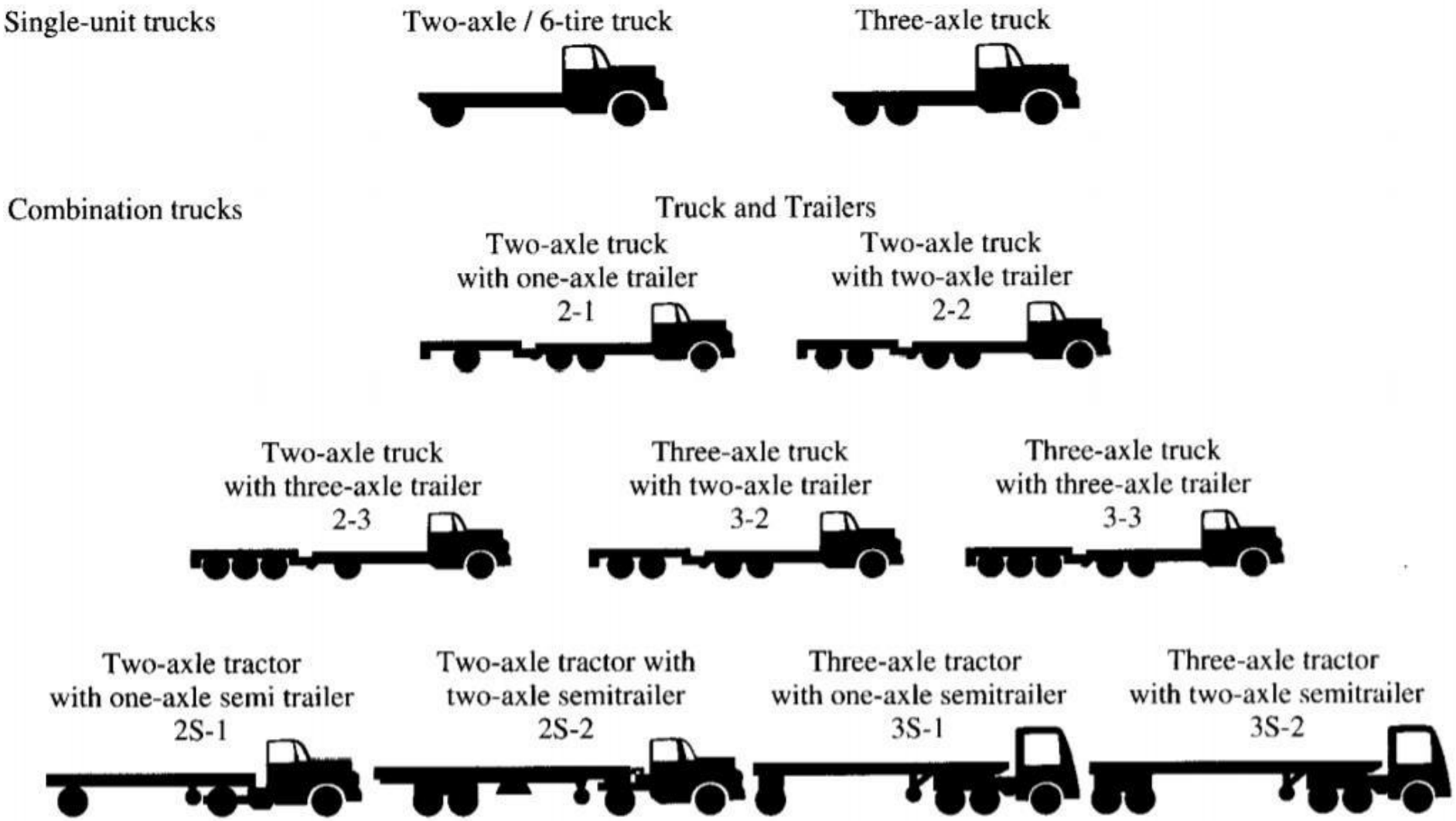


Figure 3.4
(Design of Modern Highway Bridges
-Narendra Tally)

