

## An ACI/ASCC Manual The Contractor's Guide to Quality Concrete Construction

4th Edition



MNL-5(19)



American Concrete Institute Always advancing



## An ACI/ASCC Manual The Contractor's Guide to Quality Concrete Construction

4th Edition

#### Reported by ACI Committee E703, Concrete Construction Practices

Jam	es J. Ernzen	William	D. Palmer
	Chair	Seci	retary
Scott M. Anderson	Reyn	old Franklin	Katherine M. Pfleger
Paul J. Beagley	Leona	rd J. Gagliardi	Thomas Roth
Aron J. Csont	Bever	ly A. Garnant	Frank Townsend
Daniel P. Dorfmueller	John	L. Hausfeld	Thomas G. Tyler
	Michael	l G. Hernandez	

Additional recognition to Anthony J. Lamanna, who edited the document, revised the photos, and provided content to match the intended audience and to Jeffrey W. Coleman for authoring Appendix A on legal issues. Their efforts are greatly appreciated.







Contractor's Guide to Quality Concrete Construction ISBN 978-1-64195-047-3 Copyright © 2018 American Concrete Institute

This document is published jointly by the American Concrete Institute (ACI) and the American Society of Concrete Contractors (ASCC). It has been reviewed in accordance with the Educational Committee Manual document review procedures of the ACI Educational Activities Committee.

ACI and ASCC reports are intended for guidance in planning, designing, executing, and inspecting construction. This document is 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. ACI and ASCC disclaim any and all responsibility for the stated principles. ACI and ASCC shall not be liable for any loss or damage arising therefrom.

Reference to this document shall not be made in contract documents. If items found in this document are desired by the Architect/Engineer to be a part of the contract documents, they shall be restated in mandatory language for incorporation by the Architect/Engineer.

Managing Editor: Michael L. Tholen, Ph.D., P.E. Art Program: Claire A. Hiltz and Aimee M. Kahaian Engineering Editor: Katie A. Amelio, P.E. Manager, Publishing Services: Barry M. Bergin Production Editors: Kelli R. Slayden, Tiesha Elam, Kaitlyn Dobberteen Page Design & Composition: Kelli R. Slayden Manufacturing: Marie Fuller

> First Printing: December 2018 Printed in Ann Arbor, Michigan.



American Concrete Institute 38800 Country Club Drive Farmington Hills, MI 48331 USA www.concrete.org +1.248.848.3700



American Society of Concrete Contractors 2025 S. Brentwood Blvd., Suite 105 St. Louis, MO 63144 USA www.ascconline.org +1.314.962.0210

On the cover: Front and back cover photos courtesy of Baker Concrete Construction Inc.

# About

### American Concrete Institute

The American Concrete Institute (ACI) is a leading authority and resource worldwide for the development and distribution of consensus-based standards and technical resources, educational programs, and certifications for individuals and organizations involved in concrete design, construction and materials. ACI has over 95 chapters, 125 student chapters, and nearly 20,000 members spanning over 120 countries.

ACI resources provide valuable information to concrete designers, contractors, and researchers, as well as students studying in various construction-related programs. Specifically for contractors, ACI publishes books that provide practical information and cutting-edge construction practices. The Institute provides free online videos, on-demand online courses, seminars, conventions, and events of interest to concrete contractors. Additionally, ACI has developed 25+ certification programs (see Appendix C for details) that provide individuals with credentials to build the best concrete structures in the world. Learn more at www.concrete.org/contractors.

### American Society of Concrete Contractors

The American Society of Concrete Contractors (ASCC) is a nonprofit organization dedicated to enhancing the capabilities of those who build with concrete, and to providing them a unified voice in the construction industry. Members include concrete contracting firms, general contractors, manufacturers, suppliers, designers, educators, and others interested in the concrete industry. There are over 730 member companies in the United States and abroad.

Concrete contracting requires you to make tough technical and business decisions. The quality of a project depends on the hundreds of decisions you and your employees make every day.

Membership in ASCC provides the tools, including publications like this one, to make informed, careful decisions. It connects you to a nationwide network of peers, professionals, and experts who will support you every step of the way. And, the credibility of a national organization, made up of the country's leading concrete contractors, elevates you and your industry to a level of recognition and respect that will facilitate your growth in the years ahead.

