Control of Cracking by Distribution of Reinforcement (Sec. 5.7.3.4 AASHTO 2012)

The spacing *s* of mild steel reinforcement in the layer closest to the tension face shall satisfy the following:

$$s \leq \frac{700\gamma_e}{\beta_s f_{ss}} - 2d_c$$

$$\beta_s = 1 + \frac{d_c}{0.7(h - d_c)}$$

Actual spacing of steel shall not be more than *s* calculated above.

γ_e = exposure factor
= 1.00 for Class 1 exposure condition
= 0.75 for Class 2 exposure condition

d_c = thickness of concrete cover measured from extreme tension fiber to center of the flexural reinforcement located closest thereto (in.)

f_{ss} = tensile stress in steel reinforcement at the service limit state (ksi)

h = overall thickness or depth of the component (in.)

d_ℓ = distance from the extreme compression fiber to the centroid of extreme tension steel element (in.)

Assume $f_{ss} = f_y \times (M_{SERVICE}/M_{STRENGTH})$

Shrinkage and Temperature Reinforcement (AASHTO 2012 Sec 5.10.8)

Reinforcement for shrinkage and temperature stresses shall be provided near surfaces of concrete exposed to daily temperature changes and in structural mass concrete. Temperature and shrinkage reinforcement is provided to ensure that the total reinforcement on exposed surfaces is not less than that specified herein.

For bars or welded wire fabric, the area of reinforcement per foot, on each face and in each direction, shall satisfy:

$$A_s \geq \frac{1.30bh}{2(b+h)f_y} \qquad (5.10.8\text{-}1)$$

$$0.11 \leq A_s \leq 0.60 \qquad (5.10.8\text{-}2)$$

A_s = area of reinforcement in each direction and each face (in.^{2}/ft)

b = least width of component section (in.)

h = least thickness of component section (in.)

f_y = specified yield strength of reinforcing bars ≤75 ksi

Shrinkage and Temperature Reinforcement (AASHTO 2012 Sec 5.10.8)

Where the least dimension varies along the length of wall, footing, or other component, multiple sections should be examined to represent the average condition at each section.

Spacing shall not exceed:

- 3.0 times the component thickness, or 18.0 in.
- 12.0 in. for walls and footings greater than 18.0 in. thick
- 12.0 in. for other components greater than 36.0 in. thick

For components 6.0 in. or less in thickness the minimum steel specified may be placed in a single layer. Shrinkage and temperature steel shall not be required for:

- End face of walls 18 in. or less in thickness.
- Side faces of buried footings 36 in. or less in thickness
- Faces of all other components, with smaller dimension less than or equal to 18.0 in.

Distribution Reinforcement (AASHTO 2012 Sec 9.7.3.2)

Reinforcement shall be placed in the secondary direction in the bottom of slabs as a percentage of the primary reinforcement for positive moment as follows.

For primary reinforcement parallel to traffic:

$100/\sqrt{S_c} \leq 50\%$

For primary reinforcement perpendicular to traffic:

$220/\sqrt{S_c} \leq 67\%$

where:

S_c = the effective span length of slab taken as equal to the effective length specified in Article 9.7.2.3 (ft) = clear distance between the girders.

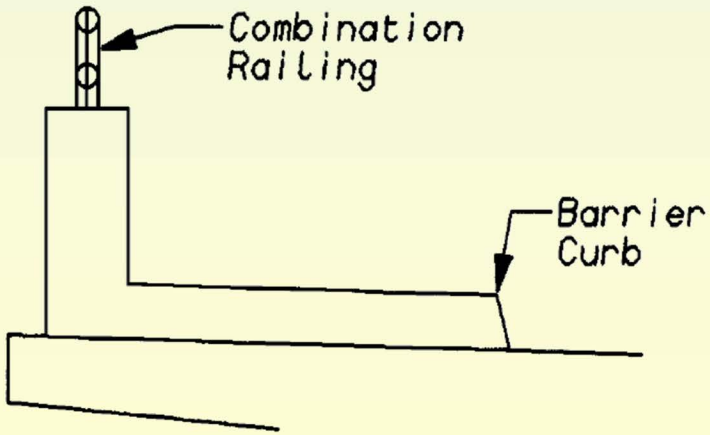
DESIGN OF RAILING

Railings shall be provided along the edges of structures for protection of traffic and pedestrians.

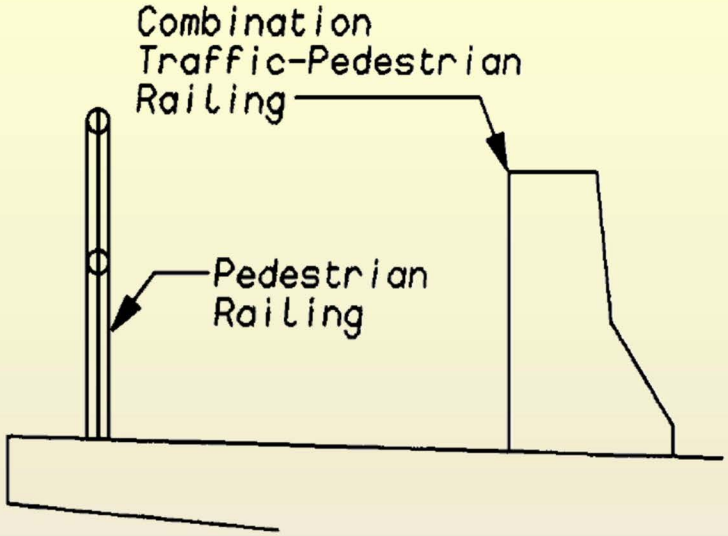
Railing Design: Chapter 13, AASHTO 2012

A pedestrian walkway may be separated from an adjacent roadway by a barrier curb, traffic railing, or combination railing.

On high-speed urban expressways where a pedestrian walkway is provided, the walkway area shall be separated from the adjacent roadway by a traffic railing or combination railing.



Low Speed Application



High Speed Application

DESIGN OF RAILING

Railings are an essential part of bridge design.

Pedestrian Railings





Traffic Railings/ Crash Barrier



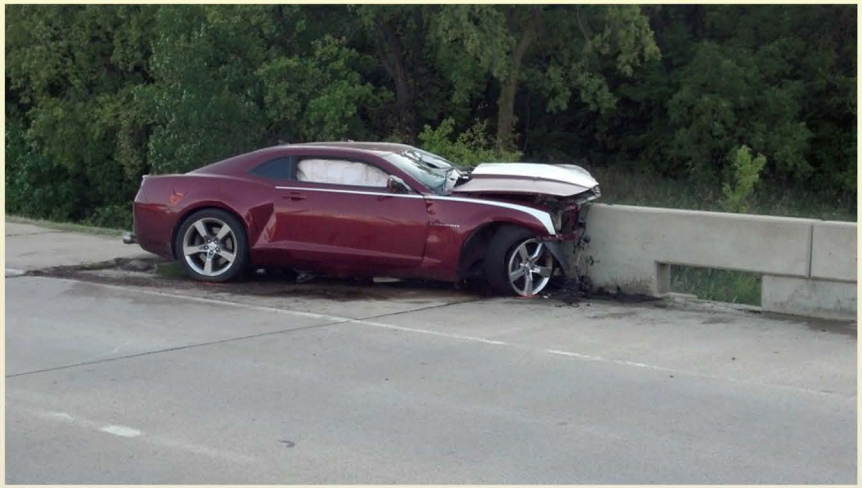


DESIGN OF RAILING

Their function is to protect pedestrian and vehicles from falling over the bridge.