Vehicular Loading

1. Design Truck Loading
2. Design Lane Loading
3. Alternate military (or Design Tandem) Loading

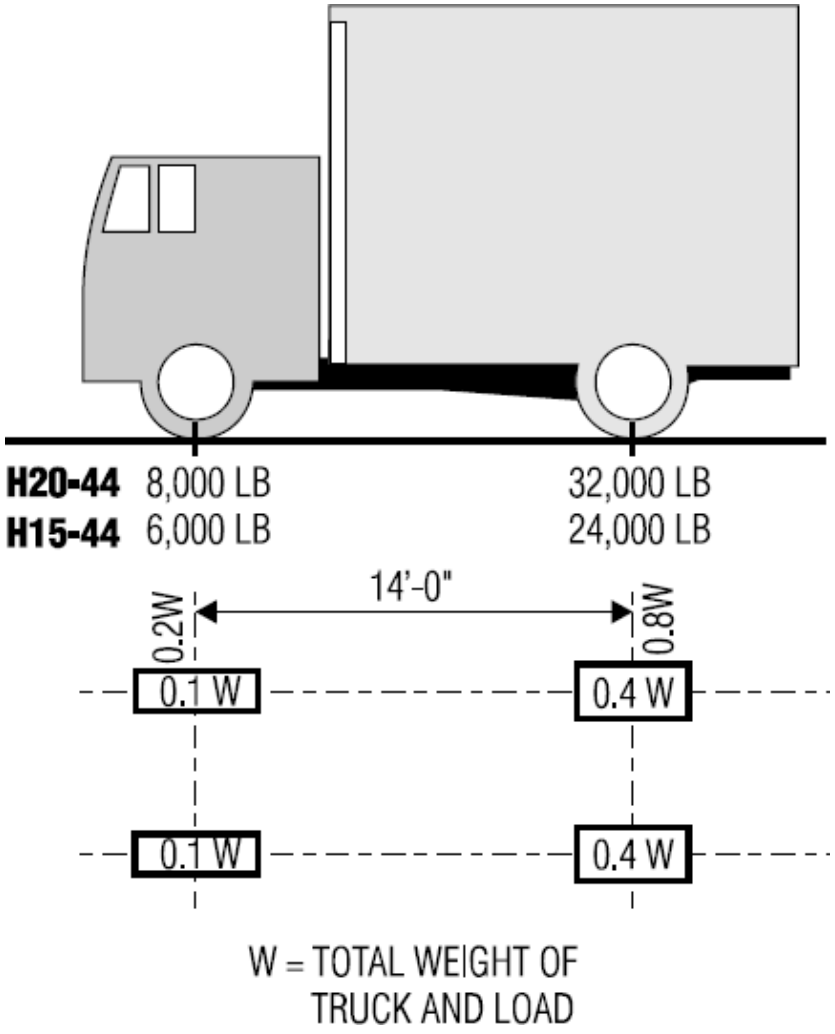
Design truck loading. Also referred to as standard truck loading, this originated in the 1920s, and although it has been revised periodically, its basic format has remained unchanged. Two systems of loadings are provided: The H loading and the heavier HS loading (the letter "S" refers to *semitrailer*). In each case, there are two standard classes of loadings (AASHTO 3.7.2), which are designated (AASHTO 3.7.3) as follows:

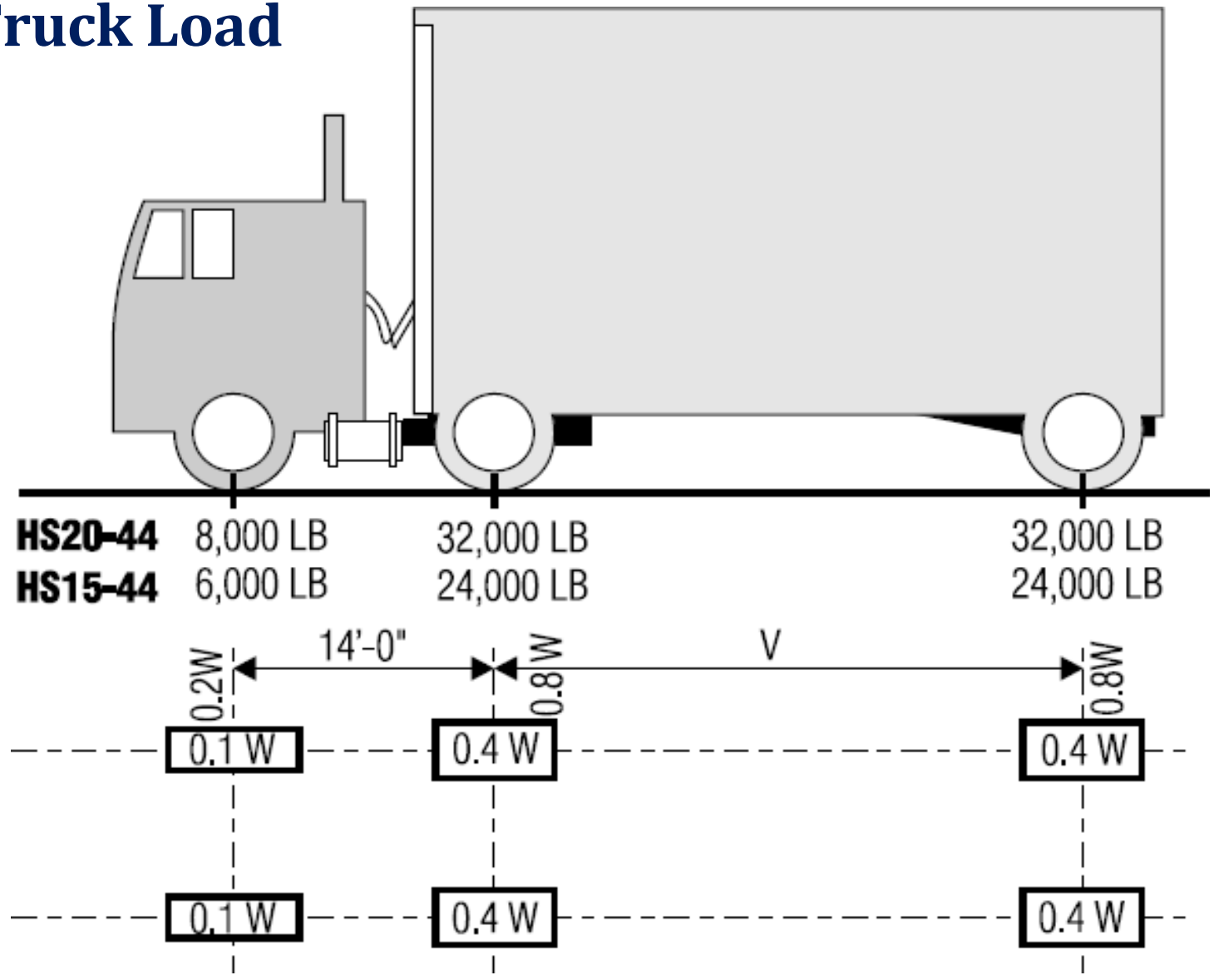
- H15-44 and H20-44
- HS15-44 and HS20-44

