CE 386
Concrete Structure Design Sessional

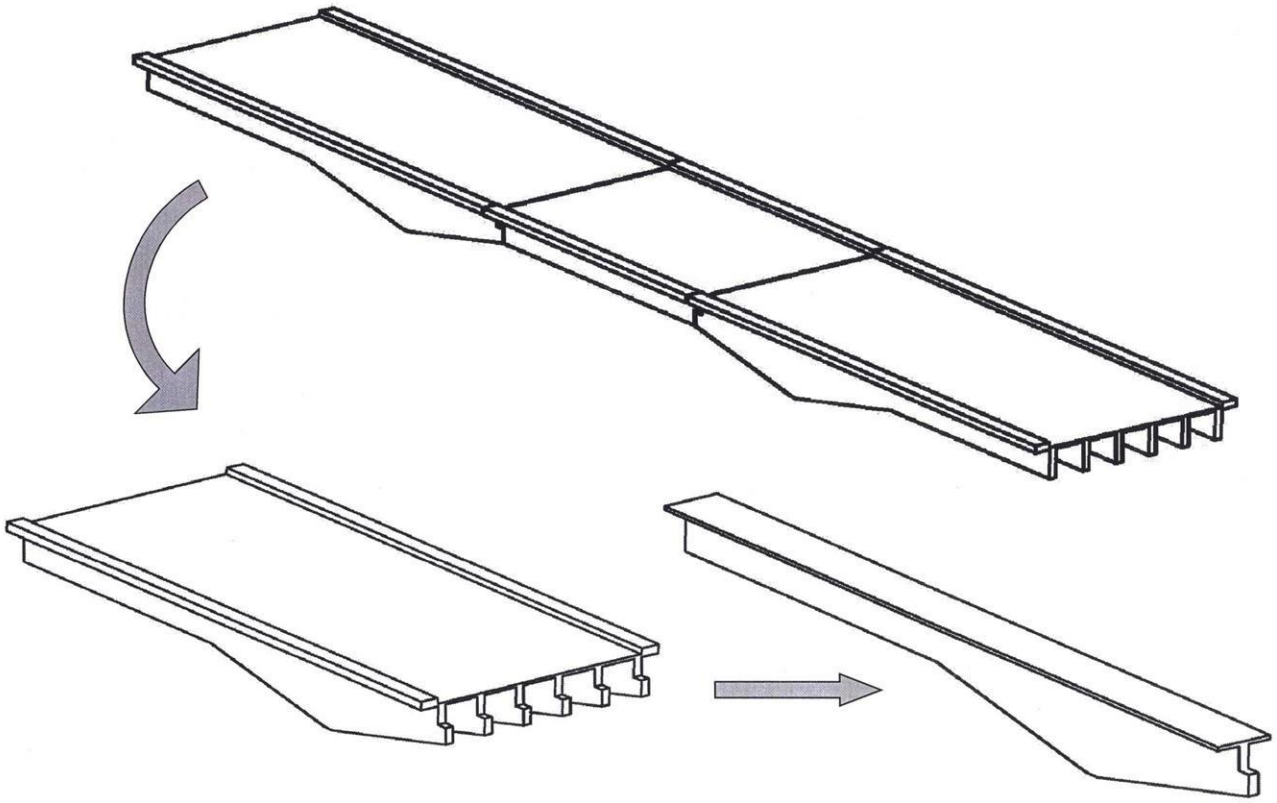
ARTICULATION

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DESIGN OF ARTICULATION



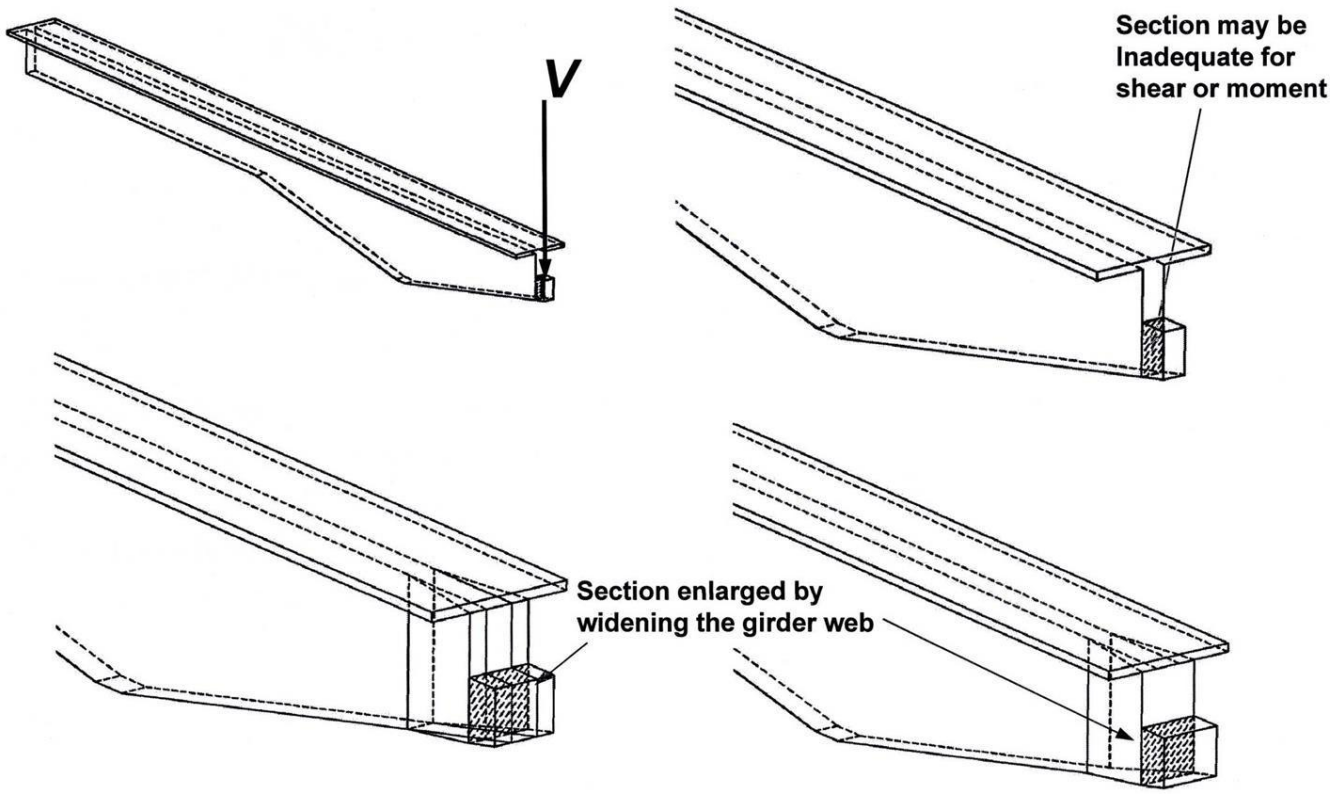


Fig: Widening of girder near articulation location

What is Articulation

- The connection between the suspended span and the edge of the cantilever is called 'Articulation'.
- The bearings at articulations can be in the form of sliding plates, roller-rocker arrangement or elastomeric pads.

