

Splice and Development Length of High Relative Rib Area Reinforcing Bars in Tension

Reported by TTTC Subcommittee ITG-2

Richard N. White
Chairman

David P. Gustafson

Roberto T. Leon

Jacob S. Grossman

John C. McDermott

LeRoy A. Lutz

Jack P. Moehle

S. Ali Mirza

Non-ITG-2 voting members:

This provisional standard was created to help designers take advantage of the improved bond characteristics of high relative rib area deformed reinforcement. This type of reinforcement can be produced by increasing rib height, decreasing rib spacing, or employing a combination of the two.

This provisional standard is intended to be a more efficient means of providing a development and splice length expression for the high relative rib area bars than altering the current ACI 318-95 Chapter 12 provisions to accommodate bars that are not yet in commercial production.

Keywords: bar ribs; bond; development length; high relative rib area; reinforcing bars; splice length.

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PROVISIONAL STANDARD

1.0—Notation

A_s	=	area of nonprestressed tension reinforcement, in. ²
A_{tr}	=	total cross-sectional area of all transverse reinforcement that is within the spacing s and crosses the potential plane of splitting through the reinforcement being developed, in. ²
c	=	$c_{min} + 0.5 d_b$, in.
c_b	=	cover of reinforcement being developed, measured to tension face of member, in.
c_{max}	=	maximum value of c_s or c_b , in.
c_{min}	=	minimum value of c_s or c_b , in.
c_s	=	minimum value of $c_{si} + 0.25$ in. or c_{so} , in.
c_{si}	=	one-half of average spacing between bars or splices in a single layer, in.
c_{so}	=	side cover of reinforcing bars, in.
C_R	=	relative rib factor as defined by Eq. (4.4)
d_b	=	nominal bar diameter, in.
f'_c	=	specified compressive strength of concrete, psi
$f_c^{1/4}$	=	fourth root of f'_c , expressed in psi units
f_{ct}	=	average splitting tensile strength of lightweight aggregate concrete, psi

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- f_y = yield strength of reinforcement being spliced or developed, psi
 K_{tr} = transverse reinforcement index for high relative rib area bars as defined by Eq. (4.3)
 ℓ_d = development length, in.
 ℓ_s = splice length, in.
 n = number of bars being developed or spliced along plane of splitting
 R_r = relative rib area, ratio of projected rib area normal to bar axis to product of nominal bar perimeter and average center-to-center rib spacing
 s = maximum center-to-center spacing of transverse reinforcement within ℓ_d or ℓ_s , in.
 α = reinforcement location factor; see 4.3
 β = coating factor; 4.3
 λ = lightweight aggregate concrete factor; see 4.3
 ω = factor reflecting benefit of large cover/spacing perpendicular to controlling cover/spacing as defined by Eq. (4.2)

2.0—Definition

High Relative Rib Area Bars—Deformed reinforcing bars with a relative rib area R_r equal to 0.10 or larger.

3.0—Scope

3.1—Evaluation of splice and development lengths of coated and uncoated reinforcing bars in tension having a high relative rib area, provided that:

3.1.1 The relative rib area is at least 0.10, but no larger than 0.14;

3.1.2 The ribs are at an angle of 45 to 65 deg inclusive with respect to the axis of the bar. Ribs shall not cross. Use of X-patterns and diamond patterns for ribs is not permitted;

3.1.3 The rib spacing is at least 0.44 of the nominal diameter d_b of the reinforcing bar;

3.1.4 The average rib width is less than or equal to one-third of the average rib spacing.

4.0—Development of high relative rib area reinforcing bars in tension

4.1—Development length ℓ_d in terms of diameter d_b for bars in tension shall be determined from 4.2, but ℓ_d shall not be less than 12 in.

4.2—The development length of high relative rib area reinforcing bars in tension ℓ_d divided by the bar diameter d_b shall be taken as

$$\frac{\ell_d}{d_b} = \frac{(f_y/f_c'^{1/4} - 1900\omega)\alpha\beta\lambda}{72(c\omega + K_{tr})} \quad (4.1)$$

in which the term $(c\omega + K_{tr})/d_b$ shall not be taken greater than 4.

The value of $f_c'^{1/4}$ shall not exceed 11.0.

The value of f_y shall not exceed 80 ksi.

The variable ω shall be taken as 1.0 or evaluated as

$$\omega = 0.1 \frac{c_{max}}{c_{min}} + 0.9 \leq 1.25 \quad (4.2)$$

The variable K_{tr} shall be evaluated as

$$K_{tr} = C_R(0.72d_b + 0.28) \frac{A_{tr}}{sn} \quad (4.3)$$

where

$$C_R = 44 + 330(R_r - 0.10) \quad (4.4)$$

with

$$0.10 \leq R_r \leq 0.14$$

Alternatively, it shall be permitted to take $K_{tr} = 0$.

4.3—The factors used in the expressions for development of high relative rib area bars in tension are as follows:

α = reinforcement location factor

Horizontal reinforcement so placed that more than 12 in. of fresh concrete is cast in the member below the development length

or splice 1.3

Other reinforcement. 1.0

β = coating factor

All epoxy-coated bars 1.2

Uncoated reinforcement 1.0

λ = lightweight aggregate concrete factor

When lightweight aggregate concrete is used . . 1.3

However, when f_{ct} is specified, λ shall be permitted to be taken as $6.7\sqrt{f'_c}/f_{ct}$ but not less than 1.0

When normal weight concrete is used 1.0

4.4 Excess reinforcement—Reduction in development length shall be permitted where reinforcement in a flexural member is in excess of that required by analysis except where anchorage or development for f_y is specifically required or the reinforcement is designed under provisions of 21.2.1.4 of ACI 318-95 (A_s required)/(A_s provided).

5.0—Splices of high relative rib area reinforcing bars in tension

5.1—Minimum length of lap for tension lap splices shall be as required for Class A or B splices, but not less than 12 in., where:

Class A splice 1.0 ℓ_d

Class B splice 1.3 ℓ_d

where ℓ_d is the tensile development length for the specified yield strength f_y in accordance with 4.2 without the modification factor of 4.4.

5.2—Lap splices of high relative rib deformed bars in tension shall be Class B splices except that Class A splices shall be allowed when the criteria of 5.2.1 or 5.2.2 are met.