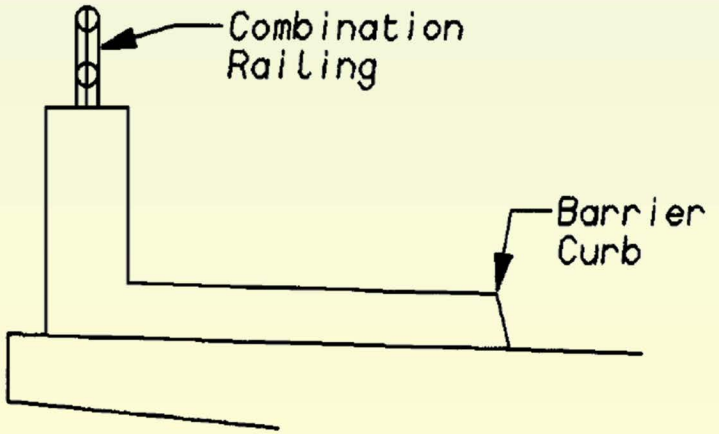




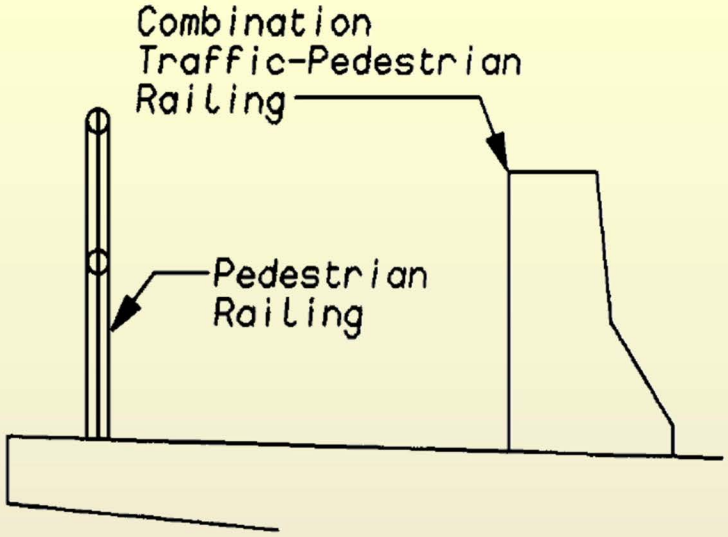
DESIGN OF RAILING

The following guidelines indicate the application of various types of rails:

- **Traffic railing is used when a bridge is for the exclusive use of highway traffic.**
- **A combination barrier in conjunction with a raised curb and sidewalk is used only on low-speed highways.**
- **On high-speed highways, the pedestrian or bicycle path should have both an outboard pedestrian or bicycle railing and an inboard combination railing.**
- **Separate pedestrian bridges should be considered where the amount of pedestrian traffic or other risk factors so indicate.**



Low Speed Application

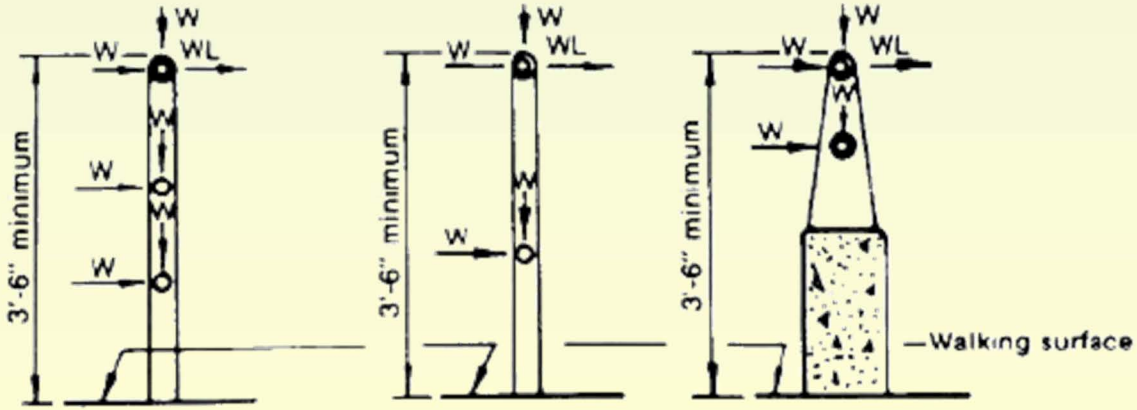


High Speed Application

Low speed may be taken as speeds not exceeding 45 mph. High speed may be taken as speeds in excess of 45 mph (72 kmh).

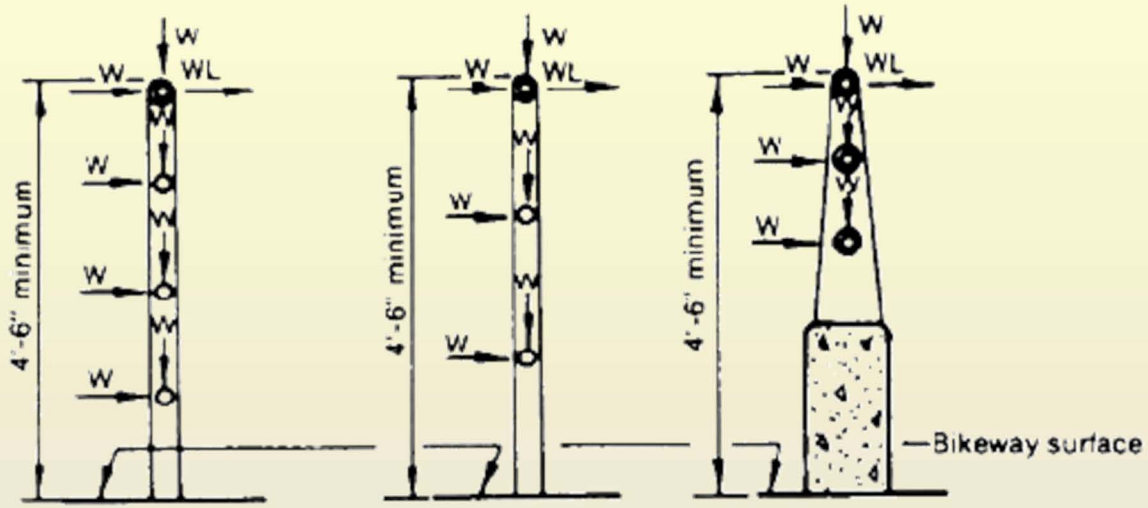
Present Cantilever Bridge design: Low-speed application

DESIGN OF RAILING



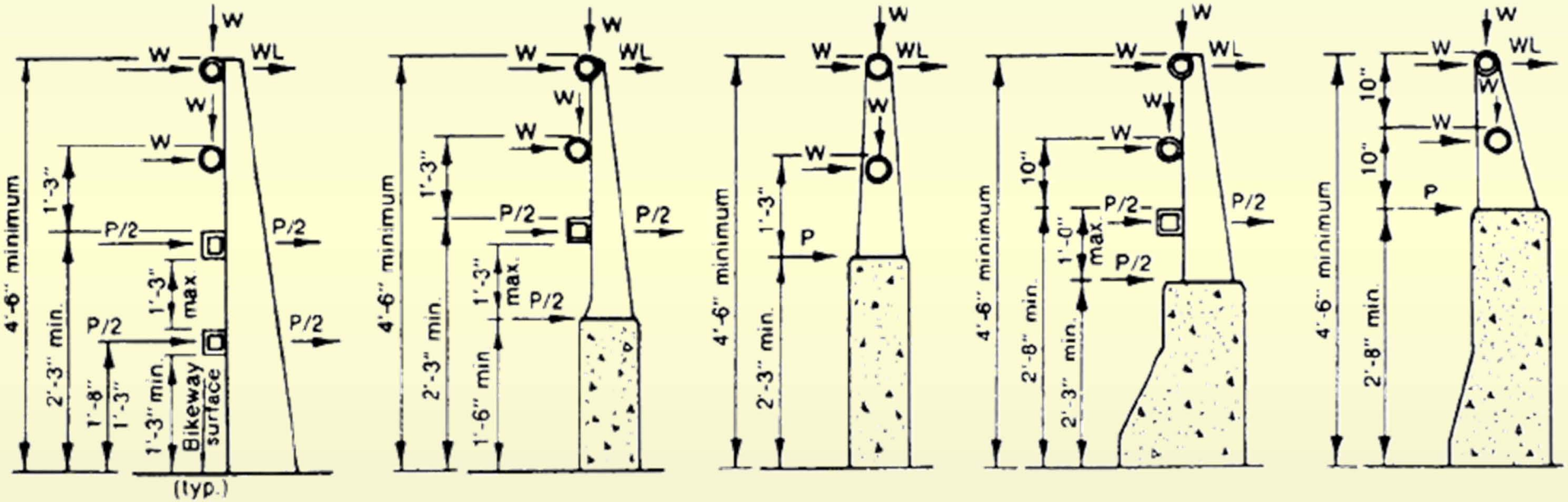
(To be used adjacent to a sidewalk when highway traffic is separated from pedestrian traffic by a traffic railing.)

