AASHTO Lap Splice Calculation for Deformed Welded Wire Reinforcement

the following is WRI's summary of the process used to determine tension development length and lap splice for deformed welded wire reinforcement using AASHTO LRFD Bridge Design Specifications, Ninth Edition (2020).

For deformed welded wire reinforcement with cross wires within the development length, use **Procedure 1**.

For deformed welded wire reinforcement without cross wires in the development region, or in instances where the designer elects to not rely on cross wire contribution to tensile development, use **Procedure 2**.

Procedure 1

1. Calculate the basic development length, l_{db}, as the greater of the following from equations 5.10.8.2.5-2 and 5.10.8.2.5-3:

$$l_{db} \geq 0.95 d_b \times \frac{f_y - 20.0}{\sqrt{f'_c}}$$

$$l_{db} \geq 6.30 \times \frac{A_w f_y}{s_w \sqrt{f'_c}}$$

   d_b = wire diameter (inches)
   f_y = specified minimum yield strength of reinforcement (ksi)
   f'_c = compressiv strength of concrete (15.0 ksi maximum for normal weight concrete; 10.0 ksi maximum for lightweight concrete)
   A_w = area of individual wire to be developed or spliced (in^2)
   s_w = spacing of wires to be developed or spliced (in)

2. Calculate the concrete density modification factor, λ, per Article 5.4.2.8. For the relatively common scenario in which specific information on splitting tensile strength is absent, this factor is simply a function of concrete density. For normal weight concrete (defined by AASHTO to be concrete with density (w_c) between 0.135 kcf and 0.155 kcf, inclusive), the value for λ is 1.0.

$$0.75 \leq \lambda = 7.5 \times w_c \leq 1.0$$

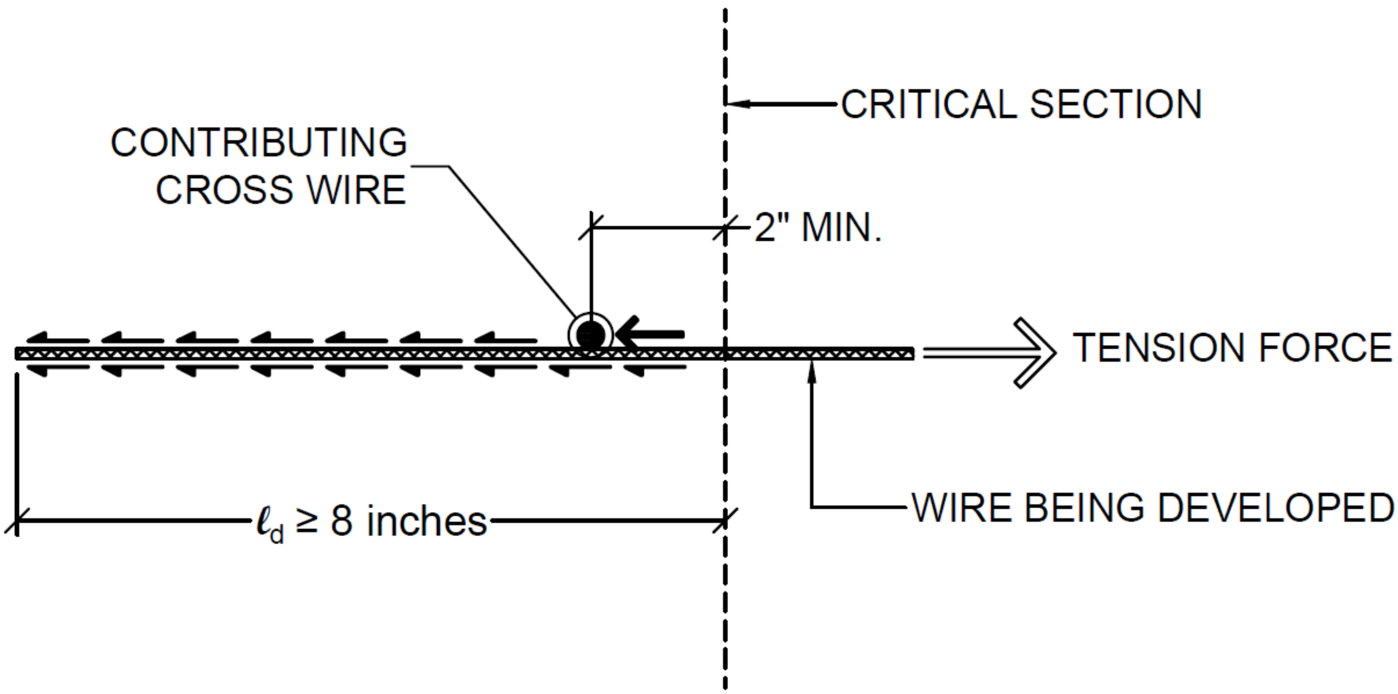
3. Calculate the excess reinforcement factor, λ_{er}, as specified in Article 5.10.8.2.1c. Per AASHTO, where anchorage or development for the full yield strength of reinforcement is not required, or where reinforcement in flexural members is in excess of that required by analysis, the excess reinforcement factor is applicable, and is calculated as a ratio of the steel area required by the design and the steel area actually provided in the design drawings. Setting this factor equal to 1.0 is acceptable, albeit potentially conservative.

