Curing Concrete

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Preface

Students are taught that curing concrete is important, but in practice curing is often a low priority on the construction site. This is most likely because the benefits of the cost of curing are not immediately apparent, and the consequences of poor curing may only appear later in the life of the structure.

The fundamental principle behind the curing of concrete is simple: The mixture should be kept warm and wet for several days after placement in order to achieve the properties needed. This is because cement hydration is a relatively slow process that requires sufficient water available to continue. Drying normally occurs at the surface, meaning that poor curing affects the surface by reducing resistance to the environment and abrasion; yet this is precisely the zone that is exposed to bad weather and tires.

Demands on modern concrete are increasing, while raw materials are changing and budgets are shrinking, together requiring that closer attention is needed to ensure that the best value is obtained from the cementitious materials in a mixture.

The aim of this book is to help those involved with working in concrete construction understand why curing is important, that it is indeed possible and worth the effort, and to show how it can best be carried out.

The discussion includes the fundamentals behind hydration and why curing is needed; how properties are affected; and how curing can be effectively specified, provided, and measured. The final chapter includes a review of published work evaluating curing in real-world structures.

Acknowledgments

I first have to acknowledge my mentors and colleagues who, through the years, have taught me about engineering, concrete, and balancing lab theory and site practice. These include people from the University of Cape Town, Cement and Concrete Institute South Africa, CTLGroup, PCA, CP Tech Center, and the U.S. paving construction industry. I am especially indebted to Brian Addis and Rachel Detwiler for teaching me how to write concisely and precisely. Thank them for this volume being short, sweet, and to the point.

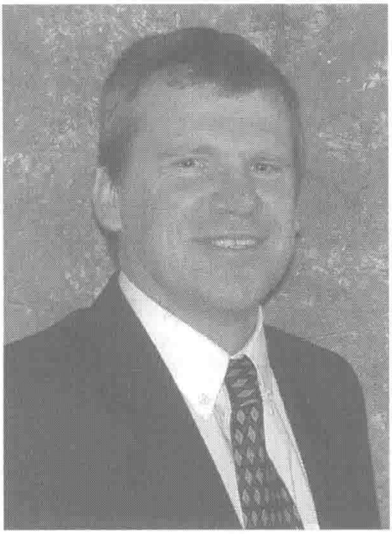
A significant amount of material came from two sources: reviews of curing practice by Kenneth W. Meeks ("Curing of High-Performance Concrete: Report of the State-of-the-Art," National Institute of Standards and Technology) and Toy S. Poole ("Curing Portland Cement Concrete Pavements, Vol. II"). Other references were obtained through the Iowa State University Library. (Life is so much easier when you can search a collection electronically from the safety and comfort of your own home. How did we do it before?)

Jim Grove and J. Z. Zhang were very responsive to my phone calls begging for photographs. More than once they jumped in their cars to go find that perfect image for me. Professor Mark Alexander spent several hours recovering an old report he had just thrown away, just so I could quote it correctly.

All of my colleagues have put up with me bouncing ideas and droning on, and in so doing helped to ensure that the following pages are worth reading and learning from.

Finally, my wife has endured many evenings of being ignored while I stared at a computer screen. Need I say more?

About the author



Peter C. Taylor was born and educated in Southern Africa, earning a BSc and PhD at the University of Cape Town. He spent 10 years with consultants in Chicago, involved in a wide range of consulting and research projects that investigated the effects of raw materials on concrete performance, both in the laboratory and in the field.

Dr. Taylor has been employed at the National Concrete Pavement Technology Center at Iowa State University since 2007. During that time he has been involved in managing and conducting research projects and programs investigating and teaching materials related to aspects of concrete pavements. His primary area of interest is in concrete durability, including the development of test methods for assessing the potential durability of concrete mixtures and the implementation of approaches to improve longevity. Dr. Taylor's responsibilities include developing technical resources, such as manuals on materials aspects of concrete mixtures. He also travels throughout the United States teaching practitioners about the latest technologies available to improve pavement reliability and sustainability.

Dr. Taylor is the author of more than 50 publications and is an active member of Transportation Research Board (TRB), ASTM International, and American Concrete Institute (ACI) committees.

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Chapter 1

Introduction

Curing is one of those activities that every civil engineer and construction worker has heard about, but in reality does not worry about much. Many publications lead with statements about how curing is critically important, yet in practice curing is often low on the list of priorities on the construction site.

The aim of this publication is to help those involved in working in concrete construction understand why curing is important, that it is indeed possible and worth the effort, and to show how it can best be carried out.

The basic need for curing of concrete is very simple. Cement hydration is a chemical process that requires the presence of water over a relatively long period of time at a reasonable range of temperatures. Curing is defined as "action taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic cement hydration and (if applicable) pozzolanic reactions to occur so that the potential properties of the mixture may develop" (American Concrete Institute 2010). In other words, curing is the work we do to encourage concrete hydration until we get the properties that we want in the mixture.

A key factor discussed is that moisture curing only affects the outer 30 to 50 mm of the surface of a concrete element. This means that moisture control is not primarily for the purpose of enhancing compressive strength of a structure. On the other hand, it is enormously influential on surface permeability and hardness, so it effectively controls the potential longevity of a system, particularly those exposed to severe environments.

Tied to this is the increasingly common use of mixtures with water–cement ratios below 0.4, which are at greater risk of self-desiccation. Although providing external water is critical to obtain the full benefits of such a mixture at the outer surface, it will not help more than about 30 mm below the surface. In this case consideration may be given to using internal curing techniques.

Another growing trend is the use of supplementary cementitious materials (SCMs), most of which tend to hydrate more slowly and for longer. A well-hydrated mixture containing SCMs will therefore generally exhibit far better potential durability in the long term, but a mixture containing SCMs