PEDESTRIAN RAILING



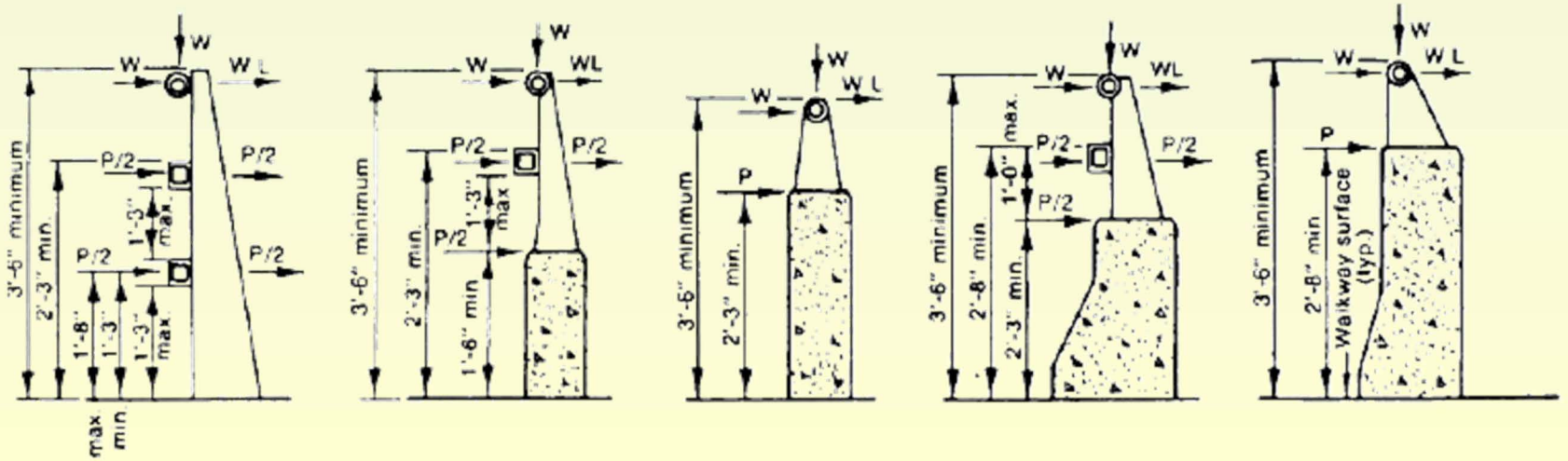
BICYCLE RAILING

DESIGN OF RAILING



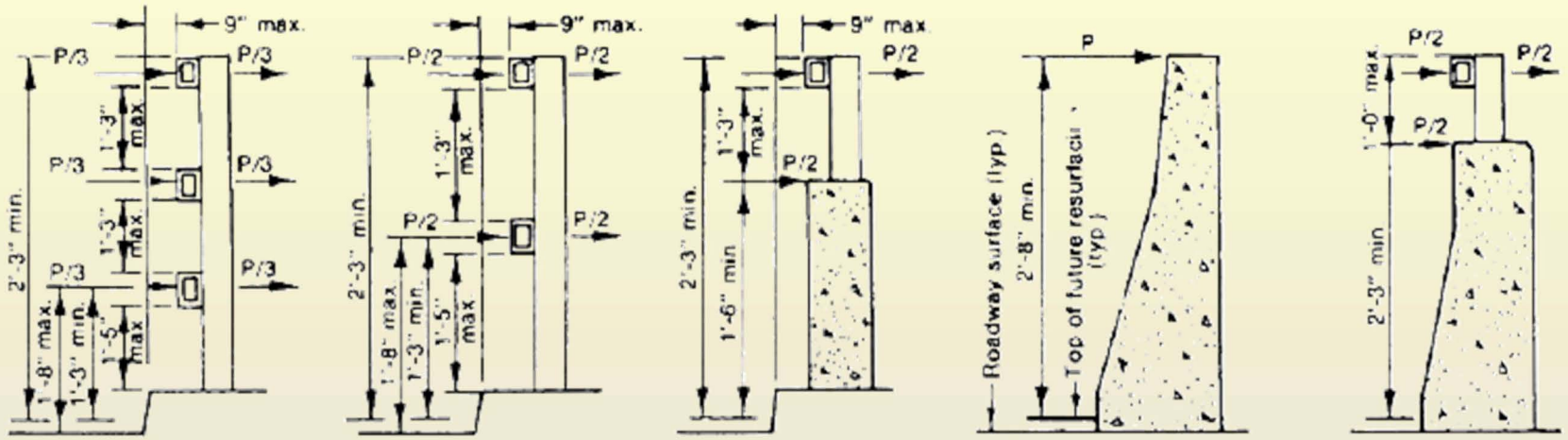
COMBINATION TRAFFIC AND BICYCLE RAILING

DESIGN OF RAILING



(To be used when curb projects more than 9" from the traffic face of railing.)

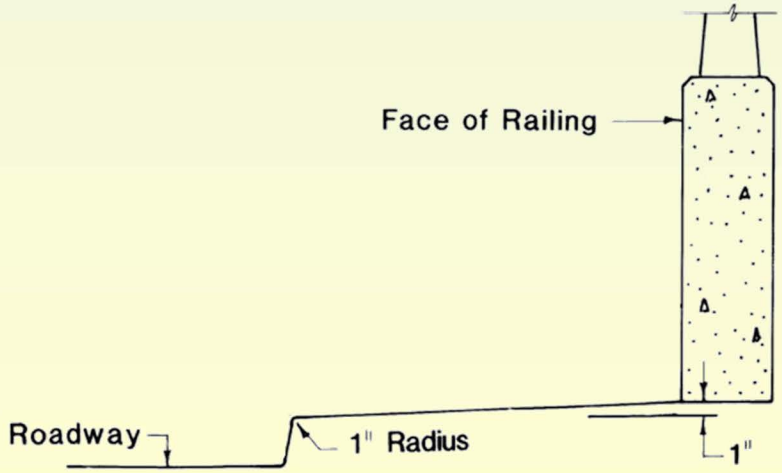
COMBINATION TRAFFIC AND PEDESTRIAN RAILING

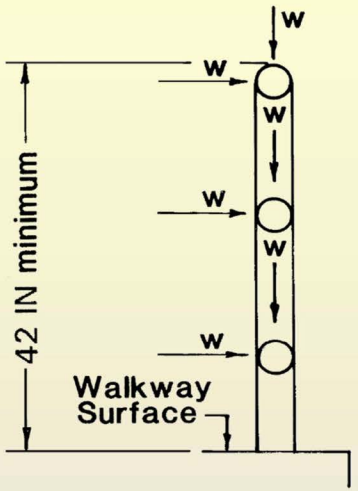


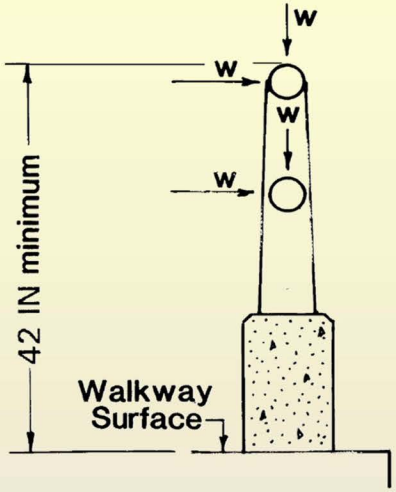
(To be used where there is no curb or curb projects 9" or less from traffic face of railing.)

DESIGN OF PEDESTRIAN RAILING

- The minimum height of a pedestrian railing shall be 42.0 in. measured from the top of the walkway.
- A pedestrian rail may be composed of horizontal and/or vertical elements. The clear opening between elements shall be such that a 6.0 in. diameter sphere shall not pass through.
- When both horizontal and vertical elements are used, the 6.0 in. clear opening shall apply to the lower 27.0 in. of the railing, and the spacing in the upper portion shall be such that a 8.0-in. diameter sphere shall not pass through.
- A safety toe rail or curb should be provided. Rails should project beyond the face of posts .
- The rail spacing requirements given above should not apply to chain link or metal fabric fence support rails and posts. Mesh size in chain link or metal fabric fence should have openings no larger than 2.0 in.