$$\lambda_{er} = \frac{Required\ A_s}{Provided\ A_s}$$

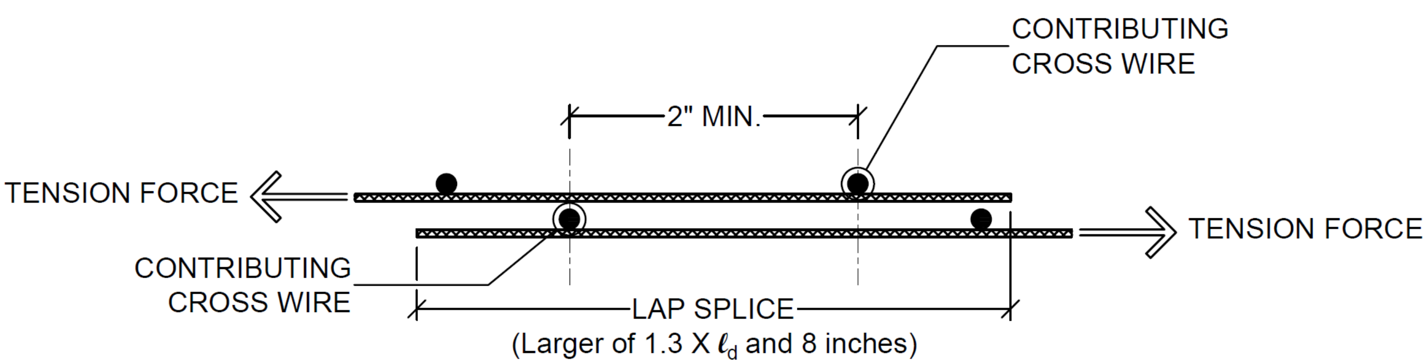
4. Establish the modified development length (l_d) per Article 5.10.8.2.5 and Equation 5.10.8.2.5-1.

$$l_d = l_{db} \times \left(\frac{\lambda_{er}}{\lambda}\right) \geq larger\ of\ values\ A\ and\ B$$

A = 8.0 inches
B = the distance that includes embedment of one cross wire located not less than 2.0 inches from the point of critical section



5. Upon calculation of the modified development length, and with contributing cross wires appropriately positioned within the splice region, calculate the tension lap splice length per AASHTO Article 5.10.8.5.1, illustratively represented in the diagram below as the larger of 1.3 x l_d and 8 inches.



Procedure 2

Based on permissions in AASHTO Articles 5.10.8.2.5 and 5.10.8.5.1 for tension development length and lap splice, respectively, the deformed surface of the wire being developed can be relied upon by itself – without any contribution from cross wires – using the procedure below.

1. Calculate the basic development length, l_{db}, per Equation 5.10.8.2.1a-2:

$$l_{db} = 2.4 \times d_b \times \frac{f_y}{\sqrt{f'_c}}$$

   d_b = wire diameter (inches)
   f_y = specified minimum yield strength of reinforcement (ksi)
   f'_c = compressiv strength of concrete (15.0 ksi maximum for normal weight concrete; 10.0 ksi maximum for lightweight concrete)

2. Calculate the concrete density modification factor, λ, per Article 5.4.2.8. For the relatively common scenario in which specific information on splitting tensile strength is absent, this factor is simply a function of concrete density. For normal weight concrete (defined by AASHTO to be concrete with density (w_c) between 0.135 kcf and 0.155 kcf, inclusive), the value for λ is 1.0.

