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Guide to Design Detailing to Mitigate Cracking

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Recommendations made in this guide offer performance-based details that can mitigate and control concrete cracking. Structural elements are reviewed individually to identify crack causation and to offer design and detailing recommendations to mitigate crack development. In addition, standard details for various structural members within a building are offered that have been used effectively to mitigate and control crack development in concrete members.

Keywords: cast-in-place; crack mitigation; crack control; cracking; detailing; environmental structure; foundation; prestressed; reinforcement; restraint; shrinkage; slab; tensile stress; thermal effects; wall.

CONTENTS

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

This guide addresses how to reduce potential cracking in reinforced concrete buildings in the design process through judicious consideration of building layout, selection of appropriate connections and joint types, and use of good reinforcement details. Each member within a structure may be subject to different types of cracks. Once the building design is developed, the type of framing system and its geometry selected, and appropriate code-required loads considered, it is then possible for the engineer to understand and identify the possible predominate crack development, crack types, and crack locations for each member within the structure. Predicting possible crack development for members within a building typically allows application of appropriate design details to mitigate and control cracking. Effective detailing of concrete members can improve strength, serviceability (deflection and durability), and aesthetics of a concrete structure.

The terms "crack mitigation" and "crack control" as used in this document have distinct meanings. Crack mitigation involves measures that are intended to prevent cracking from occurring. This includes concepts intended to minimize or eliminate restraint, such as consideration of building layout, the use of connection or element releases, or both. Crack control involves measures that are intended to control where cracks occur, or to limit the width and spacing of cracks. Crack control approaches include the use of joints and reinforcement detailing. The term "design details" in this document is a broad term intended to include all design measures intended to mitigate and control cracking.

Some of the crack mitigation and control measures described in this document involve reinforcement details and other requirements that may already be required by the Building Code for structural reasons. Other measures recommended in this document may require details and reinforcement amounts in excess of that required by ACI 315.

1.2—Objective

The *ACI Detailing Manual* (ACI Committee 315 2004) provides standard reinforcement details to aid the designer in addressing concrete cracking. The *ACI Detailing Manual* shows individual details in isolation, which may be used for a particular member, joint, or cross section. In contrast, the objective of this document is to address the mitigation and control of cracking by considering the overall nature of a structure and how members may experience additional cross-sectional stresses due to the restraint caused by the structural system. The effect of the geometry and layout of the concrete framing system on the cracking of individual members or joints is discussed, and recommendations for more favorable arrangements of structural framing to minimize restraint are presented. Additionally, specific framing conditions where the cracking of a particular part of the structure is directly or indirectly affected by the neighboring elements or the overall framing system are discussed, and suggested reinforcement and release details to avoid or minimize such cracking are provided.

1.3—Scope

This document provides recommendations for design details and structural framing guidelines to mitigate, control, or distribute crack development in concrete members and structural systems. The recommendations and guidelines are presented in terms of concepts and effective practices that have been successfully implemented to mitigate and control cracking. Specific reinforcement details are presented for some situations, but not all, as the document is intended to illustrate concepts and approaches rather than to provide comprehensive details for all situations.

The reinforcement details shown in this document are for Grade 60 deformed steel reinforcing bars. Note that these reinforcement details may not be sufficient when other types of reinforcement are used, and in particular where the elastic properties (for example, fiber-reinforced polymer), bond properties, or strength of the bars are different.

This document specifically excludes the review of concrete member cracking due to unique or special materials used, concrete mixture proportions, or placing and finishing practices. The design details presented herein are limited to building structures and may not apply to special structures or nonbuilding structures. This document is limited to cast-in-place concrete frames only, not to precast concrete and masonry elements.

CHAPTER 2—NOTATION AND DEFINITIONS

2.1—Notation

S_1, S_2 = horizontal spacing of contraction joints in slabs on ground, in. (mm)
S_{Dowel} = center-to-center spacing of dowel bars used for vertical joint load transfer in slabs on ground, in. (mm)
S_{Plate} = center-to-center spacing of steel plates used for vertical joint load transfer in slabs on ground, in. (mm)
ρ = steel reinforcement ratio