



American Concrete Institute®
Advancing concrete knowledge

ACI Style Manual – 2007

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PREFACE

The *2007 ACI Style Manual* is a reference to promote concise, unambiguous, well-written ACI technical documents. The rules outlined herein are specific to ACI technical documents. ACI codes and specifications have some additional requirements that are not covered in this manual.

Uniformity of expression throughout all ACI technical documents lends an important credibility and professionalism to the published works. The style and grammar rules in this manual have been approved by the ACI Technical Activities Committee (TAC) as acceptable for ACI technical documents. TAC is receptive to style suggestions. Each time this manual is revised, all suggestions received will be considered and incorporated if found appropriate.

The *ACI Style Manual* is a companion document to the *ACI Technical Committee Manual (TCM)*. Technical committee documents are developed following the procedures given in the *TCM*, which includes descriptions of the various kinds of documents developed by ACI technical committees.

When developing a technical committee document, the committee should refer to both the *TCM* and this style manual. The style of a technical committee document should conform to the guidelines given in the remaining chapters and appendices of this manual.

For any questions or issues that are not addressed in this manual, refer to these references:

- *Chicago Manual of Style*
- *Merriam-Webster Collegiate Dictionary*
- *ACI Technical Committee Manual*
- *ACI Cement and Concrete Terminology (CCT)* (online only)
- *ACI Specification Manual*

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CHAPTER 1—ACI STYLE

ACI committees are requested to follow ACI style as they prepare documents for submission to TAC.

1.1—Document structure

All technical committee documents should follow the same basic structure. The following is an outline of the parts of a committee document and a brief description of each. For additional requirements that apply to specifications, refer to the *ACI Specification Manual*.

1.1.1 Document number—In general, the document number is a variation of the committee number. Nonmandatory-language documents, such as guides and reports, have an “R” after the numerical designation. Staff assigns all document numbers. When submitting a new document, committees should simply list the document number as “(committee number).XR.” If revising an existing document, list the existing number.

1.1.2 Title—The title of the document should appear prominently on the first page of the draft document. The title of the document should indicate the nature of the document (code, specification, guide, report) and the subject matter.

Example:

“Guide for Selecting Proportions for No-Slump Concrete”

1.1.3 Roster—The committee roster, including the chair and secretary, should appear directly under the title of the document. The roster of the committee’s voting membership at the opening of the last letter ballot issued that contains new items on the document before submission to TAC will appear on the document, regardless of when the document is published. Only voting members are listed in the roster. If a committee is seeking reapproval of a document, the originating committee roster is retained, and the roster of the current committee is not shown.

1.1.3.1 Acknowledgement of contributions—The chair has the following options for acknowledging the contributions of individual committee members:

1. Subcommittee that prepared the document; and
2. Other individuals who contributed to the document and should receive recognition.

In all cases, an appropriate note should be placed immediately below the roster. The acknowledgements should not list specific contributions.

1.1.4 Synopsis—A one- or two-paragraph synopsis must be submitted with the document. The synopsis should state the document’s scope and purpose, and should inform and spark interest without going into too much detail. Each synopsis is printed in *Concrete International*, and should therefore make sense when read independently of the document.

1.1.5 Keywords—Keywords contain items discussed in the document and aid users in retrieving material. The title, synopsis, and table of contents of the document are good sources for keywords. Approximately three to 10 keywords should be listed. The keywords should reflect the subject

matter of the document without being too general. For example, listing “concrete” or “water-cement ratio” should be avoided. List keywords in alphabetical order and separate them with semicolons. A comma is only used in instances where the online *CCT* places the primary word before the descriptive word (for example, “high-strength concrete” becomes “concrete, high-strength”). Do not use multiple forms of the same word as keywords.

Example:

Keywords: bar, coated; concrete, high-strength; polymer; shrinkage.

1.1.6 Table of contents—Documents are required to have a table of contents that lists primary and secondary headings in all chapters. The table of contents should be proofread against the chapter and section headings of the final draft for accuracy. Headings are often revised from one draft to another, and the table of contents must be updated accordingly (see Section 1.2.2 for numbering convention). Do not include page numbers in the table of contents; page numbers are assigned by staff after final formatting of the document.