$$0.75 \leq \lambda = 7.5 \times w_c \leq 1.0$$

3. Calculate the excess reinforcement factor, λ_{er}, as specified in Article 5.10.8.2.1c. Per AASHTO, where anchorage or development for the full yield strength of reinforcement is not required, or where reinforcement in flexural members is in excess of that required by analysis, the excess reinforcement factor is applicable, and is calculated as a ratio of the steel area required by the design and the steel area actually provided in the design drawings. Setting this factor equal to 1.0 is acceptable, albeit potentially conservative.

$$\lambda_{er} = \frac{Required\ A_s}{Provided\ A_s}$$

4. Calculate the reinforcement location factor, λ_{rl}, as specified in Article 5.10.8.2.1b. For horizontal reinforcement placed such that no more than 12.0 inches of concrete is cast below the reinforcement and f’c is not greater than 10.0 ksi, set this factor equal to 1.0. Otherwise, use values noted below.

   λ_{rl} = 1.3 for horizontal reinforcement placed such that more than 12.0 inches of fresh concrete is cast below the reinforcement

   λ_{rl} = 1.3 for horizontal reinforcement in concrete with f’c greater than 10.0 ksi, placed such that no more than 12.0 inches of fresh concrete is cast below the reinforcement

5. Calculate the coating factor, λ_{cf}, as specified in Article 5.10.8.2.1b. For uncoated reinforcement, set this factor equal to 1.0. Otherwise, use values noted below.

   λ_{cf} = 1.5 for epoxy-coated bars with cover less than $3d_b$ or with clear spacing between bars less than $6d_b$

   λ_{cf} = 1.2 for epoxy-coated bars not covered above

6. Calculate the reinforcement confinement factor, λ_{rc}, as specified in Article 5.10.8.2.1c. This factor accounts for the beneficial effects of transverse reinforcement in the tension development region, resulting in a mathematical reduction of the calculated development length. <u>If transverse reinforcement is not present, or if the designer elects to not rely on transverse reinforcement that is present, set this factor equal to 1.0</u>. Otherwise calculate the factor per below.

$$0.4 \leq \lambda_{rc} \leq 1.0$$

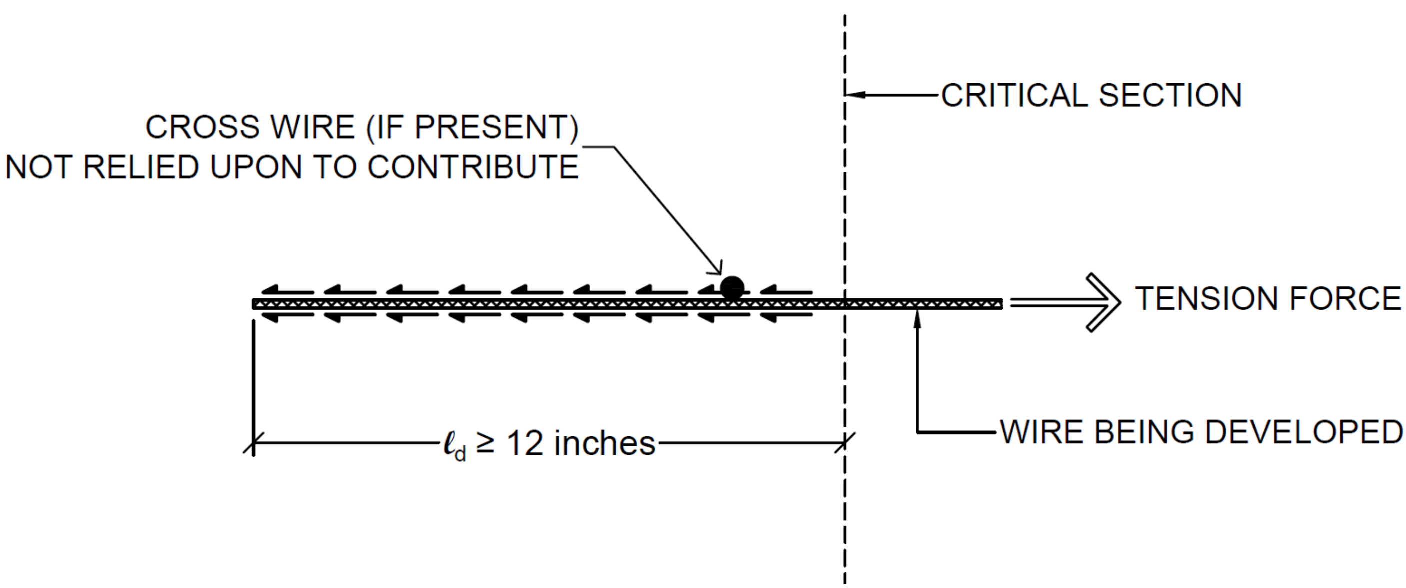
$$\lambda_{rc} = \frac{d_b}{c_b + k_{tr}}$$

