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Report on Deflection of Nonprestressed Concrete Structures

Reported by ACI Committee 435

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Report on Deflection of Nonprestressed Concrete Structures

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Report on Deflection of Nonprestressed Concrete Structures

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This report presents a consolidated treatment of initial and time-dependent deflection of nonprestressed reinforced concrete members such as simple and continuous beams and one-way and two-way slab systems. It presents the current state of practice of deflection prediction as well as analytical methods for computer use in deflection estimation. Topics include material properties, deflection of reinforced concrete one-way flexural members, deflection of two-way slab systems, and reducing deflection of concrete members.

Keywords: camber; cracking; creep; curvature; deflection; modulus of rupture; moments of inertia; serviceability; shrinkage; time-dependent deflection.

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CHAPTER 1—INTRODUCTION AND SCOPE**1.1—Introduction**

Design for serviceability is central to the work of structural engineers and code-writing bodies. It is also essential to users of the designed structures. Increased use of high-strength concrete and higher-strength reinforcing bars, coupled with more detailed computer-aided designs, has resulted in lighter and more material-efficient and, thus, more flexible structural members and systems. This in turn has necessitated better prediction and control of short-term and long-term behavior of concrete structures at service loads.

This report presents a consolidated treatment of initial and time-dependent deflection of nonprestressed reinforced concrete members such as simple and continuous beams and one- and two-way slab systems. It presents current engineering practice in design for control of deformation and deflection of concrete members and includes methods presented in **ACI 318** plus selected alternative approaches suitable for computer-based use in deflection computation. Design examples are given at the end of one- and two-way framing chapters showing how to evaluate deflection and, thus, control it through adequate design for serviceability. The content of the report as well as the step-by-step examples are intended to familiarize practitioners with the current methods for estimating deflections in buildings as well as analytical methods suitable for computer-based application. The examples apply **ACI 318** requirements and a recommended alternative approach with a lower cracking moment (to account for shrinkage restraint). Methods for predicting initial and time-dependent deflections

of prestressed concrete are not addressed in this document, although prestressing can be an effective tool for controlling both short- and long-term deflections.

1.2—Scope

The principal causes of deflections taken into account in this report are those due to elastic deformation, flexural cracking, creep, shrinkage, and temperature effects. This document is composed of two introductory chapters and four main chapters that provide information on calculating and controlling deflections of members constructed using reinforced concrete. The organization of the report is:

- a) **Chapter 1—Introduction and Scope** provides background information on the document.
- b) **Chapter 2—Notation and Definitions** provides a listing of the notation used throughout the document.
- c) **Chapter 3—Material Properties** discusses material properties that affect deflections.
- d) **Chapter 4—Deflection of Reinforced Concrete One-Way Flexural Members** discusses behavior of uncracked and cracked members, and time-dependent effects. It also includes the relevant code procedures and expressions for deflection computation in reinforced concrete beams. Numerical examples are included to illustrate the standard calculation methods for simply supported and continuous concrete beams.
- e) **Chapter 5—Deflection of Two-Way Slab Systems** covers the deflection behavior of reinforced two-way slabs and plates. This chapter gives an overview of classical and other methods of deflection estimation, such as the crossing beam analogy and the finite element method for immediate deflection computation. It also discusses approaches for determining the minimum thickness requirements for two-way slabs and plates and gives a detailed computational example for evaluating the long-term deflection of a two-way reinforced concrete slab. The chapter emphasizes the uncertainties inherent in estimating deflections of two-way slab systems.
- f) **Chapter 6—Reducing Deflection of Concrete Members** gives practical and remedial guidelines for improving and controlling the deflection of reinforced concrete members, hence enhancing their overall long-term serviceability.

It should be emphasized that the magnitude of actual deflection in concrete structural members, particularly in buildings, which are the emphasis and the intent of this report, can only be estimated with limited accuracy. This is because of the large variability in the properties of the constituent materials of these members, the quality control exercised in their construction, and the construction methods used. Therefore, for practical considerations, the computed deflection values in the illustrative examples at the end of each chapter should be interpreted with this in mind.

In summary, this single document gives design engineers the key tools for estimating, and thereby controlling through design, the expected deflection in nonprestressed reinforced concrete building structures. The material presented and the design examples will help to enhance serviceability when