1.1.7 Body text—Chapter 1, commonly titled “Introduction” or “Introduction and Scope,” should always be followed by Chapter 2, commonly titled “Notation and Definitions.” Refer to the online *CCT* for more information on definitions. The organization of the rest of the body text is up to the committee (except for specifications). Maintain a logical flow, keeping like ideas and related information centralized, so a reader does not have to flip to other sections to clarify information presented. Use references within the document as needed rather than repeat information. Repeated information could indicate that the organization is poor and that sections need to be rearranged.

Chapters 1 and 2 are commonly organized as follows:

Chapter 1—Introduction and Scope

- 1.1—Introduction
- 1.2—Scope

Chapter 2—Notation and Definitions

- 2.1—Notation
- 2.2—Definitions (see Section 3.2 for guidance on creating definitions)
- 2.3—Acronyms (if applicable)

1.1.8 Reference chapter—Reports, guides, and commentaries should include reference citations and a reference chapter. See Chapter 2 for reference guidelines.

1.1.9 Appendices—Some documents use appendices to present alternative requirements for unusual circumstances, long derivations, research data, or sample calculations. Use a separate appendix for each main purpose, lettered consecutively (Appendix A, Appendix B...). Appendices, if included, should follow the reference chapter. Appendices should also be listed in the table of contents. References that appear in an appendix should follow ACI style (see Chapter 2), and should be included in the document’s reference chapter.

1.1.10 Figures and tables—Figures and tables should be transmitted in a separate file or placed at the end of the draft document. Including figures within the text results in files that are difficult for staff to format and edit; all figures and tables will be placed in their proper position by ACI staff before publication. All submitted figures should have high contrast and be easy to read.

The following guidelines should be adhered to when submitting graphics for documents.

For electronic photos:

- **.eps, .tif, .jpg**, or high-resolution **.pdf** files are the preferred formats. **.bmp** or **.gif** files should not be used;
- Photos should be submitted at a minimum of **300 dpi**, and need to be at least **3.33 in. wide**; and
- Photos and shaded figures should be submitted in **color**.

For drawings and line art:

- **.eps, .tif, .jpg**, or **.pdf** files are acceptable. **.bmp** or **.gif** files should not be used;
- Drawings and line art should be submitted at a minimum of **600 dpi**, and should be at least **3.33 in. wide**;
- Drawings and line art should be submitted in **grayscale**.
- Avoid using fill patterns in figures, as they do not reproduce well;
- Use sans-serif fonts, such as Arial or Helvetica, for labels in drawings and graphs; and
- Avoid using fine lines and small lettering that can become illegible when the figure is reduced for publication.

For printed photographs:

- Original high-contrast photographs result in the highest quality printed image; and
- If photographs cannot be reproduced with suitable quality and contrast, staff will eliminate the image and revise the text accordingly.

When retrieving artwork from a previous version of the document or from another committee document, indicate in the submittal cover letter where each figure exists. Also indicate both the original number and new number.

Refer to Section 1.2.2 for figure and table numbering conventions. All figures and tables should have a caption or title. Figure captions are placed below the figure; table titles are placed above the table.

1.1.10.1 Using footnotes in tables—Footnotes at the bottom of tables are often used to provide additional information about the data. The following symbols should be used in order when using table footnotes: *, †, ‡, §, ||, #, **, ††, ‡‡, §§. Refer to Table 4.5 for an example of how table footnotes are used.

1.1.11 Disclaimer/copyright information—Do not include a disclaimer or copyright information in the draft. This information is added to the document by staff before publication. ACI staff will include the latest version of the ACI disclaimers, and copyright information will be included.

1.2—Document formatting

1.2.1 Aesthetics

1.2.1.1 Staff responsibility: final format—Final formatting is done by staff before publication. Therefore, it is unnecessary for a committee to make the document “look like” an ACI document. The amount of staff effort required to prepare the document for publication can be greatly reduced, however, if the committee adopts the following format when the draft is prepared.