In these designations, the number 44 refers to the fact that these loadings were standardized and first published in the 1944 AASHO specifications. The H loadings consist of a two-axle truck, and the numbers 15 and 20 in the loading classification refer to the gross truck weight in tons (1 ton = 2000 lb). The HS loadings consist of a tractor truck with semitrailer (designated by the letter "S" in "HS"). The numbers following the letters "HS" indicate the total load in tons carried by the *axles* of the tractor; the load on the semitrailer is additional.

Vehicular Loading

DesignTruck Load

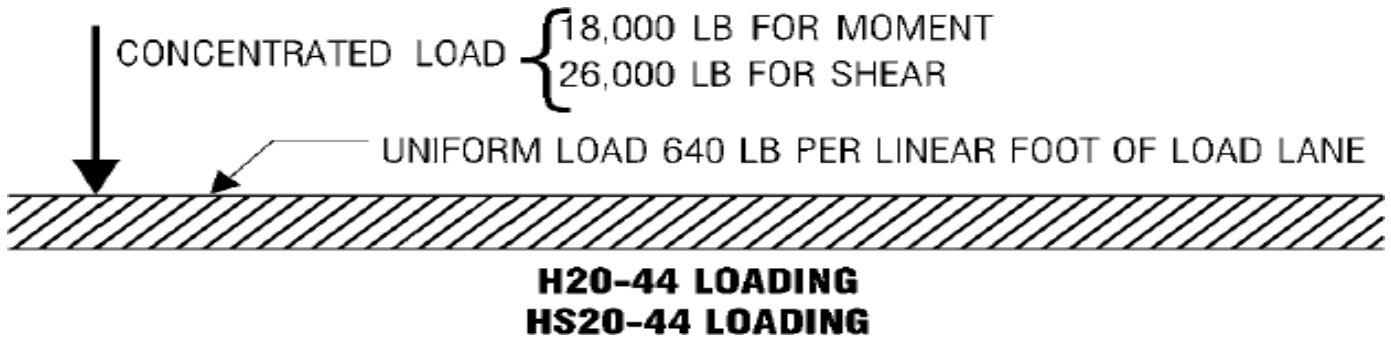




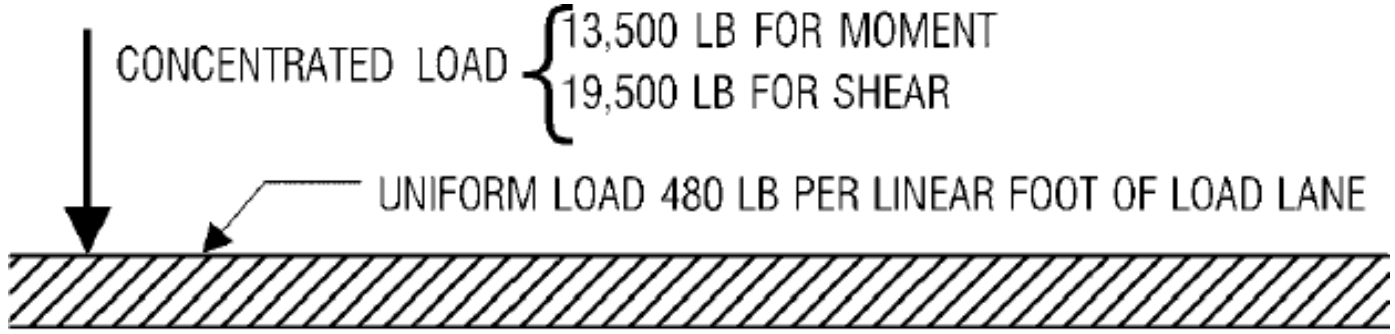
Vehicular Loading

Design Lane Load

The design lane load shall consist of a uniformly distributed in the longitudinal direction.



H20-44 LOADING
HS20-44 LOADING



H15-44 LOADING
HS15-44 LOADING

Design of the Deck slab by WSD method:

1. Determine ‘Effective Span’ and ‘Thickness’ of the slab
2. Determine loads on the bridge and calculate moments
3. Determine the allowable stresses in concrete and steel
4. Design the reinforcement
    a. Main reinforcement
    b. Distribution reinforcement
    c. Temperature and shrinkage reinforcement
5. Detailing