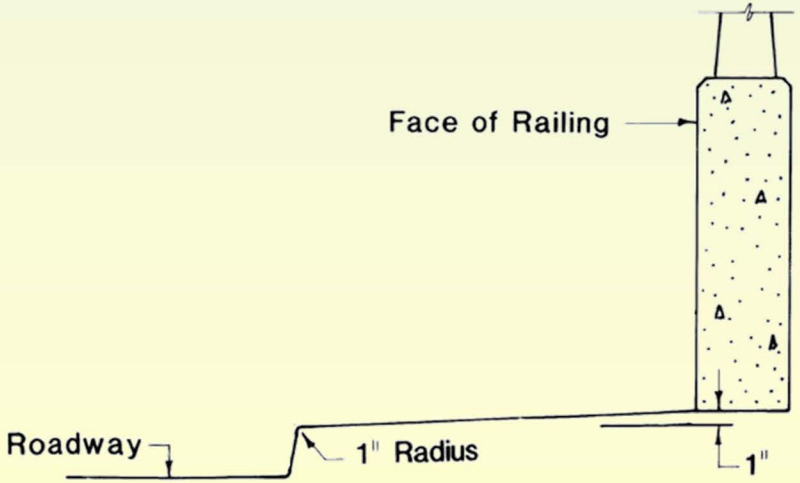


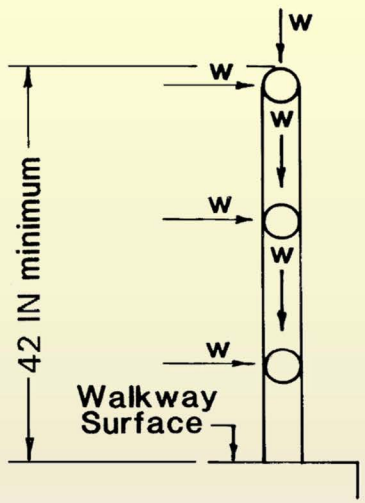
DESIGN OF PEDESTRIAN RAILING

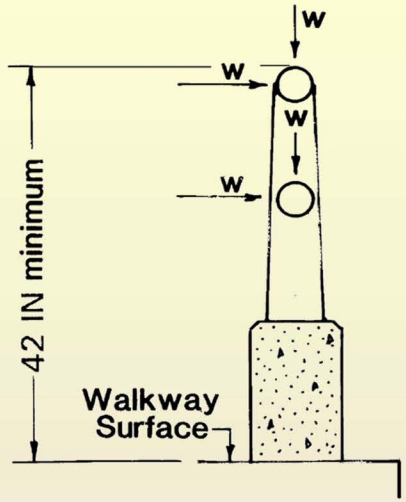
- The design live load for pedestrian railings shall be taken as w = 0.050 klf, both transversely and vertically, acting simultaneously.
- In addition, each longitudinal element will be designed for a concentrated load of 0.20 kips, which shall act simultaneously with the above loads at any point and in any direction at the top of the longitudinal element.
- The posts of pedestrian railings shall be designed for a concentrated design live load applied transversely at the center of gravity of the upper longitudinal element or, for railings with a total height greater than 5.0 ft, at a point 5.0 ft above the top surface of the sidewalk. The value of the concentrated design live load for posts, P_{LL}, in kips, shall be taken as:

$P_{LL} = 0.2 + 0.05L$, kip

Where L is the spacing of posts in ft.



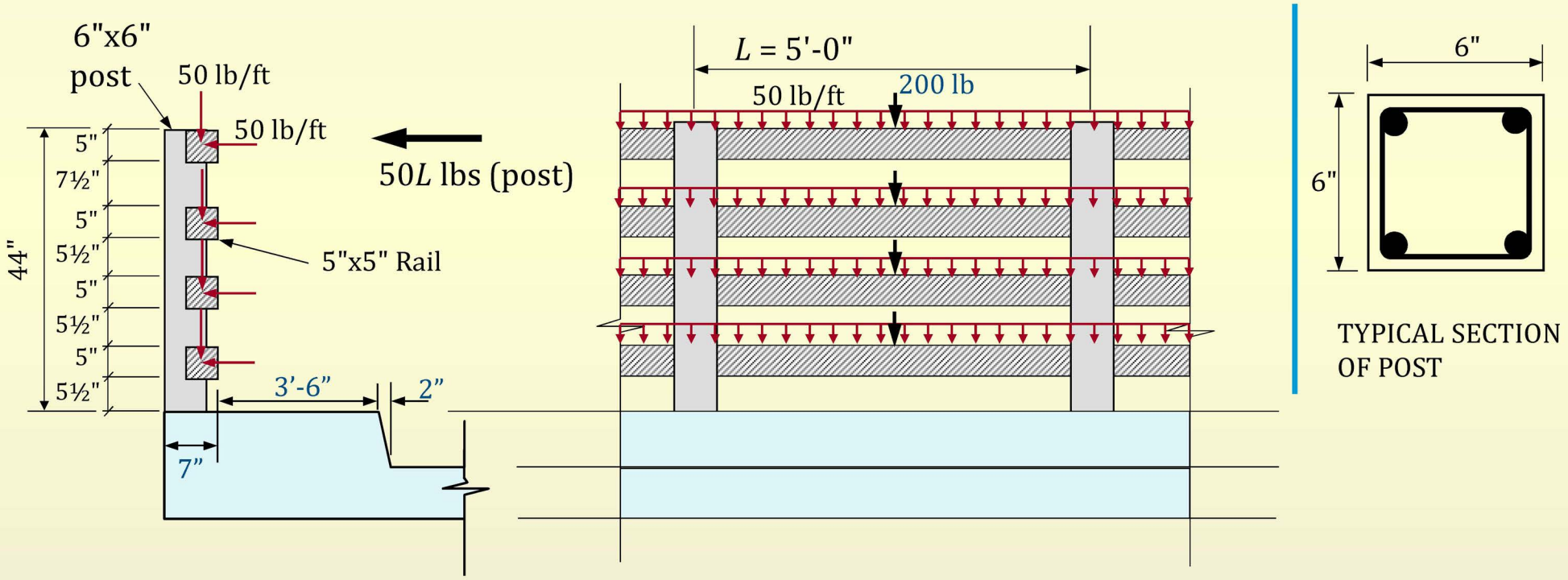




DESIGN OF RAILING(Pedestrian)

