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Report on Bond of Steel Reinforcing Bars Under Cyclic Loads

Reported by Joint ACI-ASCE Committee 408

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Note: The contributions of Brett Baker are gratefully acknowledged.

This report summarizes research on bond strength and behavior of steel reinforcing bars under cyclic loads. The report provides a background to bond problems, discusses the main variables affecting bond performance, and describes bond behavior under cyclic loads. Two general types of cyclic loads are addressed: high-cycle (fatigue) and low-cycle (earthquake and similar). The anchorage behaviors of straight bars, hooked bars, and lap splices are included. Analytical bond models are described, design recommendations are provided for both high- and low-cycle fatigue, and suggestions for further research are given.

Keywords: anchorage; bar slip; bond; bond models; cyclic loads; design recommendations; development length; fatigue; hooks; earthquake loads; splices.

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

The transfer of forces across the interface between concrete and steel by bond stresses is of fundamental importance to many aspects of reinforced concrete behavior. Satisfactory bond performance is an essential goal in detailing reinforcement in structural components. Many detailing provisions in ACI 318 are aimed at preventing bond failures.

Bond stresses in reinforced concrete members arise from two distinct situations. The first is anchorage or development where bars are terminated. The second is flexural bond or the change of force along a bar due to a change in bending moment along the member. Bond performance under static monotonically increasing deformations—referred to as monotonic loading—has been summarized in ACI 352R, ACI 408R, and ACI Committee 408 (1966, 1970, 1979). Bond behavior under cyclic loads received little attention until design for earthquake and wave loads became important design topics (ACI Committee 408 1979). Investigations over the past 40 years have clarified some of the important parameters influencing bond behavior under cyclic loads. However, the influence of many of these parameters is understood only qualitatively.

In this report, "bar" means "reinforcing bar" and "ribs" refer to the deformations on deformed reinforcing bars. Longitudinal deformations on reinforcing bars are not classified as ribs. "Bond stress" refers to the stresses along the bar-concrete interface. The steel stresses along the length of the reinforcing bar are modified by transfer of force between the bar and the surrounding concrete along the interface (refer to Fig. 1.1).

The change in bar tensile force ΔF between two cracked sections along a flexural member ΔF is given by

$$\Delta F = T_1 - T_2 = \left(\frac{M_1}{jd_1}\right) - \left(\frac{M_2}{jd_2}\right) \tag{1.1a}$$

The average bond stress u_b is usually expressed as

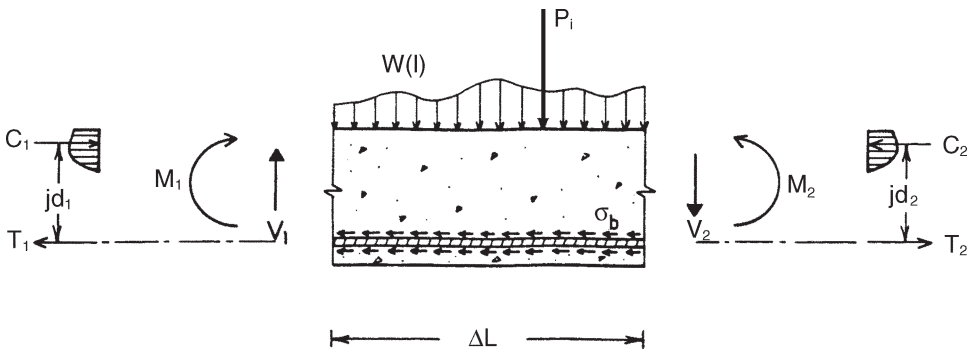

Fig. 1.1—Definition of bond stress.