# CCS-1(10) Concrete Craftsman Series: Slabs-on-Ground Third Edition





American Concrete Institute<sup>®</sup> Advancing concrete knowledge



American Concrete Institute<sup>®</sup> Advancing concrete knowledge

### **Concrete Craftsman Series: Slabs-on-Ground**

Copyright by the American Concrete Institute, Farmington Hills, MI. All rights reserved. This material may not be reproduced or copied, in whole or part, in any printed, mechanical, electronic, film, or other distribution and storage media, without the written consent of ACI.

The committees responsible for ACI documents 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.

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

### CCS-1(1

### **Concrete Craftsman Series:** Slabs-on-Ground

Reported by ACI Committee E703

William D. Palmer Chair

Scott Anderson Daniel P. Dorfmueller Reynold Franklin

Beverly A. Garnant Michael G. Hernandez Katherine Martin

Harry Moats William R. Nash Michael V. Pedraza William R. Phillips Thomas Roth

### PREFACE

The concrete craftsman can greatly influence the quality, durability, and appearance of the finished product. This manual from the ACI Concrete Craftsman Series presents information on concrete that should be useful to concrete craftsmen and deals mainly with construction practices relating to slabs-on-ground. This information can be used to train concrete craftsmen and is especially useful for those interested in earning credentials as ACI certified finishers.

Information in this manual is a guide to good practice but does not supersede the provisions in the plans and specifications for any project. If provisions in the plans and specifications vary from the guidance given in this manual, discuss the variances with the design professional. For more detailed information, also read ACI 302.1R, "Guide for Concrete Floor and Slab Construction," and other documents listed in the reference section of this manual. Prior editions of this manual included a considerable amount of information on concrete materials and testing. For expanded coverage of materials and testing information, the reader is referred to The Contractor's Guide to Quality Concrete Construction (ASCC-1), published jointly by the American Society of Concrete Contractors (ASCC) and ACI.

ACI Committee Reports, Guides, Manuals, and Commentaries 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. The American Concrete Institute disclaims any and all responsibility for the stated principles. The Institute 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.

This manual was first issued under the guidance of the ACI Educational Activities Committee in 1982 as the first book in the ACI Concrete Craftsman Series. A second edition was approved and issued in 1994. Since 1987, when ACI launched the Concrete Flatwork Finisher/Technician certification program, ACI has been using this document as the primary reference for that program. The certification program was designed to provide a basis for certifying concrete finishers and to improve the quality of concrete construction. As a result of program growth, more than 7500 people have become certified Concrete Flatwork Finishers/Technicians. Some major retailers now specify that contractors constructing concrete floors for their stores have certified ACI Flatwork Finishers on site performing the work.

ACI Committee 301, Specifications for Concrete, took a major step toward formally recognizing the value of using ACI-certified finishers and technicians when, in 2002, they approved language in ACI 301, "Specifications for Concrete," that states in part, "...Unless otherwise permitted, a minimum of one finisher or finishing supervisor shall be a certified ACI Flatwork Finisher/Technician or a certified Flatwork Technician as defined in ACI CP-10 or equivalent." This was the first time ACI Committee 301 had included language requiring the use of qualified flatwork finishers for concrete placement.

ARCOM, a partner of the American Institute of Architects, also includes optional language in their MASTERSPEC<sup>®</sup> Specification System requiring cast-in-place concrete installers to be certified ACI Flatwork Finishers and Technicians, and installer supervisors to also be certified ACI Flatwork Technicians.

CCS-1(10) (third edition) supersedes CCS-1(94) (second edition) and was adopted and published January 2010. Copyright © 2010, American Concrete Institute.

All rights reserved including rights of reproduction and use in any form or by any means, including the making of copies by any photo process, or by electronic or mechanical device, printed, written, or oral, or recording for sound or visual reproduc-tion or for use in any knowledge or retrieval system or device, unless permission in writing is obtained from the copyright proprietors.