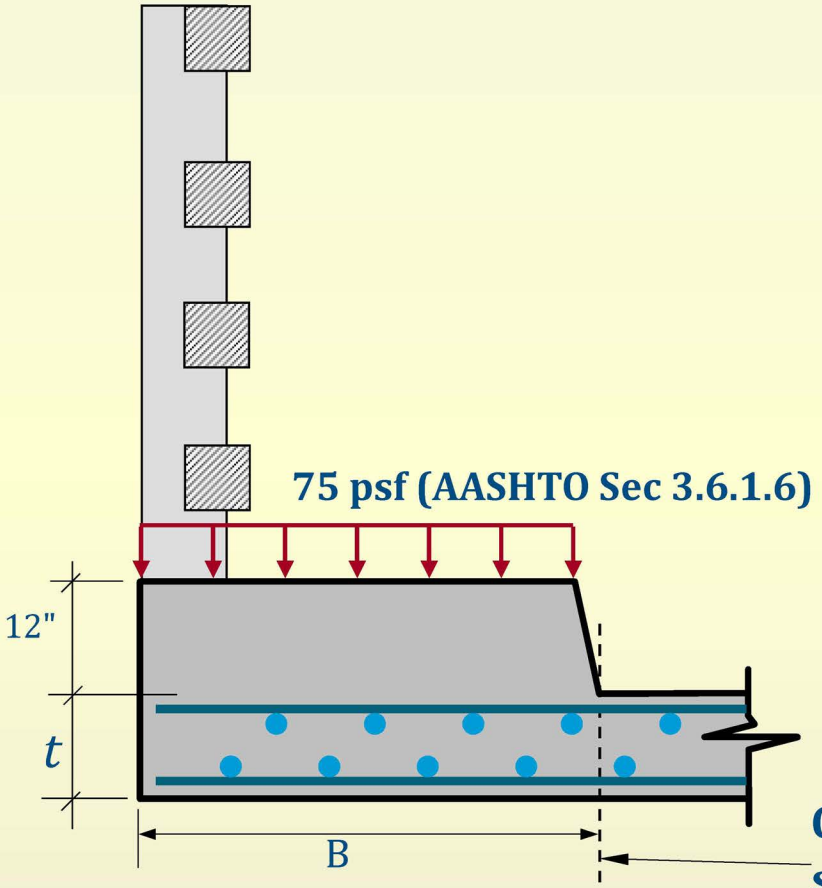
Minimum height of rail post : 42 inch

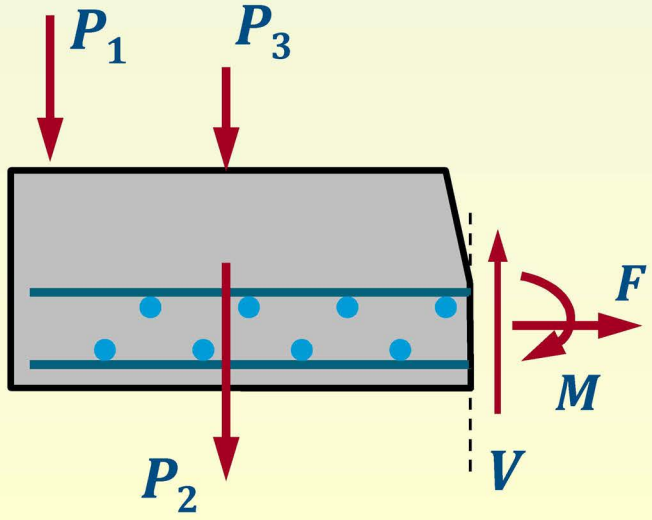
Opening between rails shall be less than 6 inch for portion 27 inch vertically from walkway surface.
Opening between rails shall be less than 8 inch for portion above 27 inch from walkway surface.

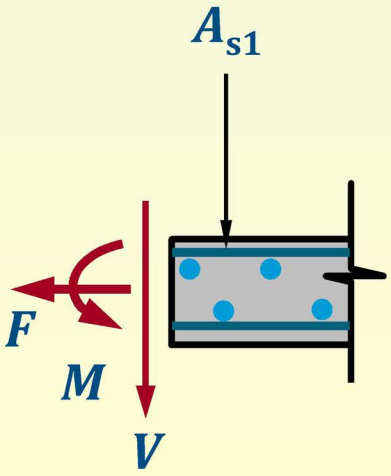


Each railing shall be designed for 50 lb/ft uniformly distributed load acting simultaneously in both vertical and horizontal direction.

DESIGN OF SIDEWALK / CURB







P_1 = Load from railing+post per foot
P_2 = Self-weight of walkway / curb
P_3 = Due to 75 psf *LL*

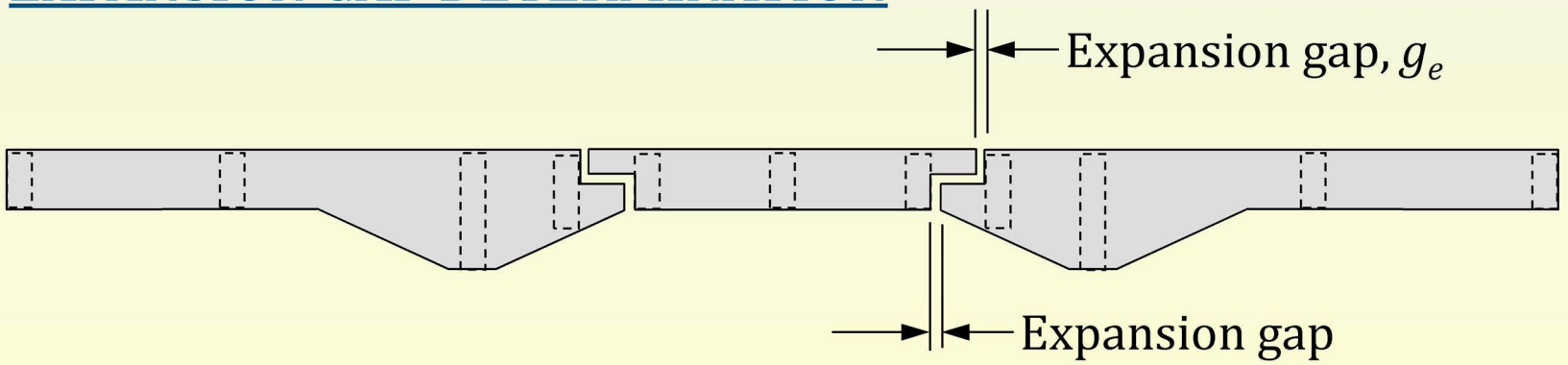
A_{s1} = Due to *M*, Section should be OK for *V*. If steel from slab design are more than above steel, then no need to provide additional steel, otherwise provide the excess required.

General Load Combination

$$1.25(DC) + 1.5(DW) + 1.75(LL)(1+IM/100)_{\text{Truck/Tandem}} + 1.75(LL)_{\text{Lane}} + 1.75(PL)$$

$M = 1.25(M_{P1}+M_{P2}) + 1.75M_{LL}$, similarly for *F* and *V*

EXPANSION GAP DETERMINATION



Expansion gap is required to accommodate the thermal expansion-contraction. In Bangladesh seasonal temperature varies between 5 °C to 40 °C. For the purpose of design we take Δt = 40 °C.

Thermal expansion co-efficient of concrete α_c = 0.00001 / °C.

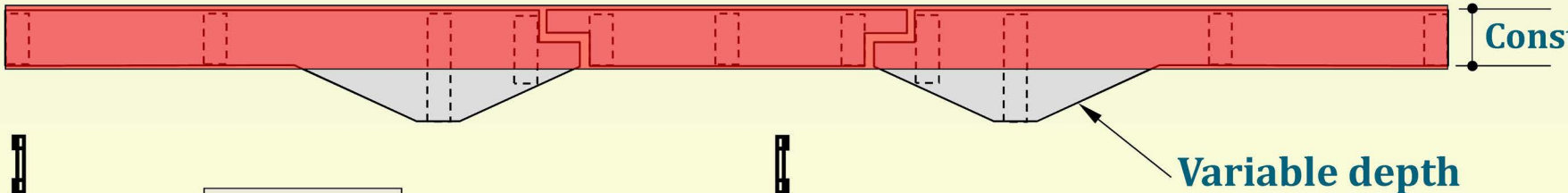
Therefore, maximum expansion/contraction shall be

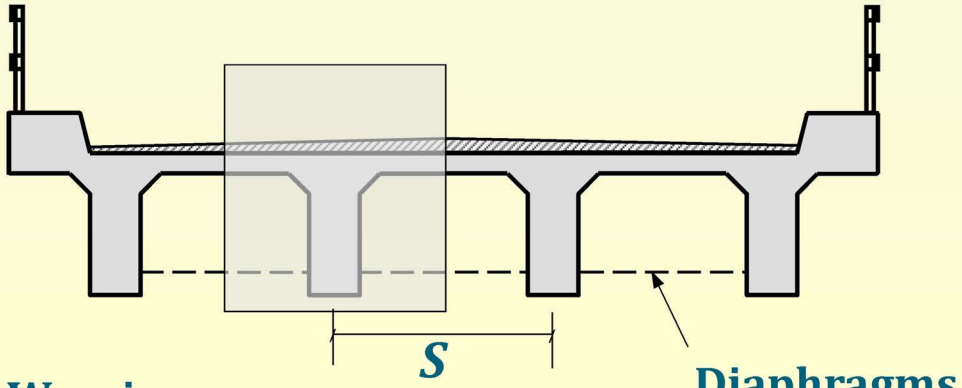
$\Delta L = \alpha_c(\Delta t)L$ where L is the length under consideration.