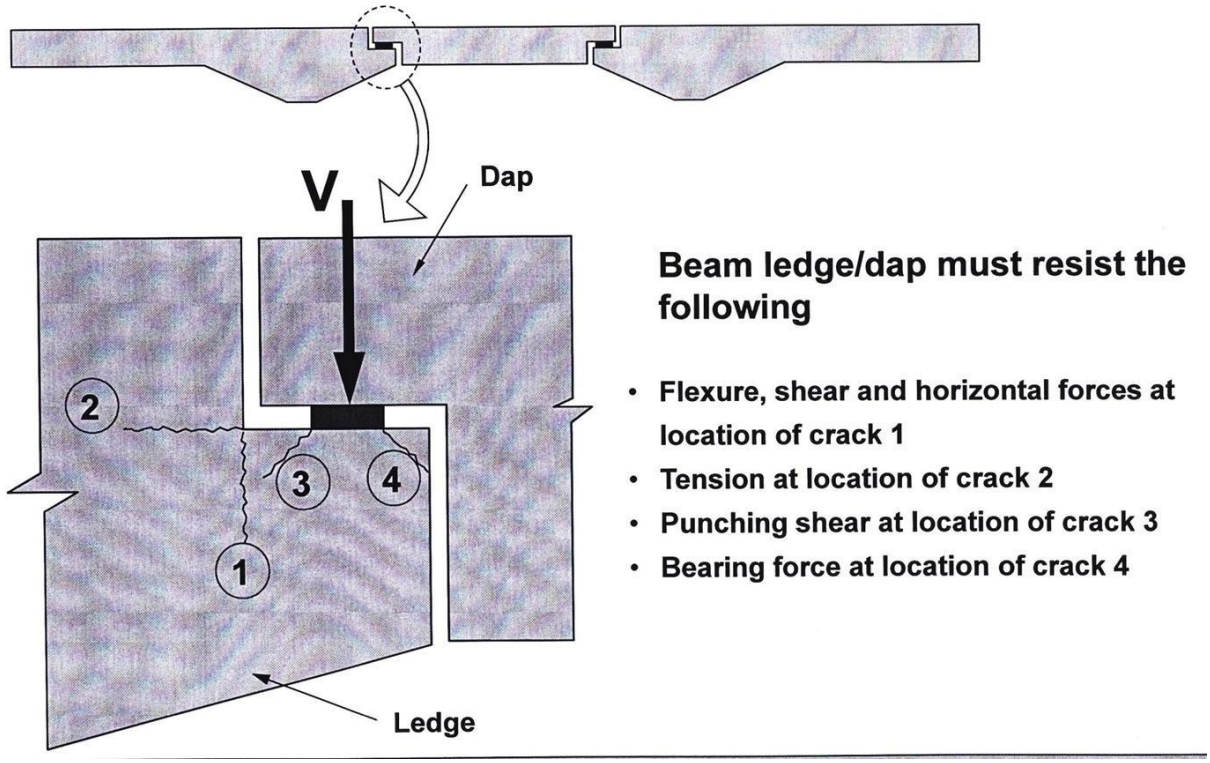


Fig: Cracks at articulation

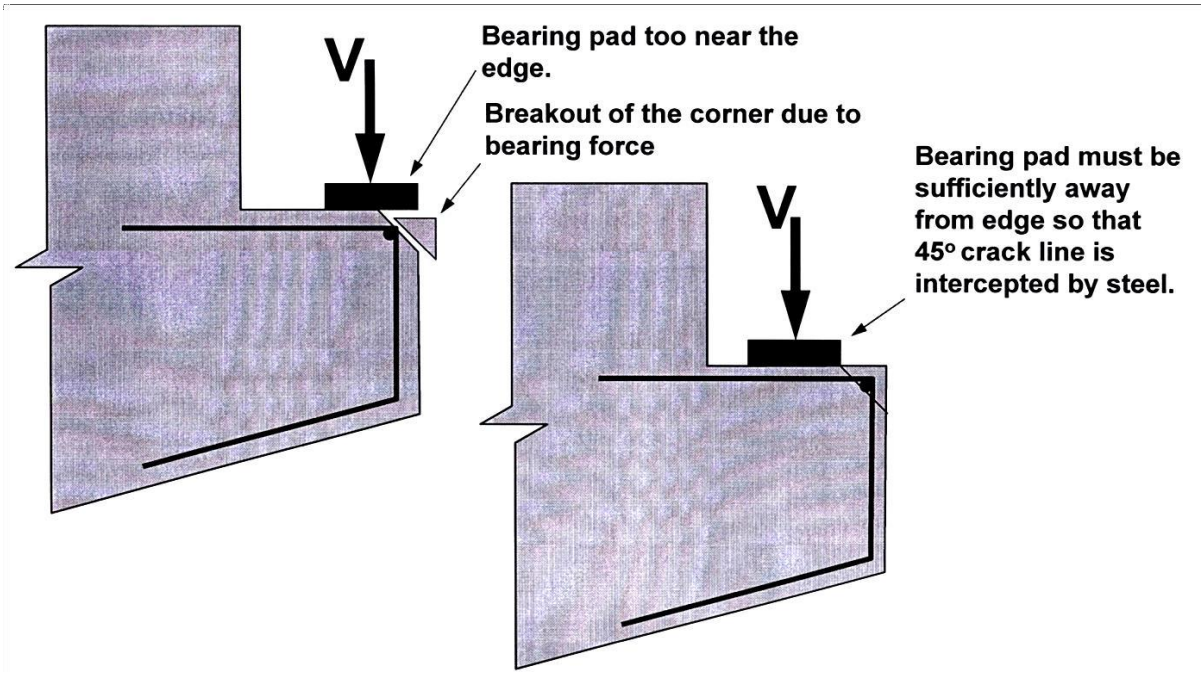


Fig: Clearance requirement around