1.2.1.2 Committee responsibility: working format

- ACI requests that documents be submitted in MS Word;
- Documents should be one column, double-spaced, with 1 in. (25 mm) margins on all sides;
- Documents should have both line and page numbering;
- A 12-point font, preferably Times New Roman, should be used;
- In-text styling, such as bold (for chapter titles), italic (for variables and subsection titles), and super/subscript, is welcome;
- Use of “table” features for constructing tables is recommended;
- Spaces or tabs should not be used to center or format text—use center justification instead;
- Use of automatic features that involve layout (such as headers and footers, columns, automatic footnote, endnotes, and comment features) should be avoided;
- Automatic hyphenation should not be used; and
- If needed, the equation editor should be used to insert equations (see 1.6.6 for equation guidelines).

The format should be consistent throughout the document. Make headings of equal level the same font. An example of suggested formatting for chapter and section headings for a report or guide is:

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

Begin text here.

1.2—Scope

1.2.2 Numbering section headings, tables, figures, and equations—Chapters and sections should have titles. Subsections may or may not be titled, but should be numbered consecutively following the decimal designation system:

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

1.1.1 1st subsection of 1.1—

1.1.2 2nd subsection of 1.1—

1.1.2.1 1st subsection of 1.1.2—

The number of subsections should be not exceed five decimal places (for example, 1.2.3.4.5).

Use “Fig.,” “Table,” or “Eq.” when referring to a specific figure, table, or equation, respectively, and give numerical designations beginning in each chapter. For example, Fig. 3.11 is the eleventh figure in Chapter 3, Table 4.2 is the second table in Chapter 4, and Eq. (2-2) is the second equation in

Chapter 2 (note that equation numbers are separated by a hyphen instead of a period.) “Figure” and “Equation” should be written out when used to begin a sentence.

1.2.3 Indicating revisions—Chairs should contact staff for an electronic version of the existing document and work from that version.

Revisions made to an existing document must be indicated. The preferred method of showing minor revisions is to indicate added text with underlining and deleted text with ~~strikeout~~. The revised file returned to ACI must reflect all changes to the original file. MS Word’s “track changes” feature shows all changes automatically.

The preferred method of showing major revisions is to submit a clean copy of the revised document with a statement that explains why the rewrite was necessary and summarizes the major differences between the new and existing text. Using strikeout and underline is not necessary in this case.

1.3—Consistency

Consistency of language in technical writing is of the utmost importance. Technical writing must be precise and convey a single, specific meaning. Using multiple terms when referring to a single item or idea creates confusion, and can lead to misinterpretation of information. ACI requirements for technical writing include:

- Avoid words or phrases that have more than one meaning that can be applicable to the context of the document;
- Do not use slang expressions;
- If there is any doubt that a specific phrase or term can be confused with another and it must be used in the manuscript, define the exact intended meaning at its first mention. Chapter 2, Notation and Definitions, is an ideal place to do this; and
- Use terminology and definitions from the online *CCT* unless there is a technical reason for using a different term. See Chapter 3 for a list of terms that should be avoided in ACI documents.

1.4—Language

1.4.1 Mandatory and nonmandatory language—Mandatory language is used when providing requirements that must be followed exactly as written or referenced, as in codes or specifications. The words “shall” and “must” are mandatory terms. Imperative sentences are also recommended in mandatory-language documents. (See examples in Section 1.4.2.1.)

Reports and guides should use nonmandatory language, and not contain mandatory language. Words such as “can,” “may,” or “should” are appropriate for use in nonmandatory-language documents.

1.4.2 Clarity of expression

1.4.2.1 Hedging—ACI technical document language should not hedge or convey uncertainty, as this causes the document to lose credibility to the reader. Avoid beginning sentences with phrases such as “It is recommended that...,” “Committee 999 recommends that...,” or “It is suggested

that...” It is understood that the document presents recommendations of the committee.

