

Guide for Lap Splice and Development Length of High Relative Rib Area Reinforcing Bars in Tension and Commentary

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Guide for Lap Splice and Development Length of High Relative Rib Area Reinforcing Bars in Tension and Commentary

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American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
U.S.A.

Phone: 248-848-3700
Fax: 248-848-3701

www.concrete.org

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Adolfo B. Matamoros
Chair

Theresa M. Ahlborn
Gyorgy L. Balazs
Robert W. Barnes
JoAnn P. Browning
Douglas B. Cleary
James V. Cox

David Darwin
Richard A. Devries
Rolf Elighausen
Anthony L. Felder
Robert J. Frosch
Bilal S. Hamad

Neil M. Hawkins
Roberto T. Leon
LeRoy A. Lutz
Denis Mitchell
Stravroula J. Pantazopoulou

Max L. Porter
Julio A. Ramirez
John F. Silva
Ahmet Koray Tureyen
Jun Zuo

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To assist the user to incorporate the information into a legal document, the relevant portion of the document is written in mandatory language. A commentary to the mandatory language portion is provided for additional information. Commentary provisions begin with an "R," such as "R1.1.1," and are shown in italics.

Keywords: bar reinforcement; bar ribs; bond; development length; high relative rib area; lap splice length.

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CHAPTER 1—INTRODUCTION

This guide is provided to help designers take advantage of higher bond strength exhibited by high relative rib area bars (Darwin and Graham 1993; Darwin et al. 1996a; Zuo and Darwin 1998) in the calculation of tension lap splice length and development length of bar reinforcement. It includes expressions for development and lap splice length applicable only for high relative rib area bars. This document has been updated to reflect improvements to the provisions of ACI 408.3-01 (ACI Committee 408 2001) proposed by Darwin et al. (2005). Because experimental data are available only to evaluate the development and lap splice lengths of straight high relative rib area bars in tension, the integrity of high relative rib area bars in compression or as hooked bars in tension should be evaluated using appropriate Chapter 12 provisions of ACI 318-08 (ACI Committee 318 2008).

To use this guide, ASTM A615/A615M for carbon-steel reinforcing bars should have the supplementary requirements imposed by the “Recommended Supplement to ASTM A615/A615M for High Relative Area Bars” that is appended to this document. With modifications to the section reference numbers, this supplement can be adapted for use with ASTM A706/A706M for low-alloy steel reinforcing bars.

CHAPTER 2—SCOPE

2.1

Evaluation of lap splice and development lengths of coated and uncoated bar reinforcement in tension shall be limited to bars having a high relative rib area, conforming to Sections 2.1.1 through 2.1.5:

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

2.1.2 The ribs shall be in accordance with (a), (b), and (c).

- (a) Ribs shall be at an angle of 45 to 65 degrees inclusive with respect to the axis of the bar;
- (b) Ribs shall not cross; and
- (c) Use of X patterns and diamond patterns for ribs is not permitted.

2.1.3 The rib spacing is at least 0.44 of the nominal diameter d_b of the bar reinforcement.

2.1.4 The average rib width is not greater than one-third of the average rib spacing.

2.1.5 The bar size does not exceed No. 11 (No. 36).

R2.1

A high relative rib area bar is defined as a bar reinforcement with R_r greater than or equal to 0.10, as conventionally deformed reinforcement has relative rib areas of 0.06 to 0.085. Based on available experimental results, the use of these provisions is limited to bar reinforcement with a maximum $R_r = 0.14$. Furthermore, consistent with the smallest spacing used in tests, the rib spacing s_r should not be less than 44% of the nominal bar diameter, as indicated in Section 2.1.3. A lower limit on width of the concrete between ribs is indirectly prescribed in Section 2.1.4 to avoid having a reduction in bond capacity due to a local shear failure of the concrete between the ribs. The variables

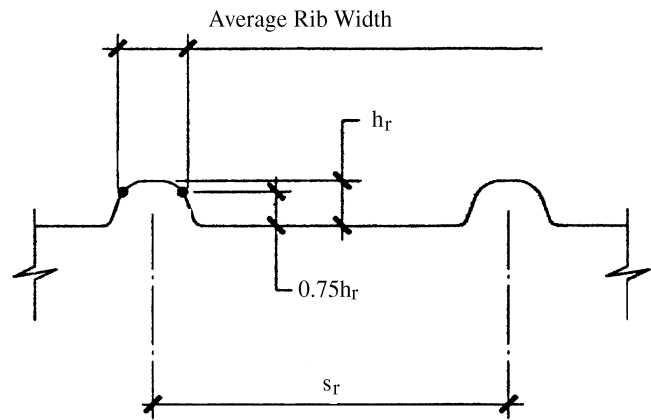


Fig. R2.1—Definition of average rib width.

in Section 2.1.4 are illustrated in Fig. R2.1. For calculating the average rib width, the width at 0.75 of the rib height, as illustrated in Fig. R2.1, was chosen in the recommended supplement to ASTM A615/A615M due to possible presence of rounded corners on the ribs. The bar reinforcements used in the experimental studies (Darwin and Graham 1993; Darwin et al. 1996a; Zuo and Darwin 1998) leading up to this guide were either machined or special rolled; both bar types had ribs with flat outer faces. The supporting research results, therefore, are based on the actual width of the outer face.

Bar with X and diamond deformation patterns are excluded from this guide because their bond properties are markedly lower than bars with parallel ribs. Earlier bond strength tests on X pattern No. 6 and 11 (No. 19 and 36) epoxy-coated bars (Treece and Jirsa 1989) gave the lowest bond strengths reported in the literature, even though the bars had relative rib areas of 0.099 and 0.110, respectively. These bond values were significantly lower than values measured for epoxy-coated bars with parallel ribs and lower relative rib areas. Also, X pattern bars are not allowed in the Canadian Code (CSA 1992) because Canadian bond pullout tests on X pattern bars gave significantly lower strengths than did parallel rib bars. In addition to the bond strength issue, a National Cooperative Highway Research Program (NCHRP) study (Helgason et al. 1976) indicated that X pattern bars have lower fatigue life than bars with other types of deformation patterns.

The bamboo pattern for ribs (ribs oriented at 90 degrees to the bar axis) are also excluded by the angle restrictions adopted in this guide because of problems associated with the bending of conventionally deformed bars with this rib orientation.

No. 11 (No. 36) bars were the largest high relative rib area bars used in the experimental program that formed the basis for these provisions. Thus, these provisions are not intended to be used for No. 14 and 18 (No. 43 and 57) bars.

2.2

The design provisions in this guide shall be used only to calculate the development length or lap splice length of high relative rib area bars in reinforced concrete members made with normalweight concrete.