bearing pad near articulation

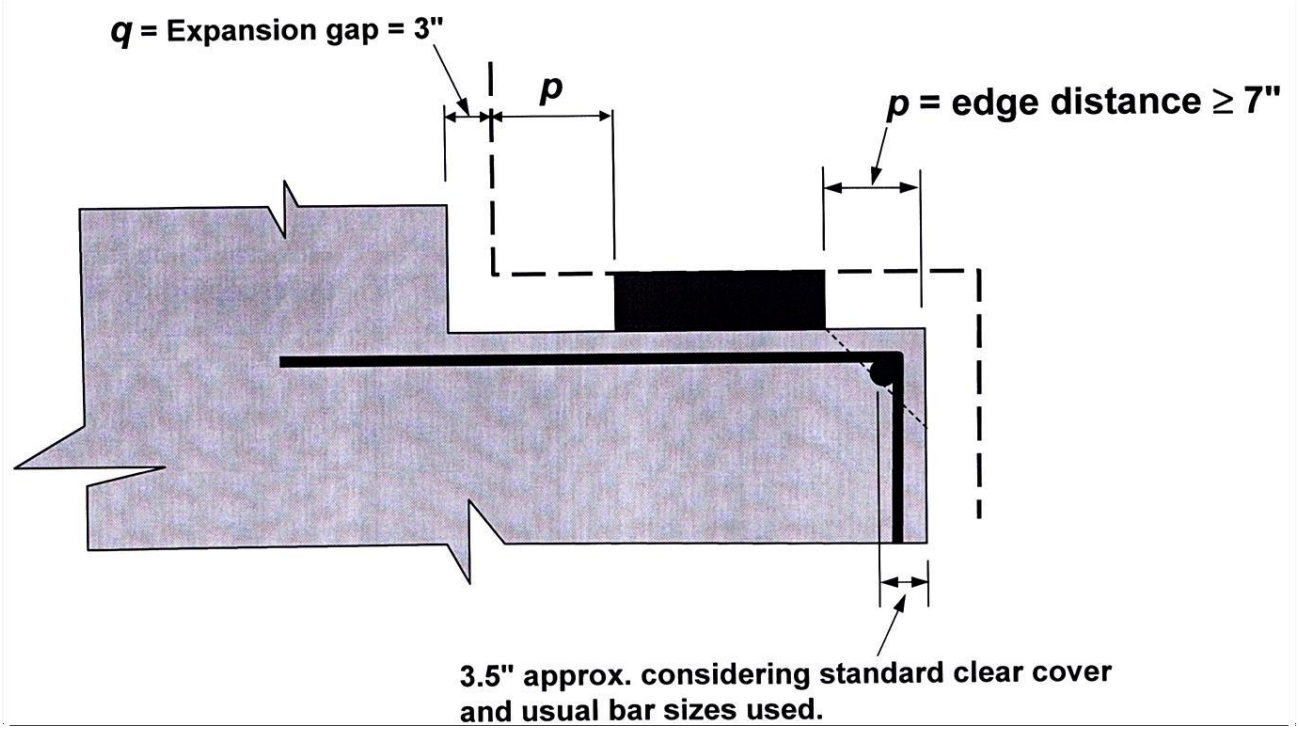
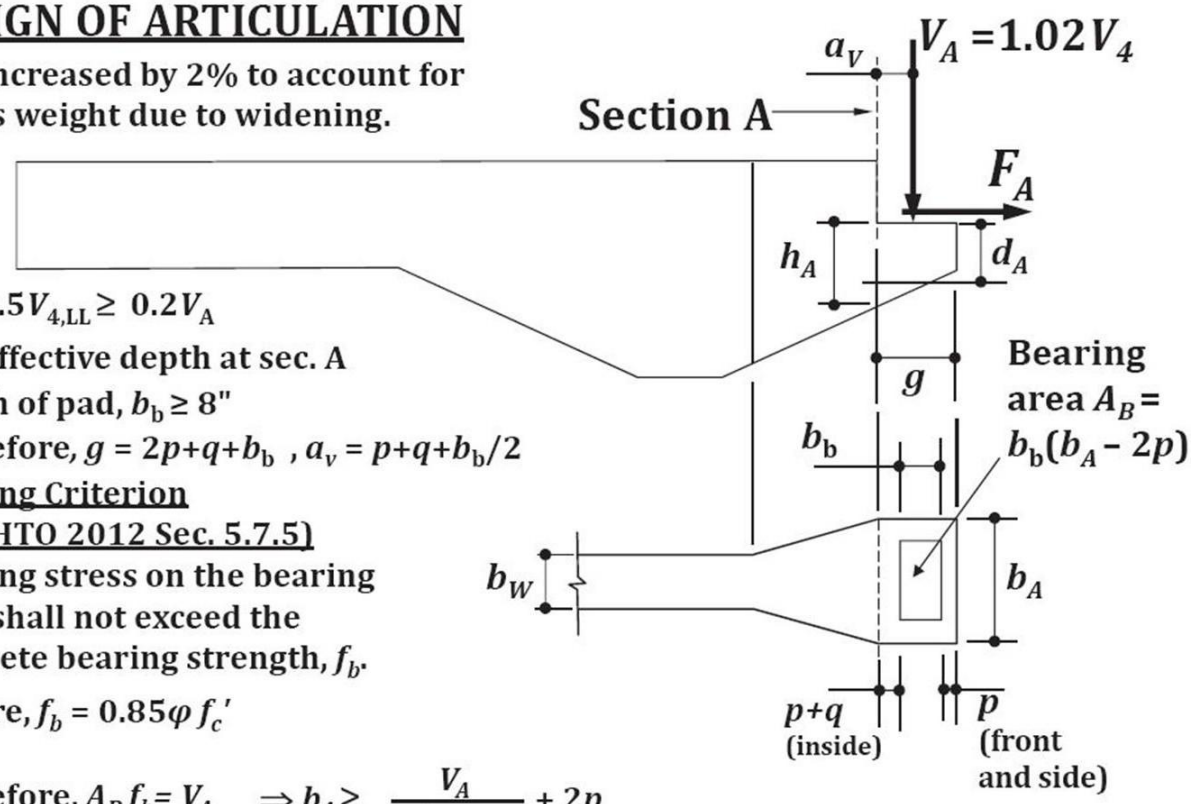


Fig: Expansion gap and edge distance around bearing pad

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V_4 is increased by 2% to account for excess weight due to widening.