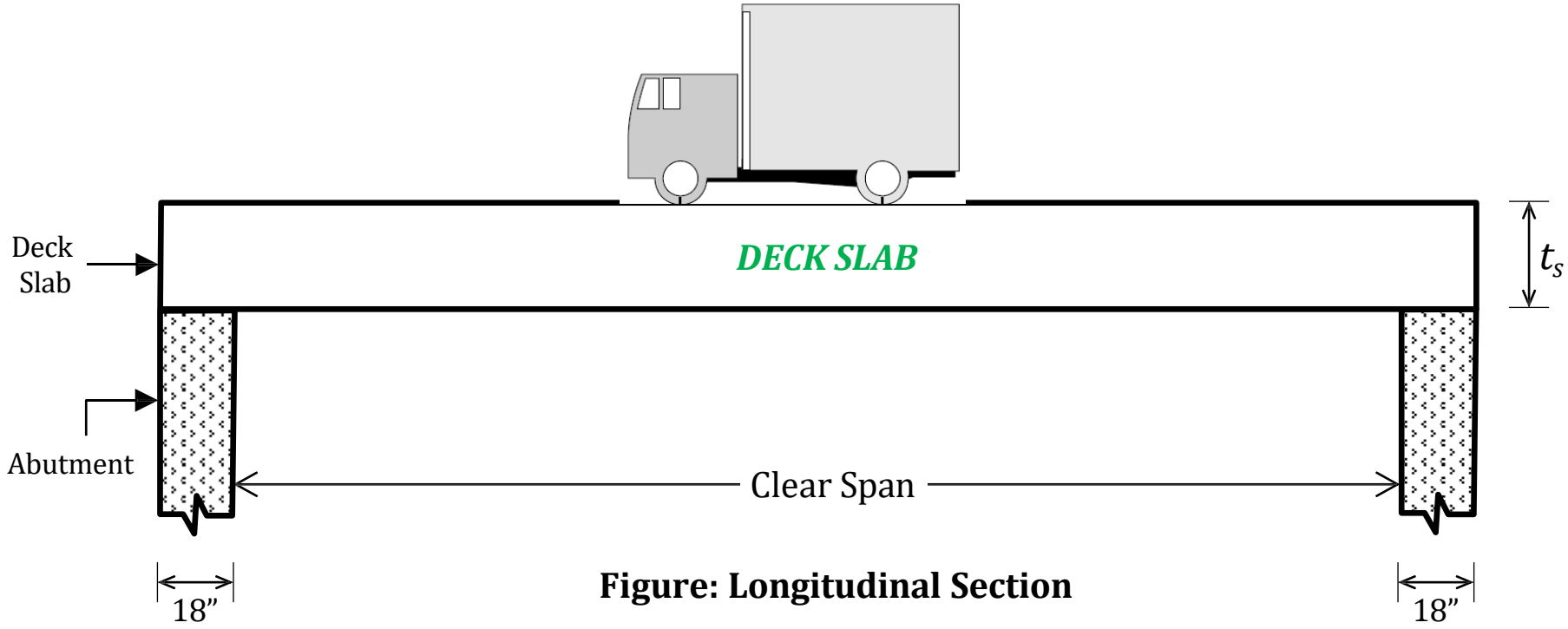


Figure: Longitudinal Section

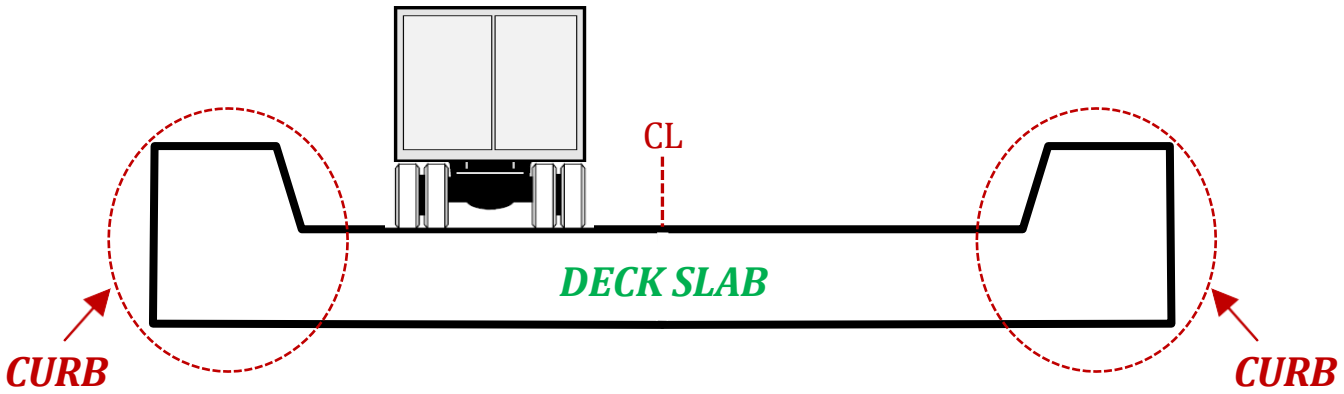


Figure: Transverse section of the bridge

Determine 'Effective Span' and 'Thickness' of the slab

Find by trials between these two

a. Effective Span, $L = S =$ (c/c distance between supports) OR,
(clear span + slab thickness) →whichever is smaller

b. Determine minimum thickness of the slab.

$$t_{min} = 1.2 \times \left(\frac{S + 10}{30}\right)$$ [deflection control criteria]