### CONTENTS Chapter 1—Planning for slab-on-ground placement, p. CCS-1—3

Introduction Specification requirements Determining the size of concrete placements Ordering concrete Concrete delivery Equipment Size of placing and finishing crews Preconstruction meeting

### Chapter 2—Concrete materials, mixture proportioning, and control tests, p. CCS-1—9

Portland cements Supplementary cementitious materials Blended cements Aggregates Maximum size of aggregate Aggregate grading Harmful substances in aggregate Mixing water Admixtures Mixture proportioning Control tests

## Chapter 3—Preparation before placing concrete, p. CCS-1—19

Subgrade preparation Compaction around buried pipes and excavations Establishing grades Placement sequence Setting side forms and screed guides Vapor retarders or barriers Reinforcement for shrinkage control Bulkheads and jointing Checklist of tools and materials

## Chapter 4—Floor flatness and levelness, p. CCS-1–23

Measuring floor flatness and levelness The 10 ft (3 m) straightedge method F-number system Factors affecting floor flatness and levelness

### Chapter 5—Placing equipment, p. CCS-1—27

Placing concrete directly from truck mixers Manual or motorized buggies Crane and bucket Concrete conveyors Concrete pumps

## Chapter 6—Placing and finishing tools and equipment, p. CCS-1—33

Spreading tools Consolidating or vibrating tools Laser-guided screeds Hand screeding tools Tools for smoothing after screeding Jointing and edging tools Hand floats and trowels Power floats and trowels Power saws

### Chapter 7—Procedures for finishing slabs-onground, p. CCS-1—39

Striking off (screeding) the concrete Bull floating or darbying Highway-type straightedging Waiting period Edging and jointing Brooming Floating Troweling Machine float and trowel direction and patterns Floating-to-troweling sequence Finishing when setting time varies from load to load Floating edges Walk-behind basics Hand floating and troweling Blade tilt

### Chapter 8—Jointing, p. CCS-1—49

Isolation joints Contraction joints Construction joints Joint filling

## Chapter 9—Curing and protection of concrete, p. CCS-1—55

Importance of curing When to start curing Curing methods Effects of high temperatures on concrete Causes and prevention of plastic shrinkage cracking Effects of low temperatures on concrete

## Chapter 10—Finishing problems and possible solutions, p. CCS-1—61

Excessive or insufficient bleeding Slow setting Surface crusting Blistering Delamination Fast setting Erratic setting Sticky concrete Rained-on surfaces Random cracking Craze cracking Discoloration Dusting Curling Scaling

#### CHAPTER 1—PLANNING FOR A SLAB-ON-GROUND PLACEMENT Introduction

Specifications are written to help ensure that the contractor constructs a slab-on-ground that satisfies the owner. This manual supplements specifications by presenting basic information about slab-on-ground placing and finishing practices for commercial, industrial, and institutional projects. Most of the information can also be used to improve the quality of flatwork for residential projects. In the field, concrete placements are often referred to as concrete pours. In this manual, the preferred term *placement* will be used in place of the term *pour*.

#### **Specification requirements**

Just as project specifications may require the contractor to use certified ACI Flatwork Finishers, they also may contain much more information on the specific requirements for the slab-on-ground placements. It's important that the finisher foreman read and understand the specifications (Fig. 1.1) because they convey the owner's requirements. Typical project specifications contain requirements related to:

- Material properties;
- Concrete strength and durability;
- Mixture proportions;
- Vapor retarders or barriers;
- Reinforcement;
- Slab flatness and levelness;
- Joint spacing and depth, and timing of the joint forming (whether by grooving the fresh concrete or sawing with an early-entry or conventional saw); and
- Curing and protection.

If the specifications or drawings do not address these issues, it's best to address them at the preconstruction meeting before starting any slab-on-ground placement.

#### Determining the size of concrete placements

Slab-on-ground placements can range from very small to more than 50,000 ft<sup>2</sup> (4650 m<sup>2</sup>) in a single placement (Fig. 1.2). Refer to the sidebar for the factors to consider when determining the appropriate size of the concrete placement. The concrete delivery rate should be matched with the placing equipment capability and production capabilities of the placing and finishing crews. If a concrete producer is told to deliver 300 yd<sup>3</sup>/hour (230 m<sup>3</sup>/hour) to a job on which a crane and bucket can place only 50 yd<sup>3</sup>/hour (38 m<sup>3</sup>/hour), placement delays can cause fresh concrete properties to vary from truck to truck. Inconsistent concrete properties make the finishers' job more difficult.