$F_A = 0.5V_{4,LL} \geq 0.2V_A$

d_A = effective depth at sec. A

Width of pad, $b_b \geq 8"$

Therefore, $g = 2p+q+b_b$, $a_v = p+q+b_b/2$

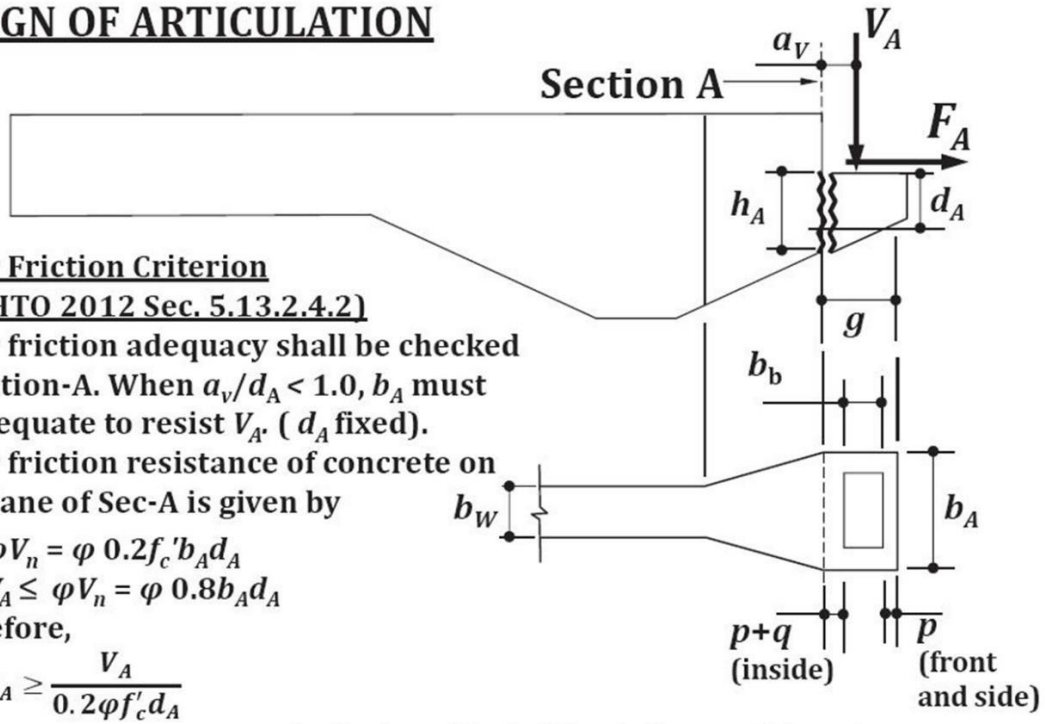
Bearing Criterion
(AASHTO 2012 Sec. 5.7.5)

Bearing stress on the bearing area shall not exceed the concrete bearing strength, f_b.

Where, $f_b = 0.85\varphi f_c'$

Therefore, $A_B f_b = V_A \quad \Rightarrow b_A \geq \dfrac{V_A}{b_b f_b} + 2p$

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Shear Friction Criterion
(AASHTO 2012 Sec. 5.13.2.4.2)

Shear friction adequacy shall be checked at Section-A. When $a_v/d_A < 1.0$, b_A must be adequate to resist V_A. (d_A fixed).