Loads

a) Dead load

$w_{DL} = (w_{self\text{-}weight} + w_{wearing\ surface})$ psf

$M_{DL} = \frac{w_{DL} \times S^2}{8}$

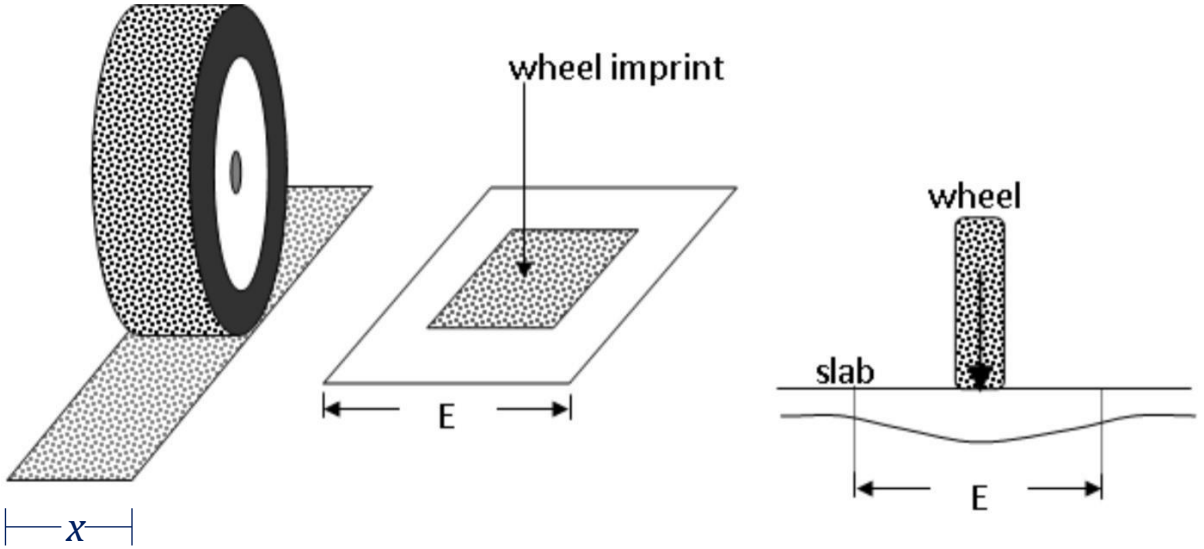
b) Live load

From vehicular loading

c) Impact Load

b) Live load

From vehicular loading



- Wheel load distribution width,
  $E = (4 + 0.06S)$ ft $\leq 7\ ft$

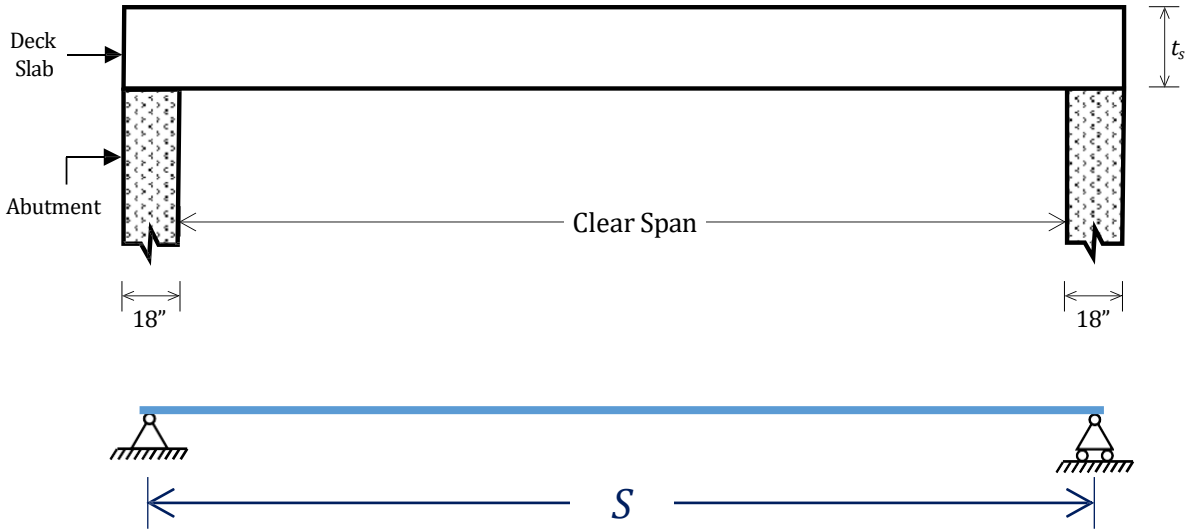
$$M = \frac{P'S}{4}$$

S = span (ft)

P' = P/E for truck loading

= $P/2E$ for lane loading

Figure: Longitudinal Section



Calculate Live load moment:

Take larger of these two

$$M_{LL(truck)} = \frac{(P/E)S}{4} \text{ lb-ft/ft width}$$

$$M_{LL(lane)} = \left[\frac{(P/2E)S}{4} + \frac{(w/2E)S^2}{8}\right] \text{ lb-ft/ft width}$$

P = 12,000 lb for HS15/H15

= 16,000 lb for HS20/H20

= 13,500 lb for HS15/H15 lane loading

= 18,000 lb for HS20/H20 lane loading

*Note: For lane loading, Moment due to UDL has to be added.