A Decorative Concrete Council, Concrete Polishing Council, and Safety & Risk Management Council address specific issues in these facets of the industry.

## Contents

### Chapter 1–Safety

### Chapter 3–The Concrete Specification

Specification Formats
Sources for Concrete Specifications References
Reference Specifications
Specification Categories
Acceptance Criteria
Assignment of Risk
Strength
Acceptance Testing
Early Strength Requirements
Flexural Strength
Water-Cement Ratio $(w/c)$ and Water-Cementitious
Materials Ratio (w/cm)
Minimum Cement Content
Slump
Air Entrainment
Chemical Admixtures
Delivery Time for Ready Mixed Concrete
Hot Weather Concrete
Mass Concrete Placements
Cold Weather Concrete
Flatwork Finish Acceptance Criteria
Chapter 4—Foundations
F1 0 1D1

The Ground Below
Bearing Capacity
Geotechnical Investigations
Compaction
Basic Foundation Types

Groundwater Control	48
Footing Forms	49
Moisture Control	51
Backfilling	51
Chapter 5–Formwork	54
Safety Precautions	55
Formwork Affects Concrete Quality	56
Types of Forms	57
Form Material and Hardware	64
Design of Forms	68
Placing Concrete in Forms	73
Cost of Formwork	/8
Form Removal Shaving and Discharing	81
Formwork for Slobs on Cround and Continuous Footing	02 84
Formwork for Stabs-on-Ground and Continuous Footings	04
Chapter 6–Reinforcement in Structures	88
Why Use Steel Reinforcement?	88
Engineering and Placing Drawings	90
Types of Reinforcement	91
Reinforcing Bar Fabrication	97
Storing and Handling Reinforcing Bars on the Job	99 100
Tolerances in Placing Steel D sinforcement	100
Placing of R einforcement	100
Bar Supports and Spacers	101
Splicing Reinforcing Steel	104
Coordination	105
Chapter 7–Joints and Embedments in Structures	108
Types of Joints in Structural Elements	109
Construction Joints for Supported Deams and Slabs	110
Isolation Joints for Walls	111
Construction Joints in Walls	112
Waterstops	112
Embedments	114
Anchors	117
Points to Remember	119
Chanter Q. Jointo and Doinforcoment for	
Slabs-on-Ground	120
Volume Changes	121
Contraction (Control) Joints	121
Construction Joints	124
Isolation Joints (Expansion Joints)	125
Reinforcement in a Slab	126

2 Contents -

This is a preview. Click here to purchase the full publication.

Chapter 9—Planning for Quality	
Elements of Quality Management	132
Management Responsibility	133
Quality Management System	133
The Site-Specific Quality Plan	134
Contract Review	135
Design Control	136
Document and Data Control	136
Purchasing	137
Process Control	138
Inspection and Testing	139
Control of Nonconforming Product, Corrective Action,	
and Preventive Action	140
Control of Quality Records	140
Training and Certification	140
Chapter 10—Preparing for Concreting	144
Contractor/Ready Mixed Concrete Producer	

Contractor/Ready Mixed Concrete Producer	
Cooperation	145
Preconstruction Conference	147
Jobsite Preparation	150
A Checklist for Major Projects	151

### Chapter 11–Concrete Placement and Finishing

Depositing Concrete from the Concrete Truck
Buggying Concrete
Belt Conveyors
Bucket Placement
Pumping Concrete
Pumping Lightweight Concrete
Consolidation during Placement

132	Controlling Placement	179
132	Hot Weather Placement	179
133	Cold Weather Placement	181
133	Vibratory Screeds	182
134	Finishing a Slab-on-Ground	182
135	Floor Surface Finish Tolerances	184
136	Curing to Maintain Proper Moisture Content	186
136 137	Chapter 12—Common Field Problems— Cause and Prevention	190
138	Fresh Concrete	190
139	Hardened Concrete	196
140	Appendix A—Legal Issues	204
140	Responsibility for the Concrete Mixture	204
140	Concrete Defects	205
	Cracking of Concrete	206
144	Standard of Care	209
4.45	Substantial Performance	209
145	Delivery Tickets and Acceptance	210
14/	Spearin Doctrine	210
150	Unforeseen Conditions	210
151	Inspection/Observation/Supervision	211
174	Dispute Resolution	211
174	Personal Injury	212
175		
175	Appendix B-ASCC Position Statements	214
176	Appendix C—ACI Certification Programs	258
176	Testing Programs	258
177	Inspection Programs	259
178	Construction/Specialist Programs	260

# Chapter 1 Safety



(Photo courtesy of Baker Concrete Construction Inc.)