Total expansion may be divided at the two expansion gaps at the ends of the suspended span. Also we shall maintain a minimum of 1 inch gap in the event of extreme condition. Thus,

$$g_e = \alpha_c \Delta t \; L + 1 = 0.00001 \times 40 \times L \text{ (inch)} + 1 \text{ [rounded to higher ½ inch]}$$

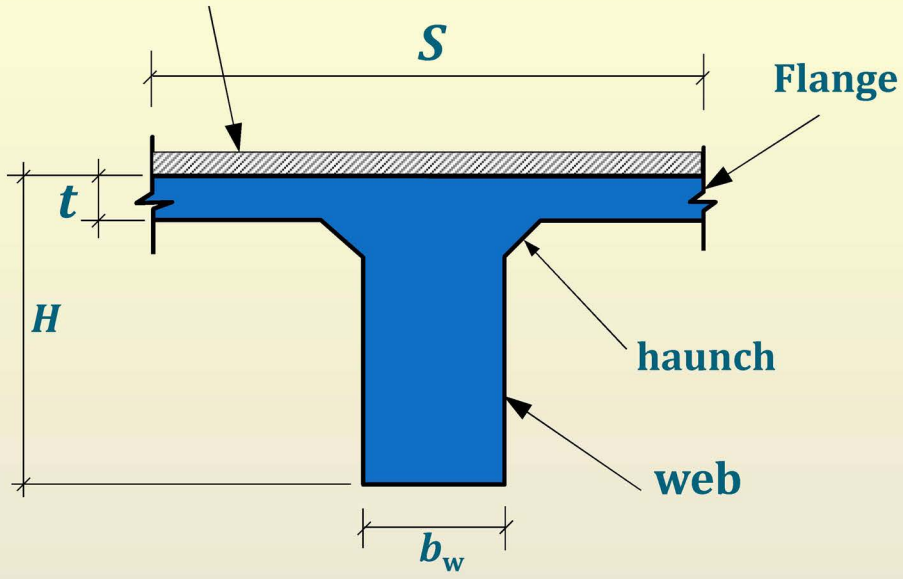
INTERIOR GIRDER : DEAD LOAD ANALYSIS





Weight from constant depth part

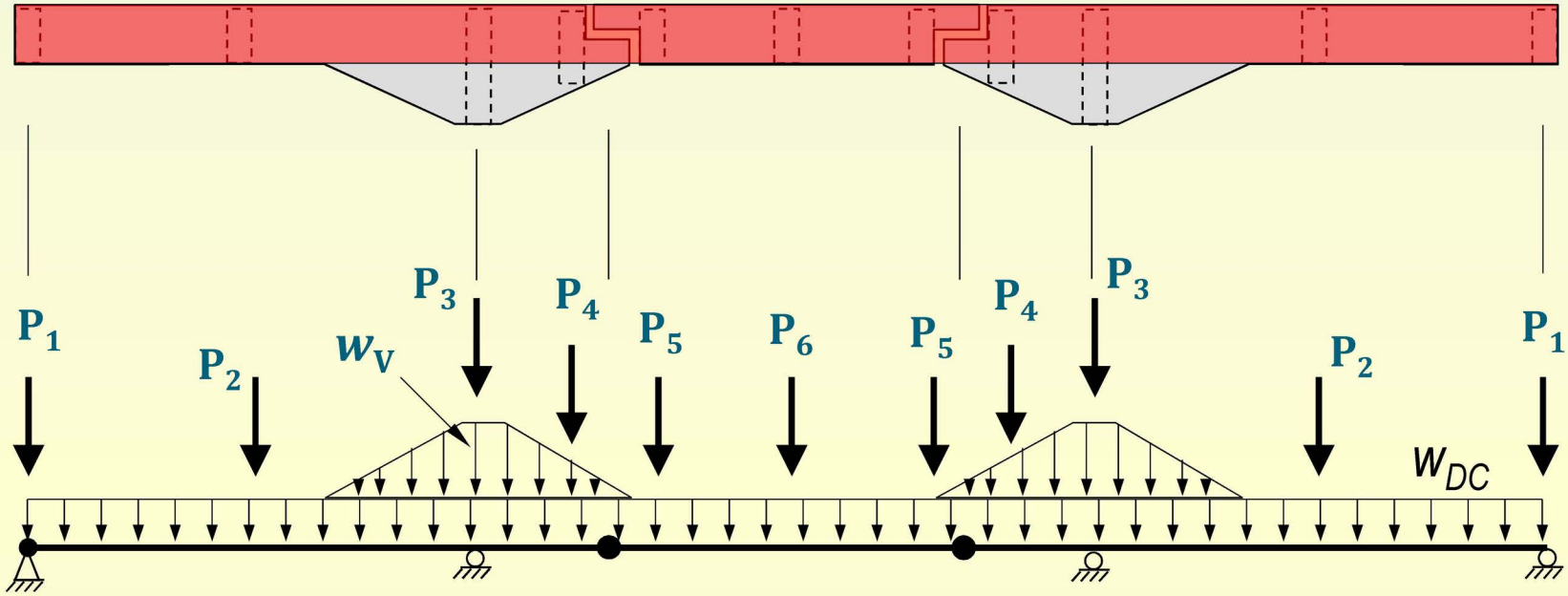
w_{sw} = from concrete section
w_{wc} = from wearing surface



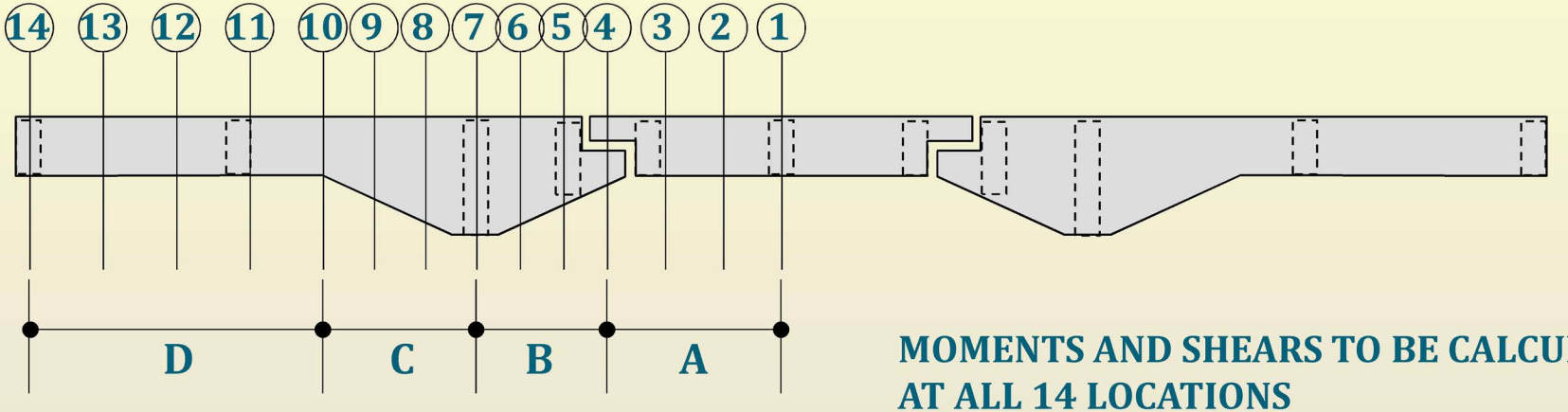
Diaphragms

1. Width = 10" (intermediate), 18" (support)
2. Depth = 12" less than main girder
3. Spacing = 30ft max.

INTERIOR GIRDER : DEAD LOAD ANALYSIS (DC)