Both UDL & concentrated load is distributed within 2E.

c. Impact load

- Calculate Impact Factor.

$$IF = \left(\frac{50}{S+125}\right) \leq 0.3$$

- Moment due to Impact, $M_I = IF * M_{LL}$

W= 480 lb/ft for HS15/H15

W= 640 lb/ft for HS20/H20

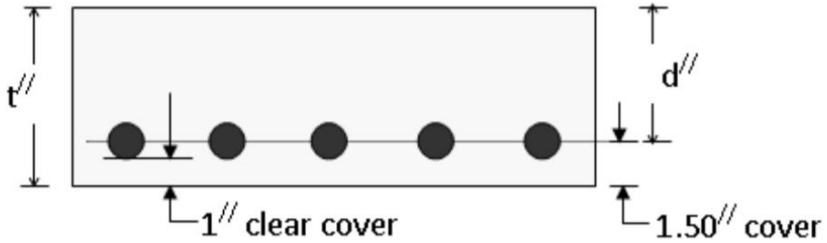
Total Moment, $\boldsymbol{M_{design}} = M_{DL} + M_{LL} + M_I$

Calculate and design Reinforcement

a. Main reinforcement
   - Along the span (parallel to traffic direction here)
   - Comes from flexural requirement

b. Distribution reinforcement
   - Perpendicular to traffic direction here

c. Temperature and shrinkage reinforcement
   - Along both direction



$E_c = 57{,}000\sqrt{f_c'}$ psi

$E_s = 29{,}000$ ksi

$*$ n shoud be rounded to nearest integer and not less than 6

a) Main reinforcement:

- Allowable concrete compressive stress is, → $f_c = 0.45\, f'_c$
- Allowable stress in steel is, −−−−−−−− → $f_s = 0.40\, f_y$

$$n = \frac{E_s}{E_c} = 9 \; ; \qquad r = \frac{f_s}{f_c}$$

$$k = \frac{n}{n+r} \; ; \qquad j = 1 - k/3$$

- Check '$d_{required}$' with the following formula for WSD.

$$M_{design} = \frac{1}{2} f_c \, kj \, bd^2$$

Adjust slab thickness if needed.

- Determine main reinforcement,

➢ Required steel , $A_{s(main)} = \frac{M}{f_s \times j \times d}$ in^2/ft

$A_{s(main)}$ →#?? @??" c/c

Check for minimum reinforcement:

$f_r = 7.5\sqrt{f_c'}$; $I_{cr} = bh^3/12$

$$M_{cr} = \frac{f_r I_{cr}}{h/2}$$

Check if M_{design} is more than 1.2 M_{cr}. If so, ok.

If not, increase slab thickness.

b) Distribution reinforcement

- For main reinforcement parallel to traffic:

  $(100/\sqrt{s} \leq 50)$ % of $A_{s(main)}$

- For main reinforcement perpendicular to traffic:

  $(220/\sqrt{s})$ % of $A_{s(main)}$

$\boldsymbol{A_{s(distribution)}}$ **→#?? @??" c/c**

c) Temperature and shrinkage reinforcement

- Provide Temperature reinforcement.

According to AASHTO 8.20.1, $A_{s(temp.\ \&\ shrnkg)}$= 1/8 in^2 /ft need to be provided under all exposed surfaces.

$\boldsymbol{A_{s(temp.\&\ shrnkg.)}}$ **→#?? @??" c/c**

- Check for shear and bond. Not necessary for slabs designed for bending in this method.

Detailing of the Deck slab:

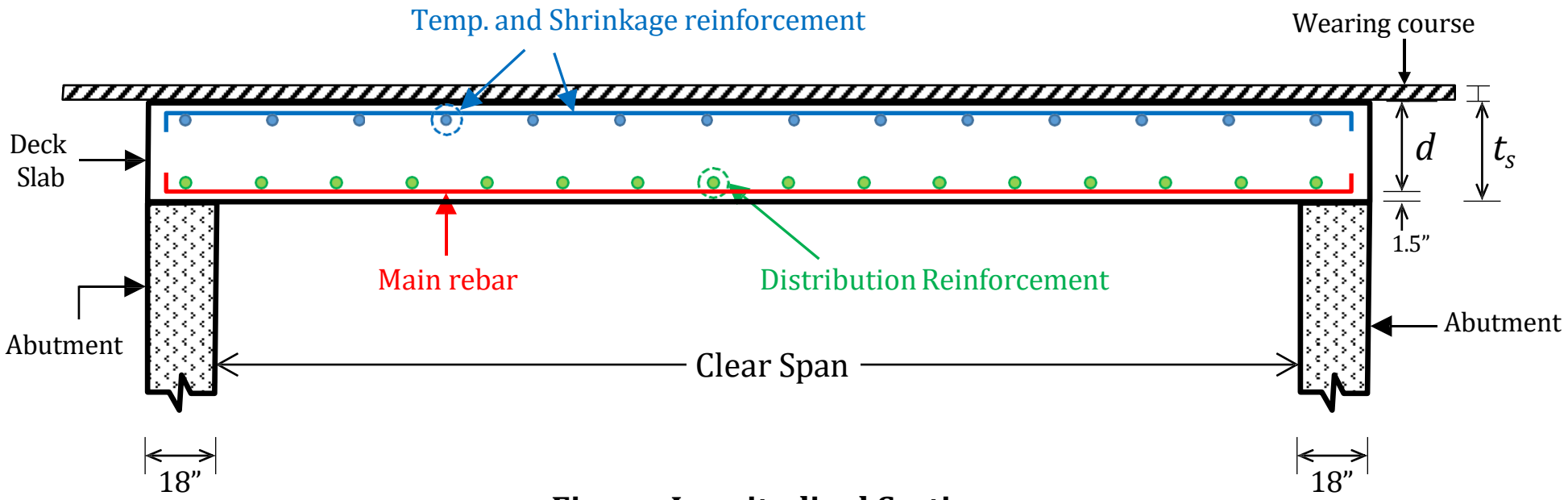


Figure: Longitudinal Section

Design of Curb/Edge Beam

Similar to Beam

Analysis and Design:

- Assume width of the beam, b .
- Provide a curb 10” high.
- Calculate w_{DL} for self weight & railing.