Many contractors make a small first placement on every project to ensure smooth coordination between the concrete producer, the placing equipment, and the placing and finishing crews. After confirming that all activities are coordinated, placement size can be increased. Construction schedules and contractor economics typically dictate daily concrete placements of 10,000 to 20,000 ft<sup>2</sup> (900 to 1800 m<sup>2</sup>) unless a laser-guided, wheel-mounted screed is used, in which case daily placements from 30,000 to 50,000 ft<sup>2</sup> (2800 to 4600 m<sup>2</sup>) are possible.

#### ACI 301-05

### Specifications for Structural Concrete

Reported by ACI Committee 301

	W. Calvin McCall Chair	Colin L. Lobo Secretary	
Jon B. Ardahl	Marwan A. Daye	Clifford Gordon <sup>†</sup>	David K. Maxwell
Domingo J. Carreira"	Mario R. Diaz	David P. Gustafson*	Timothy L. Moore
Oleh B. Ciuk	James A. Farny*	Jerry A. Holland	Jerry Parnes
Steven R. Close*	W. Bryant Frye	Roy H. Keck"	Aimee Pergalsky
D. Gene Daniel	Richard D. Gaynor	James A. Lee	James M. Shilstone, Sr.
James E. Anderson Ramon L. Carrasquillo Paul A. Decker Dan Ellery <sup>†</sup> Alphonse E. Engelman Thymas M. Greene	Voting Subcome Gene Hightower Narendra V. Jadhav Michael L. Leming William M. Klorman Mark A. Payne Kensend B. Rear	nittee Members G. Michael Robinson Edward D. Russell Mehmet A. Samee W. Thomas Scott William C. Sherman Deurolog J. Scotol	Daniel J. Stanley Bruce A. Suprenant Robert L. Teerman Michael A. Whisonant Michelle L. Wilson Bichward M. Wine
Thomas M. Greene	Kenneth D. Rear	Douglas J. Soruyi	Kichard M. Wing
Jeffrey W. Coleman Steven H. Gebler	Consulting Gilbert J. Haddad Atilano Lamana	t <b>Members</b> Ross S. Martin Bryant Mather <sup>↑</sup>	Joseph A. McElroy Carlos Videla

Subcommittee chair. Deceased.

This specification is a Reference Specification that the Engineer or Architeccom make applicable to any constraintion project by citing it in the Projec Specifications. The Architect/Engineer supplements the provisions of thi Reference Specification as needed by designating or specifying individual project requirements.

and preservative steels; production plasming and units of control of concenter and framework during and construction. Methods for treatment of pionts and embedded items, repair of surfaces of deeps, and fluidbing of formal and sufference are specified. Segnature sciencia and devoluformal and sufference are specified. Segnature sciencian and devolution and sufference are specified. Segnature sciencians and evolution and an expension for a segnative science of the structures are included.

Keyworks admisture, aggregate, air entraimmeti, architectural concrete content; cenentitious materials; cold weather; compressive strength; concrete; concrete construction; concrete durability; concrete slab; consolididon; conveyor; curing; curiou; capool-aggregate finish; finos; formscork; grout; growing; hot weather; inspection; joint (construction, placing; prostressed concrete; prestressing used; reinforced concrete; nei; micraticolin, subprache; tentoring; shoring; and the prestressed specification; subgrade; tentopenture; test; tolerance; water-cementitions material antis; welded wire eniformetent. NOTES TO SPECIFIER This specification is incorporated by reference in the project specifications using the wording in P3 of the preface and including the information from the mandatory, optional, and submittal checklists following the specification.

#### PREFACE

P1. ACI Specification 301 is intended to be used by reference or incorporation in its entirety in the Project Specification. Do not copy individual Parts, Sections, Articles, or Paragraphs into the Project Specification, because taking them out of context may change their meaning.

P2. If Sections or Parts of ACI Specification 301 are copied into the Project Specification or any other document,

ACI 301-65 superveises ACI 301-69 and because effective April 20, 2005. Copyright 0-2005, American Concernet Institute. All rights reserved including rights of reproduction and use in any form or by any means. Instiduing line making of corpits by any photo process, or by detectionic or tion or for use in any knowledge or retrieval systems or device, unless permission in writing is obtained from the copyright proprinters.