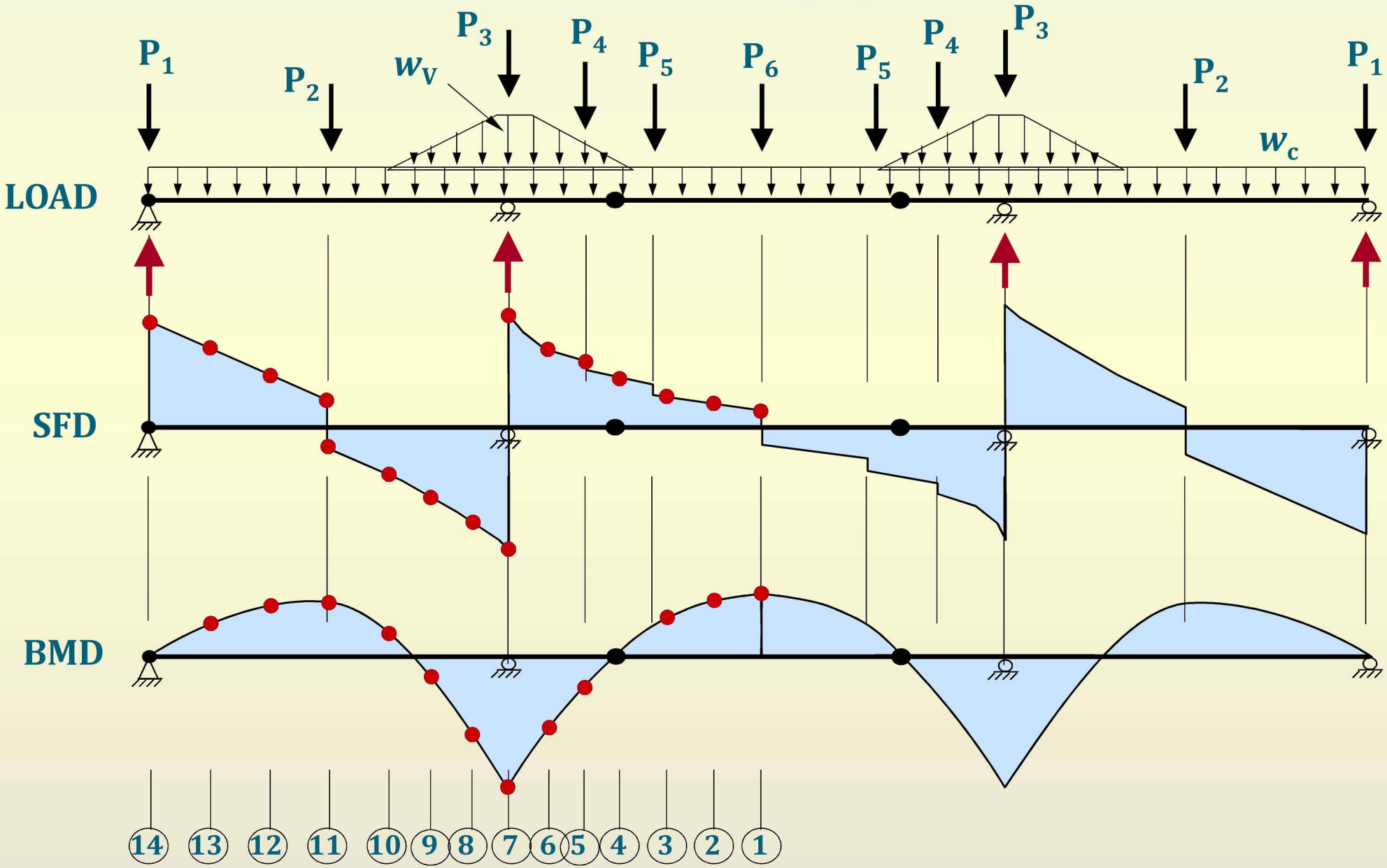


DESIGN SECTIONS

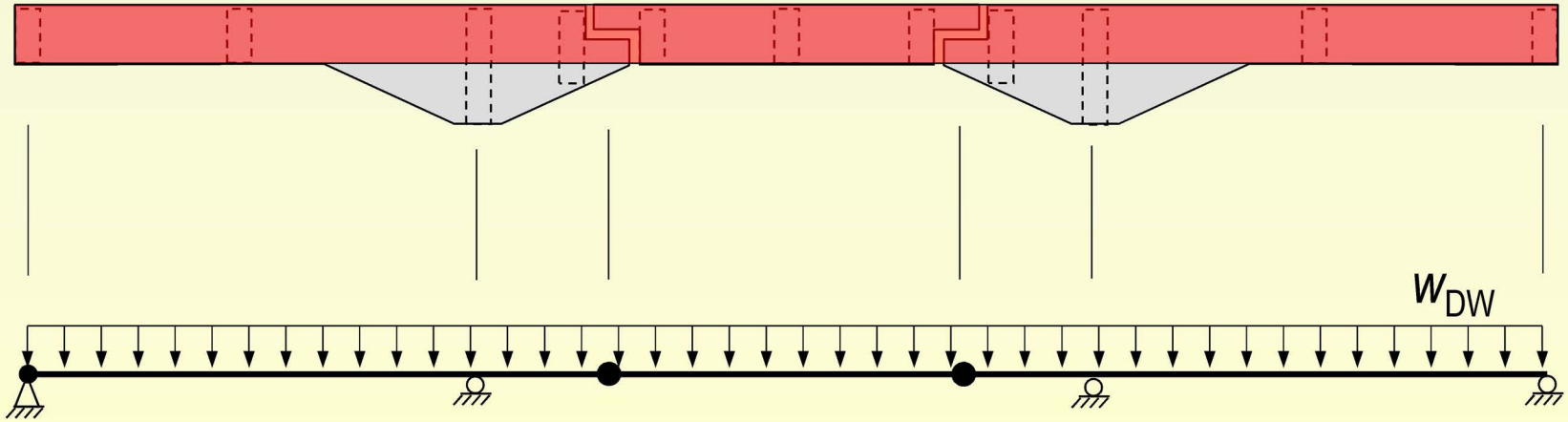


MOMENTS AND SHEARS TO BE CALCULATED AT ALL 14 LOCATIONS

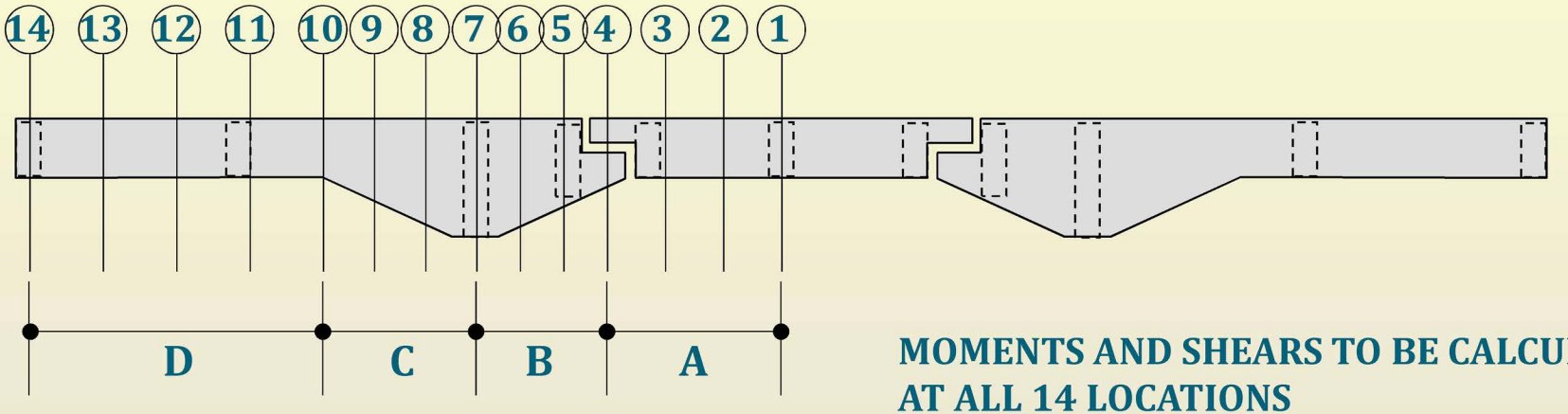
INTERIOR GIRDER : DEAD LOAD ANALYSIS (DC)



INTERIOR GIRDER : DEAD LOAD ANALYSIS, WEARING COURSE (DW)