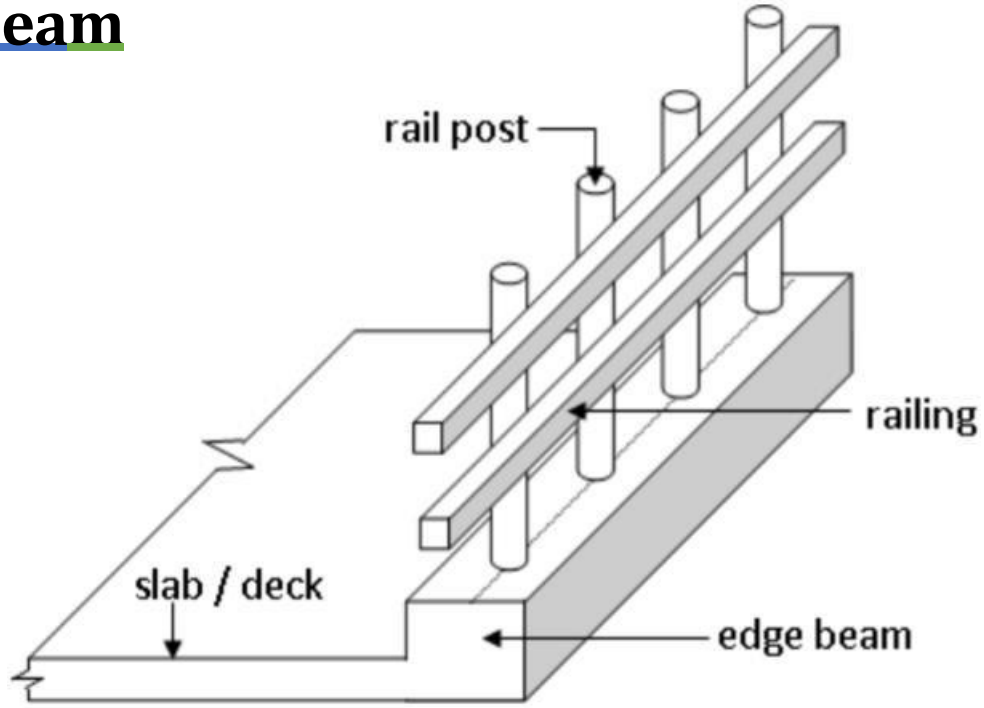
  Self weight includes slab and curb weight.

  Weight of railing is assumed to be 15 lb/ft.
- Compute DL & LL Moments.

  $M_{DL} = w_{DL}L^2/8$ lb-ft

  $M_{LL} = 0.10\ P^*S$ lb-ft [P= P_{15} or, P_{20}]

  Design moment, $M_{total} = M_{DL} + M_{LL}$



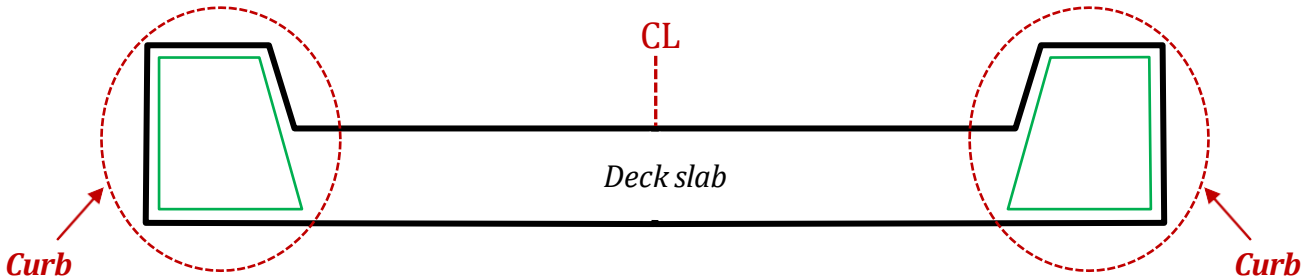


Figure: Transverse section of the bridge

Curb Design

Similar to Beam

Analysis and Design:

$$\text{Self weight} = \frac{10" + t"}{12} \times \frac{24"}{12} \times 150 = ??\ \text{lb/ft}$$

Railing weight $= 15$ lb/ft (assumed)

$w_{DL} = ??$

$M_{DL} = w_{DL} \times S^2/8$

$M_{LL} = 0.1 \times P \times S$ [P= 12^k for HS 15 and 16^k for HS 20]