$$k_{tr} = 40 \times \frac{A_{tr}}{sn}$$

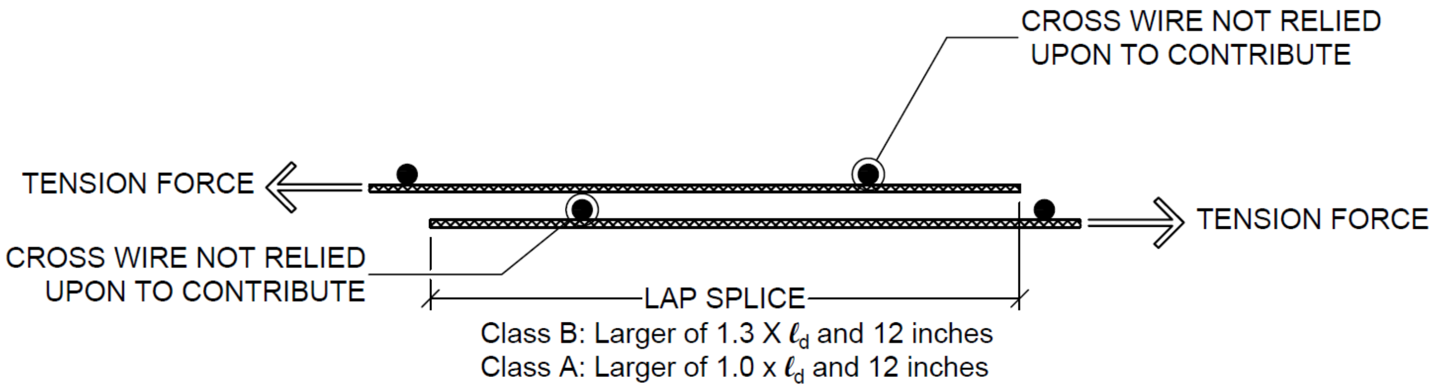
c_b = the smaller of the distance from center of wire being developed to the nearest concrete surface and one-half the center-to-center spacing of the wires being developed (inches)
k_{tr} = transverse reinforcement index
A_{tr} = total cross-sectional area of all transverse reinforcement which is within spacing s and which crosses the potential plane of splitting through the reinforcement being developed (in^2)
s = maximum center-to-center spacing of transverse reinforcement withing l_d
n = number of wires developed along plane of splitting

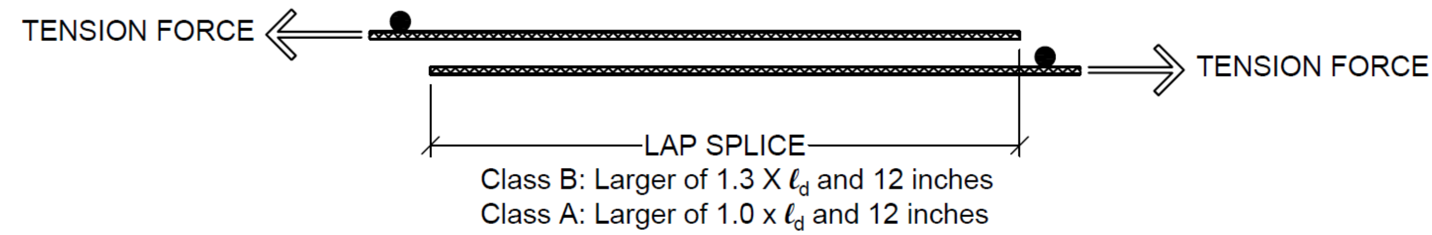
7. Establish the modified development length (l_d) per Article 5.10.8.2.1a and Equation 5.10.8.2.1a-1. Note that $\lambda_{rl} \times \lambda_{cf}$ need not be greater than 1.7.

$$l_d = l_{db} \times \frac{\lambda_{er} \times \lambda_{rl} \times \lambda_{cf} \times \lambda_{rc}}{\lambda}$$



6. Upon calculation of the modified development length, calculate the tension lap splice length per AASHTO Articles 5.10.8.5.1 and 5.10.8.4.3a, same as for deformed wire.





For more information on WWR, refer to www.wirereinforcementinstitute.org.