301-1

Fig. 1.1—ACI 301, "Specifications for Structural Concrete," requires at least one finisher or finishing supervisor to be a certified ACI Flatwork Concrete Finisher/Technician or a certified ACI Flatwork Technician.

### Factors to consider when determining appropriate placement size

- Concrete delivery rate, yd<sup>3</sup>/hour (m<sup>3</sup>/hour);
- Placing equipment rate, yd<sup>3</sup>/hour (m<sup>3</sup>/hour);
- Placing crew production,  $yd^2$ /hour (m<sup>2</sup>/hour);
- Finishing crew production, ft<sup>2</sup>/hour (m<sup>2</sup>/hour);
- Availability of equipment or manpower in case of a breakdown or shortage;
- Ability to install an emergency construction joint;
- Ability to handle problems that may arise due to cold or hot weather;
- Concrete setting time;
- Experience of equipment operators and placing and finishing crew;
- Floor flatness and levelness requirements;
- Specialty surface finishes, toppings, or dry-shake hardeners required;
- · Construction schedule; and
- Economics

#### Ordering concrete

Concrete is sold by volume—in cubic yards or cubic meters—while in a freshly mixed unhardened state and as discharged from the truck mixer. The next sidebar contains



Fig. 1.2—Construction schedules and contractor economics typically require concrete placements of 10,000 to 20,000  $ft^2$  (900 to 1800  $m^2$ ) or from 30,000 to 50,000  $ft^2$  (2800 to 4600  $m^2$ ) when a laser-guided, wheel-mounted screed is used. This figure shows a 300,000  $ft^2$  (27,900  $m^2$ ) placement that was completed within 24 hours.

an example of how the volume of concrete needed for a slab placement is calculated.

In addition to the volume of concrete needed, the concrete producer needs to know who is ordering the concrete, what properties are required, where the concrete will be delivered, and when it is needed. Be prepared to provide an accurate delivery address, date and time of delivery, quantity, and mixture properties desired. The items in the following checklist should be given to the concrete producer when ordering concrete.

#### Checklist for ordering concrete

- Volume of concrete;
- Who is ordering;
- Where to deliver;
- When to deliver;
- Delivery rate; and
- Mixture properties:
  - ° Strength;
  - <sup>o</sup> Water-cementitious material ratio;
  - ° Slump;
  - Air content; and
  - <sup>o</sup> Maximum aggregate size.

#### **Concrete delivery**

Because fresh concrete properties start to change as soon as the concrete is mixed with water, finishers should be prepared for concrete delivery. First, make sure the truck has adequate space to enter the site and reach the placement area. This may require the use of a flagger to direct traffic and keep all other traffic out of the way when the concrete truck arrives. Other construction materials can sit for hours and

### How is concrete quantity calculated?

Consider as an example a 10,000 ft<sup>2</sup> (900 m<sup>2</sup>) strip concrete placement measuring 200 ft (60 m) long x 50 ft (15 m) wide and 5 in. (125 mm) thick. First, convert all measurements (length, width, and thickness) to feet (meters) and then multiply them together. This gives the volume of concrete in ft<sup>3</sup> (m<sup>3</sup>). For the example, convert the 5 in. to feet by dividing by 12 to obtain 5/12 ft = 0.42 ft (convert 125 mm to meters by dividing by 1000 to obtain 125/1000 m = 0.125 m). Because all the other measurements are in feet (meters), multiply the length times the width times the thickness, or 200 ft × 50 ft × 0.42 ft to get 4200 ft<sup>3</sup> (60 m × 15 m × 0.125 m to get 112.5 m<sup>3</sup>). Because there are 27 ft<sup>3</sup> in 1 yd<sup>3</sup>, divide the volume in ft<sup>3</sup> by 27 to obtain the volume in yd<sup>3</sup>. For this example, 4200/27 = 155.6 yd<sup>3</sup>.