$M_{design} = M_{DL} + M_{LL}$

$$d_{reqd.} = \sqrt{\frac{M_{design}}{0.5\, f_c k j b}} \quad b = 24"$$

$$A_{s(main)} = \frac{M_{design}}{f_s j d} = ??\ \text{in}^2$$

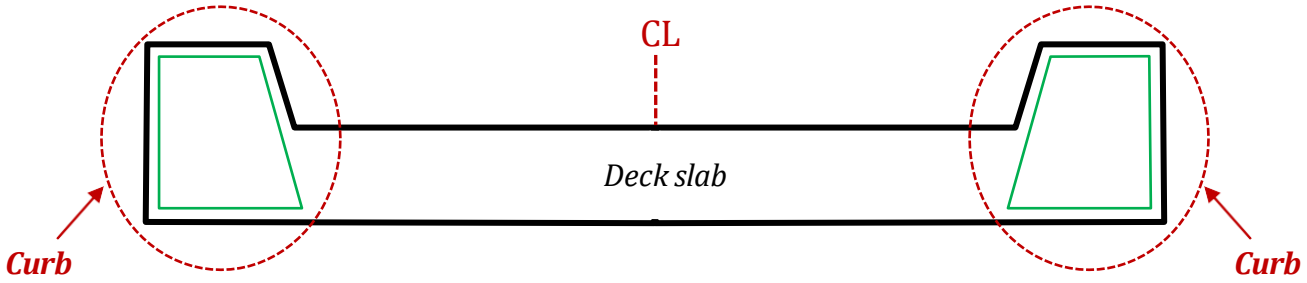
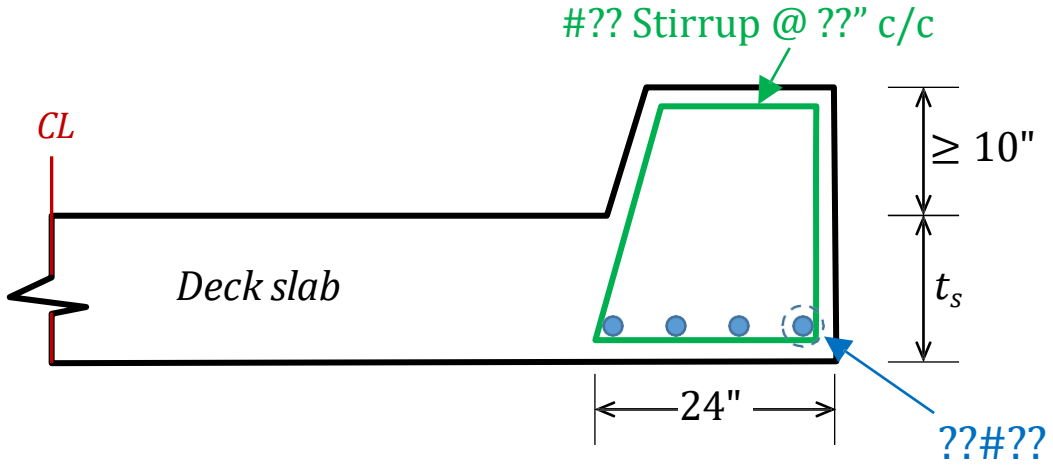
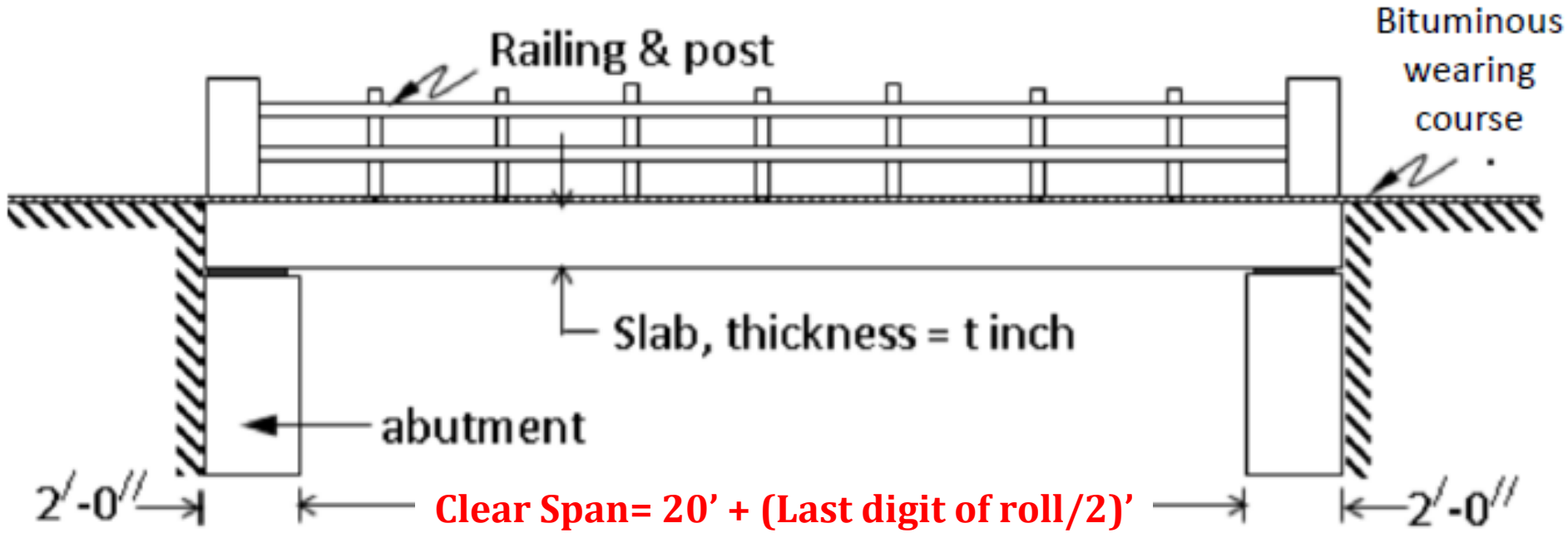


Figure: Transverse section of the bridge



❑ Do the Design of the Following Slab Bridge for H20-44 Loading :



Slab bridge (longitudinal section)