Shear friction resistance of concrete on the plane of Sec-A is given by

$V_A \leq \varphi V_n = \varphi\ 0.2 f_c' b_A d_A$

And $V_A \leq \varphi V_n = \varphi\ 0.8 b_A d_A$

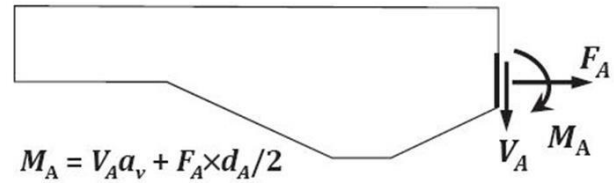
Therefore,

$$b_A \geq \frac{V_A}{0.2\varphi f_c' d_A}$$

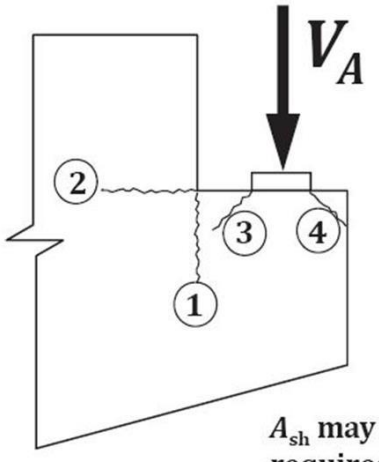
$$\text{or, } b_A \geq \frac{V_A}{\varphi\ 0.8 dA}$$

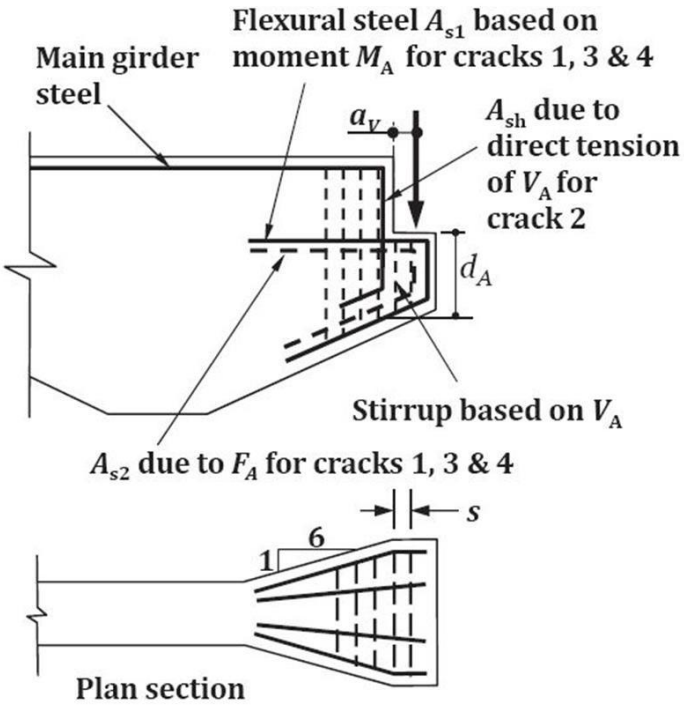
Final value of b_A shall be the larger of the value obtained from bearing and shear friction criteria.

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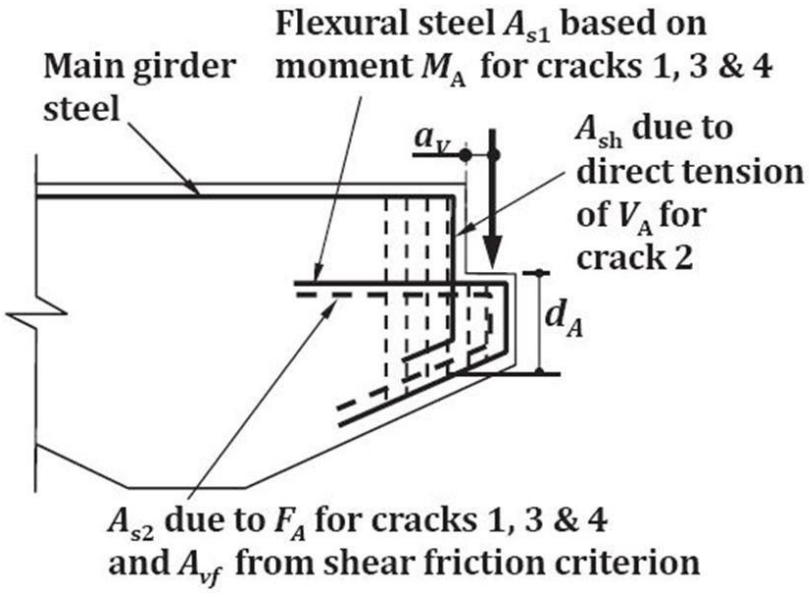