It's common to add 10% or 15% to small loads and 5% to 10% to larger orders to compensate for subgrade settlement, uneven subgrade, spillage, and waste. In this example, add 5% of the total:  $155.6 \text{ yd}^3 \times 0.05 = 7.8 \text{ yd}^3 (112.5 \text{ m}^3 \times 0.05 = 5.6 \text{ m}^3)$ . The volume of concrete to be ordered for this placement would be  $155.6 \text{ yd}^3 + 7.8 \text{ yd}^3 = 163.4 \text{ yd}^3 (112.5 \text{ m}^3 + 5.6 \text{ m}^3 = 118.1 \text{ m}^3)$ . Usually, the order is rounded up to the nearest yd<sup>3</sup> (m<sup>3</sup>), or 164 yd<sup>3</sup> (119 m<sup>3</sup>). That would require 16 trucks carrying 10 yd<sup>3</sup> loads and one partial load of 4 yd<sup>3</sup> (15 trucks carrying 7.5 m<sup>3</sup> loads and one partial load of 6.5 m<sup>3</sup>).

Some finishers mark locations on the forms where they should have placed a given volume of concrete. For this example, when the placement is halfway done, the amount of concrete used should be about 164  $yd^{3}/2 = 82 yd^{3} (119 m^{3}/2 = 59.5 m^{3})$ . For 10  $yd^{3}$  (7.5 m<sup>3</sup>) trucks, about eight truckloads should have been placed at the halfway point of the placement. If more than eight trucks have discharged when the halfway point is reached, more concrete than originally anticipated may be needed to finish the placement. The concrete supply needs should be re-evaluated during placement, and any changes should be communicated to the concrete producer.

still be useable, but delays in concrete placement can result in concrete that is hard to transport, place, and finish.

Determine whether there is enough space for two or more concrete trucks to be on site and discharging concrete without truck-to-truck delays. For concrete placements using a pump, it's best to have access so that two concrete trucks can both be in position to discharge into the pump hopper. That way, as one truck is finishing, the other truck can already be backed in and ready to unload concrete so there is a continuous flow of concrete to the pump.

Most project specifications refer to ASTM C94, "Standard Specification for Ready-Mixed Concrete" (Fig. 1.3). This specification limits how long the truck can wait before the concrete is used. The concrete must usually be completely discharged within 1-1/2 hours after water has been added to the cement and aggregates or before the drum has reached 300 revolutions, whichever comes first. The truck driver's batch ticket lists the time that the concrete was loaded, so the end of the 1-1/2-hour time period can be determined. Trucks are equipped with a revolution counter that records the number of times the drum revolves. An inspector looks at the batch ticket and the revolution counter to determine if the concrete can still be used. Workers should be prepared before concrete is delivered so they can discharge the trucks before the time limit or drum revolutions is reached.

The number of trucks arriving for each placement will vary. Plan to get the trucks onto the site for discharge, then to a washout area and away from the site as quickly as possible.

A 10  $yd^3$  (7.5  $m^3$ ) load of concrete can be completely discharged from a concrete truck in about 4 to 5 minutes, but trucks are unlikely to discharge that quickly on most jobs. Typically, it takes about 15 to 20 minutes to empty a truck, depending on whether it can discharge completely in one spot or must be moved to different areas before the mixing drum is empty. Because of the time limit on discharging concrete, limited space at most construction sites, and congestion at the point of truck discharge, most finishers prefer concrete truck arrivals to be spaced about 15 minutes apart, especially when concrete will be discharged from the chute and onto the slab base course. This usually allows enough time for the first truck to be about empty when the next truck has arrived on site. The new load of concrete can be checked or tested, and the new truck can be positioned when the preceding truck pulls away.

#### Equipment

Required equipment for each placement varies, but some general equipment is required on each job. Spare equipment, such as vibrating screeds, power trowels, or curing compound sprayers, may be needed in case of breakdowns. Materials for installing emergency bulkheads (forms for closing a section of the slab and creating a construction joint) should also be available. Emergency bulkheads may be needed if concrete delivery is interrupted or if placing equipment breaks down and can't be replaced.

