ACI 223R-10

Guide for the Use of Shrinkage-Compensating Concrete

Reported by ACI Committee 223

American Concrete Institute®

First Printing
December 2010

American Concrete Institute®
Advancing concrete knowledge

Guide for the Use of Shrinkage-Compensating Concrete

The technical committees responsible for ACI committee reports and standards strive to avoid ambiguities, omissions, and errors in these documents. In spite of these efforts, the users of ACI documents occasionally find information or requirements that may be subject to more than one interpretation or may be incomplete or incorrect. Users who have suggestions for the improvement of ACI documents are requested to contact ACI. Proper use of this document includes periodically checking for errata at **www.concrete.org/committees/errata.asp** for the most up-to-date revisions.

ACI committee documents are intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. Individuals who use this publication in any way assume all risk and accept total responsibility for the application and use of this information.

All information in this publication is provided “as is” without warranty of any kind, either express or implied, including but not limited to, the implied warranties of merchantability, fitness for a particular purpose or non-infringement.

ACI and its members disclaim liability for damages of any kind, including any special, indirect, incidental, or consequential damages, including without limitation, lost revenues or lost profits, which may result from the use of this publication.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations, including but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

Order information: ACI documents are available in print, by download, on CD-ROM, through electronic subscription, or reprint and may be obtained by contacting ACI.

Most ACI standards and committee reports are gathered together in the annually revised *ACI Manual of Concrete Practice* (MCP).

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

ISBN 978-0-87031-404-9

Guide for the Use of Shrinkage-Compensating Concrete

Reported by ACI Committee 223

John W. Rohrer
Chair

Karl J. Bakke
Secretary

Benoit Bissonnette, David A. Crocker, C. Rick Felder, Barry E. Foreman, Terry J. Fricks, Herbert G. Gelhardt III, Robert J. Gulyas, George C. Hoff, Jerry A. Holland, Federico Lopez Flores, Kevin A. MacDonald, Jerry Parnes, Roy H. Reiterman, Edward H. Rubin, Edward D. Russell, Henry G. Russell, Caroline M. Talbot, James I. Turici Jr., Lawrence J. Valentine

Shrinkage-compensating concrete is used in construction to minimize drying-shrinkage cracking. Its characteristics are similar to those of portland-cement concrete. The materials, proportions, placement, and curing should ensure that expansion compensates for subsequent drying shrinkage.

This guide sets forth criteria and practices to ensure the development of expansive strain in concrete. In addition to a discussion of basic principles, methods and details are given covering structural design, concrete mixture proportioning, placement, finishing, and curing.

The materials, processes, quality control measures, and inspections described in this document should be tested, monitored, or performed as applicable only by individuals holding the appropriate ACI Certifications or equivalent.

Keywords: cement, calcium; cement, expansion; concrete, shrinkage-compensating; cracking, shrinkage; mixture proportions; restraints; shrinkage, drying; slab-on-ground; structural design.

CONTENTS

ACI 223R-10 supesedes 223-98 and was adopted and published December 2010.

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

Shrinkage-compensating concrete is made with an expansive cement or expansive component system in which initial expansion, if properly restrained, offsets strains caused by drying shrinkage. Since the mid-1960s, shrinkage-compensating concrete has been used in many applications. These applications include highway and airport pavements, bridge decks (Gruner and Plain 1993; Ramey et al. 1999), hydraulic structures, wastewater treatment plants, containment structures (Valentine 1994), post-tensioned structures (Hoffman 1980; Eskildsen et al. 2009), parking structures, and slabs-on-ground (Keith et al. 1996, 2006; Bailey et al. 2001).

Shrinkage-compensating concrete is used to minimize cracking and structural movement caused by drying shrinkage in concrete. Drying shrinkage is the contraction in the concrete caused by moisture loss from drying concrete. It does not include plastic volume changes that occur before setting when surface evaporation exceeds concrete bleeding rate or length and volume changes induced by temperature, structural loads, or chemical reactions.

The amount of drying shrinkage that occurs in concrete structures depends on the constituent materials, mixture proportions, curing, drying environment, and restraint. Tensile stresses caused by restraint to drying shrinkage can occur before concrete tensile strength is fully developed. When concrete is restrained by reinforcement, subgrade friction, or other means, drying shrinkage causes tensile stresses to develop. When drying shrinkage stresses exceed the tensile strength of the concrete, it cracks. The spacing and size of cracks that develop in structures depend on the amount of shrinkage, degree of restraint, and amount of reinforcement.

Shrinkage-compensating concrete is proportioned so concrete volume increases after setting and during early-age hardening. When restrained by reinforcement, concrete expansion results in tension in reinforcement and compression in concrete. Upon drying, the shrinkage, instead of causing tensile stress that results in cracking, relieves compressive stresses caused by initial expansion of the shrinkage-compensating concrete.

1.2—Scope

Recommendations of this guide include proportioning, mixing, placing, finishing, curing, and testing. Shrinkage-compensating concrete is produced using expansive cements or expansive component systems.

There have been significant changes and advances in the use of shrinkage-compensating concrete since it was first introduced into the market but, in some areas, the original practices remain the best current practice. Although many references used in this guide are over 10 years old, they remain a valid reference to today's practice.

CHAPTER 2—NOTATION AND DEFINITIONS

2.1—Notation

c = bar diameter/2 = $d_b/2$
d_b = bar diameter
E = modulus of elasticity of the bar
f_y = stress in reinforcing bar
I = moment of inertia of bar
L = length
ℓ = total length of wall between free ends
M = moment in reinforcing bar
T = tolerance allowance
Δ = anticipated wall movement relative to footing
ε = expansion of wall

2.2—Definitions

ACI provides a comprehensive list of definitions through an online resource, "ACI Concrete Terminology," http://terminology.concrete.org. Definitions provided herein complement that resource.

concrete, shrinkage-compensating—a concrete made with an expansive cement or component system in which the expansion, if properly restrained, induces compressive stresses that approximately offset tensile stresses caused by shrinkage.

cement, expansive—a cement that, when mixed with water, produces a paste that, after setting, increases in volume to a significantly greater degree than does portland cement paste; used to compensate for volume decrease due to shrinkage or to induce tensile stress in reinforcement.

1. **cement, expansive, Type K**—a mixture of portland cement, anhydrous tetracalcium trialuminate sulfate ($C_4A_3\overline{S}$), calcium sulfate ($CaSO_4$), and lime (CaO); the $C_4A_3\overline{S}$ is a constituent of a separately burned clinker that is interground with portland cement or alternately, it may be formed simultaneously with the portland-cement clinker compounds during the burning process.
2. **cement, expansive, Type M**—interground or blended mixtures of portland cement, calcium-aluminate cement, and calcium sulfate suitably proportioned.
3. **cement, expansive, Type S**—a portland cement containing a high computed tricalcium aluminate