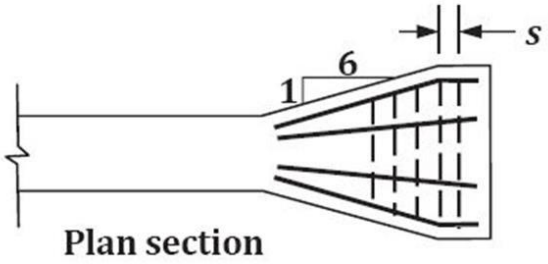
$M_A = V_A a_v + F_A \times d_A/2$





A_{sh} may be provided by extending and bending the main top bar as required. Similarly, A_{s1} and A_{s2} may be provided by extending and bending the girder bottom steel.





For flexural steel A_{s1}

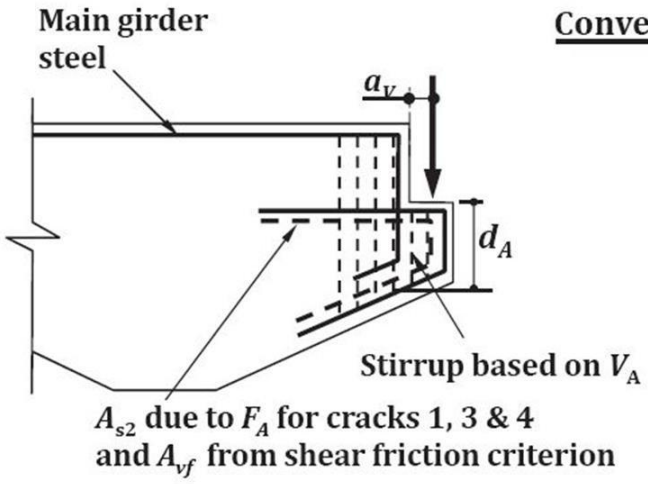
$$A_{s1} = \frac{M_A}{\varphi f_y (d_A - a/2)}$$

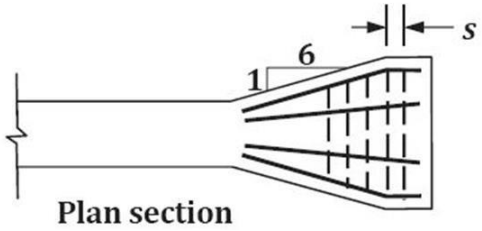
$$a = \frac{A_{s1} f_y}{0.85 f'_c b_A}, \quad \varphi = 0.9$$

For steel A_{sh} and A_{s2}

$$A_{sh} = \frac{V_A}{\varphi f_y}, \quad \varphi = 0.85$$

$$A_{s2} = \frac{F_A}{\varphi f_y}$$





Conventional flexural shear criterion: $a_v/d_A > 1.0$

$$s = \frac{\varphi A_v f_v d_A}{V_A - \varphi V_c}$$

$$V_c = 0.0316\beta(\sqrt{f_c'})\, b_A d_A$$

Check $s_{max} < 12"$ or $d_A/2$

Though conventional flexural shear steel is required only when $a_V/d_A > 1$, we shall, nevertheless, provide such steel even when $a_V/d_A < 1$.

Design Steps

1. Determine flexural steel area A_{s1} based on moment $M_{A.}$
2. Determine steel area A_{s2} based on $F_{A.}$
3. Determine steel area A_{sh} based on V_A
4. Determine required spacing s for stirrup
5. Check spacing of stirrup with maximum spacing