While there are many things important to concrete construction, such as quality work and making a profit, safety must always be the number-one priority. For that reason, safety is in the front of this book to emphasize its importance to a successful project.

onstruction can be a hazardous business. The hazards can be greatly reduced or eliminated when a culture of accountability for safety is reinforced with proper safety planning, training, hazard inspections, and rule enforcement. A well-planned and implemented safety program is required to make everyone at a jobsite aware of hazards and to help mitigate them. Concrete construction involves teamwork. You must consider your safety and the safety of others as you work. Safety is not about numbers and statistics—it's about the care and concern that we share for one another.

The new employee is the most vulnerable person in construction. New employees are exposed to more unknowns than those familiar with the project. Safety training for new employees will produce safer and more efficient crews. New employees see more unknowns and risk than experienced project workers. While new employees are at risk, experienced workers are not immune from injuries. While proper training and compliance with worker protection programs is critical to protecting workers, co-worker awareness and avoiding complacency is equally important. Many companies have implemented a behavior-based safety approach that provides focus on coworkers' mindsets and behaviors, regardless of the worker's level of experience.

Creating, implementing, following, and improving a safety plan often prevents injuries. Failure at any point exposes workers to hazards. Failure to follow a site-specific safety plan and use personal protective equipment (PPE) can lead to injuries. Injuries can be costly to both the injured employee and the company, and may lead to a long-term or permanent reduction in a person's physical abilities.

In addition to concern for the injured person, the company will lose that person's skills and face a potential drop in the performance of the work during the time that worker is off the job. Accidents disrupt the flow of work, causing further impact to the project. Insurance costs increase, making it difficult to maintain project budgets. Unsafe practices expose all project stakeholders to injury, financial loss, and a less-than-desirable public perception.

### MOST ACCIDENTS ARE NOT ACCIDENTS

Accidents are preventable. Accidents are often due to not following a plan or not thinking through what you are doing. You MUST plan for safety.

How many times have you used an overloaded or damaged forklift or other faulty equipment as the result of your desire to quickly complete a task? How many times have you not stopped to sand a slippery working surface, or lifted with your back instead of your legs when you're tired?

Time spent for safety training is a basic cost of the construction business that pays off in increased production, lower insurance rates, and less lost time of skilled craftsmen. The full cost of accidents will far exceed the cost of a good safety program. Safety can be a profit center in both human and financial terms.

### THE NEED FOR A COMPANY SAFETY PROGRAM

This chapter is not a safety manual for concrete construction. The American Society of Concrete Contractors (ASCC) has published the *ASCC Safety Manual* that everyone working in concrete construction should read and periodically revisit. You should also be familiar with the regulations of appropriate governmental agencies, especially those of the Occupational Safety and Health Administration (OSHA).

Every concrete construction project is unique. Casting a slab-on-ground is quite different from casting the 40th floor of a high-rise office building. Each has dangers that can be avoided if you are aware of those dangers. That is why, in addition to the *ASCC Safety Manual*, every contracting firm must develop a written safety policy that sets clear lines of authority for training new personnel and retraining long-term personnel in safety regulations and procedures related to their construction specialty. Designers are generally not responsible for safety measures during construction.

Every company is responsible and accountable for providing safe working conditions, and every person is responsible for following the safety rules of their company and making safety a part of their job. Helping new employees adjust to the specific dangers of the jobsite through training and mentoring are components of a successful safety program.

### **CONCRETE CONSTRUCTION HAZARDS**

The following list of things to watch for on a concrete construction jobsite is not intended to be comprehensive. This list does, however, serve to alert you to some of the more common safety concerns:

- Fresh concrete can cause eye injuries and skin burns. When working with fresh concrete, wear protective clothing (long-sleeved shirt, rubber boots, and rubber gloves) and proper eye protection to avoid getting fresh concrete on your skin or in your eyes. If you do get fresh concrete on your skin, have safety data sheets (SDS) on hand and wash skin as prescribed. Have eyewash solution on the job. Should concrete splash in your eye, flush the eye with clean water immediately and obtain prompt medical attention. Think ahead. Have a supply of clean water and eyewash solution available whenever concrete placement is scheduled and remember that the tool clean-off bucket is not clean water.
- Among concrete workers, the most common skin disorders are dry skin, irritant
  contact dermatitis, and cement burns. The best way to keep skin healthy is to wear
  gloves and practice good hygiene. Wash your hands two to four times a day and
  whenever you remove your gloves using pH-neutral or slightly acidic soap. Placement
  crew members should wear long-sleeved shirts and long pants, protective goggles
  or face shields, hardhats, chemical-resistant gloves, over-boots, and kneepads (and
  use kneeboards). Immediately remove clothing that has become saturated with wet
  concrete. Clothes that have become hard with dried concrete should not be re-worn.
- Keep your fingers away from the metal joints of a concrete truck chute. These are heavy! Should a finger be caught in the gap of the joint as the heavy chute is dropped from its folded, stored position, severe damage, including the loss of the finger, is possible.

- The simple use of PPE (hardhats, gloves, boots, eye protection, fall protection, respirators, and so on) can save workers from the short- and long-term effects of construction site conditions. Have PPE available and wear it! PPE should be considered the last line of defense with a preference for the use of engineering controls to avoid hazards. For tasks that require the use of PPE, make sure co-workers are trained and that they are wearing it.
- Safety glasses with side shields or goggles must be worn whenever working on a construction site. Appropriate ANSI Z87 rated eye and face protection such as safety glasses, mono-goggles, or face shields must be worn during specific tasks performed on construction sites.
- Ear plugs must be used when the noise level gets to the point where you have to raise your voice to speak to the person next to you. It doesn't take much exposure to noise to permanently damage your hearing. Long-term exposure to concrete mixers can lead to hearing damage.
- If there is a potential for inhaling air contaminated with harmful dust, silica dust, fog, fumes, mist, gas, smoke, spray, or vapor, the employer is required to either remove the hazard completely or supply and implement the use of appropriate respiratory protection. Workers required to use respiratory protection must first be medically cleared to wear respiratory protection, fit-tested by a certified tester, and then trained in the use and care of the respirator assigned to them. In addition, the employer is required by OSHA to establish and maintain a written respiratory protection program.
- Respirable (breathable) silica dust is generated by cutting, drilling, or grinding concrete. This dust can get deep into lungs, cause irreversible damage, and lead to silicosis. If you can see dust in the air, it is too much dust. Always use vacuums or wet techniques to control silica dust. If that is not possible, then properly fitted respirators are required.
- Ladders and stairways are a major source of injuries and fatalities among construction workers. Employers should ensure that employees are trained by a competent person in the nature of fall hazards; the correct procedure for erecting, maintaining, and disassembling fall protection systems; proper construction, use, placement, and care in handling stairways and ladders; and the maximum intended load-carrying capacity of ladders. Workers climbing ladders, including those on the side of concrete trucks, must maintain three points of contact at all times, and ropes must be used to hoist materials, not carried by a worker.
- Do you know how to properly set an extension ladder? The distance along the ground from the bottom of the ladder to a point beneath where the ladder is supported near its top should be approximately a quarter of the length of the ladder. If the slope is flatter than that, the ladder can easily become overloaded. If it's steeper, the ladder can fall. The ladder must be secured at both the top and bottom against movement, and supervised by a designated competent person. It should extend at least 3 ft (0.9 m) above the platform or landing.
- Scaffolding should only be erected by a person who has been trained and certified to erect scaffolding. A competent person should inspect the scaffold prior to the start of each shift for defective parts or conditions before anyone begins work on it. If the scaffold passes inspection, it should be date-tagged that it has passed inspection. If the scaffold does not pass inspection, it must be tagged "out of service" with no one allowed on it until the defects have been corrected.
- Employees exposed to a fall of 6 ft (1.8 m) or more are required to use fall protection. General industry requires fall protection at 4 ft (1.2 m); some construction sites use this smaller distance. Always attempt to design a control measure that will remove the hazard. Articulating man lifts with a restraint system and full body harness; guardrails with top rail, mid-rail, and toe board; personal fall arrest systems; horizontal lifelines; warning lines; safety nets; or controlled access zones with a safety monitor can be used. Anchor points are required to be rated to support 5000 lb (2300 kg). Employees must be trained in the fall protection method being used prior to the start of the operation.