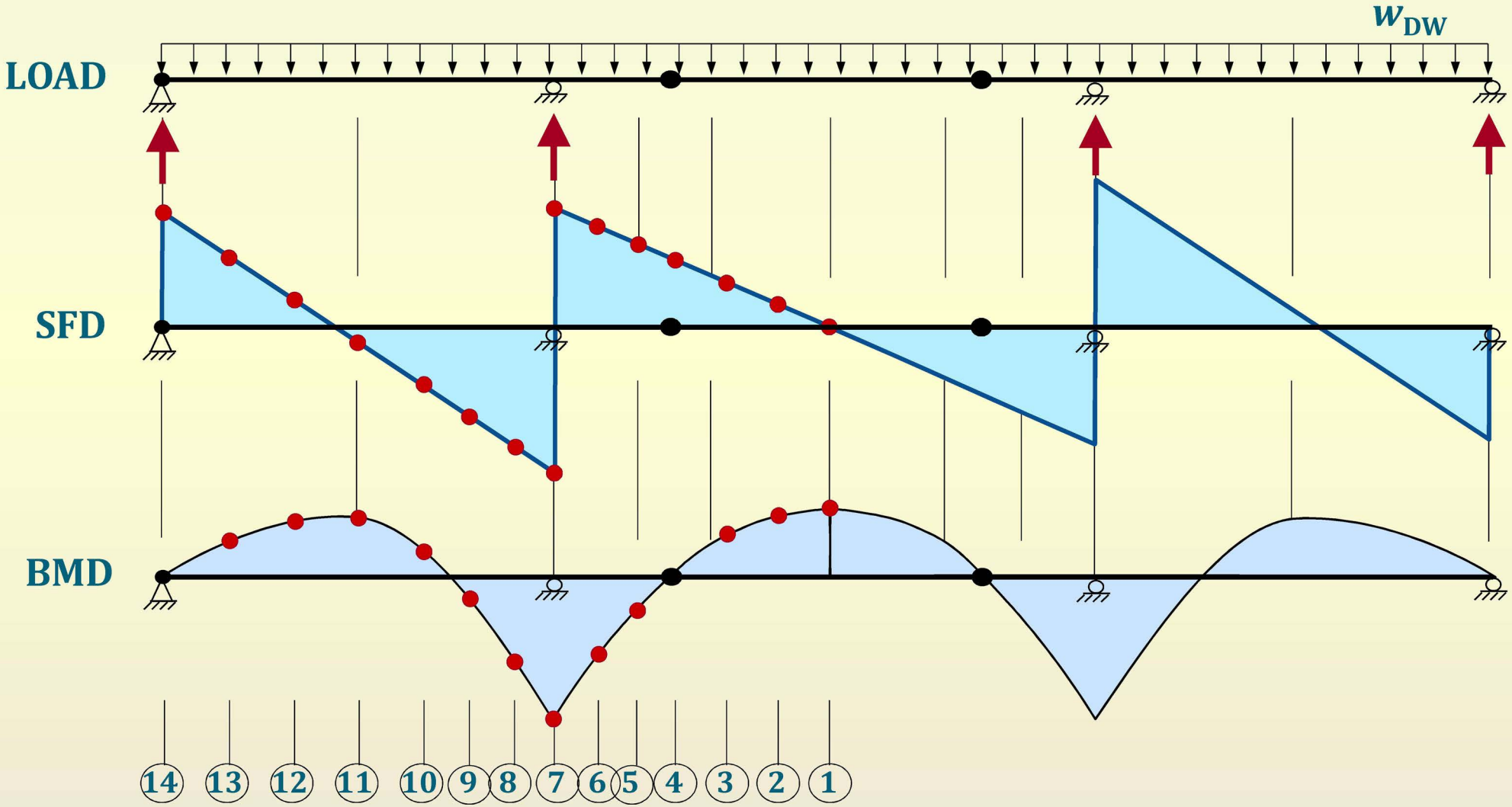


DESIGN SECTIONS

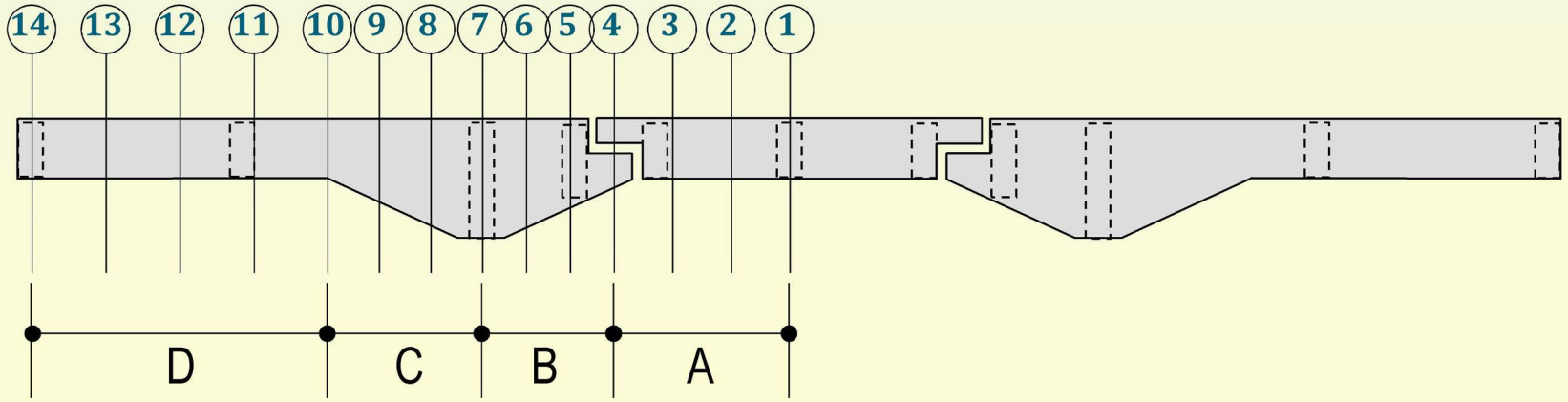


MOMENTS AND SHEARS TO BE CALCULATED AT ALL 14 LOCATIONS

INTERIOR GIRDER : DEAD LOAD ANALYSIS, WEARING COURSE (DW)

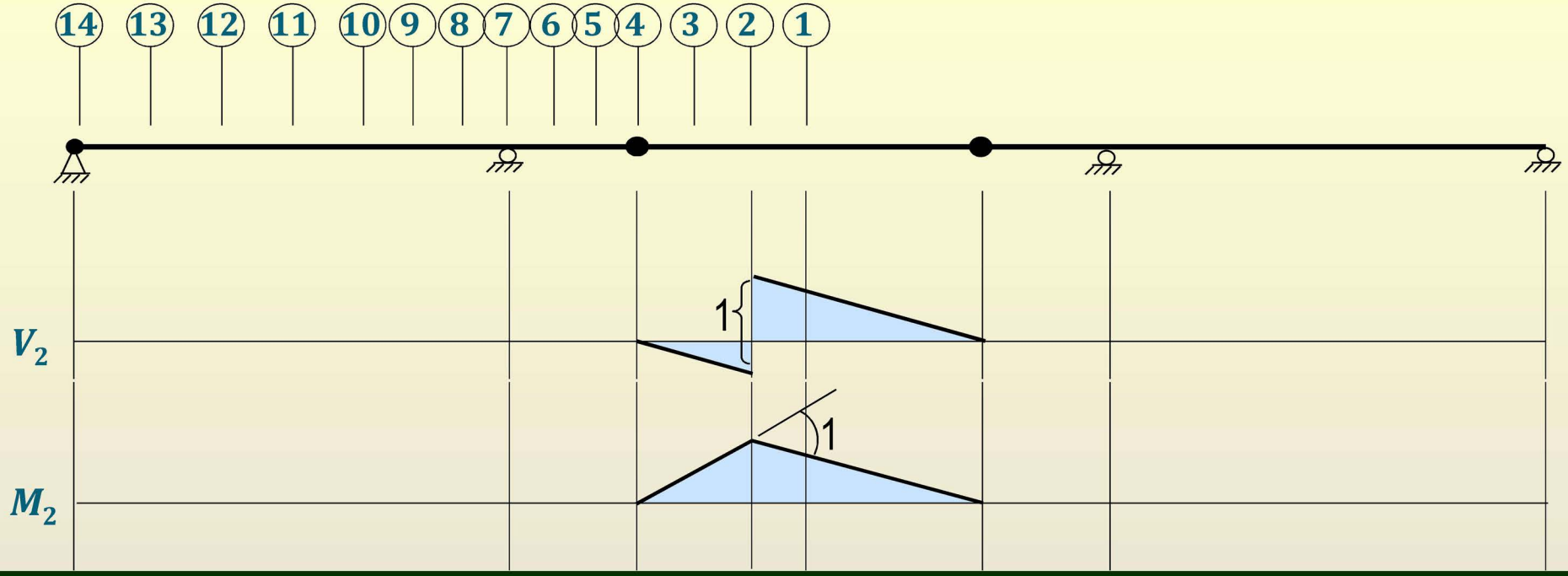


INTERIOR GIRDER : LIVE LOAD ANALYSIS



I.L. FOR SHEAR AND MOMENT AT ALL 14 DESIGN SECTIONS NEED TO BE DRAWN

A FEW ARE SHOWN BELOW.....



INTERIOR GIRDER : LIVE LOAD ANALYSIS

INFLUENCE LINES CONTD.....