The productivity of each piece of equipment varies greatly depending on the experience of the placing and finishing crews and the concrete properties. Some average production

Standar Ready-l	d Specification for Mixed Concrete <sup>1</sup>		
$ \begin{cases} V_{1,2} & \cdots & v_{2N} V_{2N} V_{2N} \\ v_{1,2} & v_{1,2} & v_{2N} & v_{2N} \\ N_{1,2} & v_{2N} & v_{2N} & v_{2N} \\ V_{2N} & v_{2N} & v_{2N} & v_{2N} \\ V_{2N} & v_{2N} & v_{2N} & v_{2N} \\ \end{array} $	$\begin{split} & (\partial_{X_{i}} \partial_{Y_{i}} - \partial_{Y_{i}} \partial_{Y_{i$	e matheration (Arabia) Ramany Heraha arise Arabia e provinsioner (Braha data arise e trajationer arise e Heraha	an den stada, giga 1965 a. je 20. gada te di San se ogga e cal
<ol> <li>Scope*         <ol> <li>Scope*                 <ol> <li>Bactured and delivered to unbardened state as here under a concorted.</li> </ol> </li> </ol></li></ol>	overs ready mixed concrete mana- a purchases in a treshly inived and matter specified. Requirements for	2. Referenced Documents 2.4. ASTM Standards (* C. S. C. U.M. Practice for 2 Specimens in the Field	daking and Curring Concrete. Tes
specified by the parch of the purchaser dif- purchaser system, and the purchaser system, and the system system and the system of control parchaser and of the solution system contournable with the outformatic with the outformatic outform outform as a country vanishing these upon prob-	Discharge of the coi completed within 1- the drum has revolv revolutions, whiche after the introduction water to the cement or the introduction of the aggregates. Internal These networks and notified and prove the introduction of the aggregates. Internal These networks and notified and the weak to the resembling to address of the address and may cause chemical burits to mged use ()	Arete shall be -1/2 h, or before ed 300 ver comes first, n of the mixing and aggregates of the cement to 	Compressive Strength of Cy. 5 to Concrete and Concrete tor Density (Unit Weight) uncitics of Concrete 1 or Shimp of Hydraubi, and Cement Firshb Mixed Concrete for An Content of Freshb metrix Mithels Content of Freshb Mixed ethical intaming Admixtures for ethical Ministrum Density of Mixetura ended Hydraubi Cemens of Hy Ash and Revier Calmens in for Chemical Admixtures for etermining Density of Mixetura ended Hydraubi Cemens of Hy Mixad Revier Calmens of Hy Mixad Revier Calmens of Hy Mixad Revier Calmens and Mutars alon for Chemical Admixture
B. Specific work is confined to an effective work work in the control of work works. Appendix a set for an Reader M. in the control of our approximation of the optimation of the form of the set of the set of the control of the set of the control of the set of t	Berner and Berner ANTM Control To, COMPAN- and Collard System Development of Solution Control (1) (1999) Investigation of Solution Company on an approximation (2000) Solution of Solution (2000) Approximation (2000) Solution (2000) (2000) (2000) Solution (2000) Solution (2000) (2000).	For advice a VAM or other taken WMM a new Association VAN Association advantage in the Sec	con the ANIM website wear releasely of the control we backboard Kine – ANI (b) conduct – Decented Networks paces

Fig. 1.3—Most project specifications refer to ASTM C94, "Standard Specification for Ready-Mixed Concrete."

rates to assist finishers in selecting the needed equipment (Fig. 1.4) for a placement include:

- Walk-behind power trowel: 1000 to 3000 ft<sup>2</sup> (90 to 280 m<sup>2</sup>) daily;
- Ride-on trowel: 3000 to 6000 ft<sup>2</sup> (280 to 560 m<sup>2</sup>) daily; and
- Laser-guided, wheel-mounted screed: 30,000 to 50,000 ft<sup>2</sup> (2800 to  $4600 \text{ m}^2$ ) daily.

For comparison purposes, an experienced hand-finishing crew can finish about 1000 to 2000  $ft^2$  (90 to 190 m<sup>2</sup>) of slab in a day.

### Size of placing and finishing crews

The size of each crew affects the labor cost for the placement. Although keeping placing and finishing crew size to a minimum reduces labor costs, it might not provide enough labor to handle some possible job-site contingencies, such as:

- Workers who call in sick or are injured during the placement;
- Concrete that sets faster than expected due to weather changes;
- Inconsistent fresh concrete properties that delay finishing;
- Equipment breakdowns; and
- The need for early sawing to prevent cracking on windy days.

Overlapping placing and finishing crews provides some flexibility. If the finishing crew needs more help, some