Example:

Avoid: It is recommended that measurements be taken in advance.

Better (for nonmandatory-language documents): Measurements should be taken in advance.

Better (for mandatory-language documents): Measurements shall be taken in advance.

Best (imperative statement for mandatory-language documents): Take measurements in advance.

When using phrases such as “It has been observed that...” or “Research has shown that...,” the reader wonders, “Who observed? What research?” In these instances, identify the source or cite a reference.

Example:

Avoid: Research has shown that pumping is an effective placing method.

Use: Pumping is an effective placing method (Banchero and Cormier 2007).

1.4.2.2 Relative language—When possible, avoid using adjectives and adverbs that convey an undefined quantity. Words such as “very,” “excessive,” “slightly,” or “significant” are not useful in technical writing.

Example:

Avoid: Allow for slight expansion.

Use: Allow for expansion between 0.2 and 0.5 in. (5 and 13 mm).

Avoid: This can increase slump significantly.

Use: This can increase slump by 20%.

1.4.2.3 Active versus passive voice—When possible, write in the active voice. This means that the subject of the sentence performs the verb of the sentence, which makes for more forceful and direct writing.

Example:

Active: This manual provides helpful hints for writing technical papers.

Passive: Helpful hints for writing technical papers are provided in this manual.

(Note: The passive voice usually employs a form of the verb “to be.” When using the passive voice, the subject of the sentence receives the action of the verb.)

Both of the example sentences are grammatically correct, but the active voice is more direct. Technical writing should be easy to understand and succinct. The active voice is usually the best choice for technical writing.

1.4.2.4 Run-on sentences—In addition to writing in the active voice, avoid long sentences that attempt to convey several ideas. Run-on sentences are easily misinterpreted, and can skew the ideas being presented.

Example:

Avoid: This report outlines procedures for concrete evaluation and may also be useful for general evaluation of concrete structures and is intended to be used as a guide to assist the person(s) responsible for the evaluation.

Use: This report outlines procedures for concrete evaluation. It may also be useful for general evaluation of concrete structures. It is intended to be used as a guide to assist the person(s) responsible for the evaluation.

1.4.2.5 Referencing sections within the same document—

Avoid using constructions such as “the following” and “the above.” If it is necessary to refer to specific information in another part of the document, referencing a section number is more useful to the reader than a generalization like “as discussed above.”

Example:

Avoid: The above discussion addresses this problem.

Use: Section 8.1.3 addresses this problem.

Avoid: These situations are given in the following list.

Use: These situations are:

1.4.3 Spelling—Always run a spell-check program. ACI style uses U.S. English rather than British English spelling. Examples: “mold” not “mould” and “behavior” not “behaviour.”

1.4.4 Numbers—Within the body of text, always spell out numbers less than 10 unless accompanied by units of measurement or a decimal place. Use numerals for numbers 10 and higher.

Example:

Use numerals: “3 in. (76 mm)” and “5 hours.”

Use numerals: The average family has 2.3 children.

Use words: “eight construction projects” and “repeat three times.”

Use commas to separate numbers greater than 9999.

Example:

Correct: “A compressive strength of 12,500 psi...”

Correct: “The pavement was loaded more than 1000 times.”

Numerals should not be used to begin a sentence. When a sentence cannot be restructured to move the numeral elsewhere in the sentence, spell out the number.

Example:

Correct: Fourteen inches (355 mm) is sufficient length.

(Note that “inches” is also spelled out in this case. See Chapter 4 for information on units of measurement.)

1.4.5 Abbreviations and acronyms—When using abbreviations or acronyms in the body of the document, define the term at its first mention in the body of the document, and

then consistently use the abbreviation or acronym from that point forward.

Example:

A high-range water-reducing admixture (HRWRA) can be used in this structure. The HRWRA will increase flowability...

Be consistent with the use of capitalization or periods in abbreviations and acronyms throughout the document. See Section 4.2 for abbreviations of units of measurement.

1.4.6 Gender-specific language—Avoid using gender-specific terms, such as “he,” “she,” or “man,” when possible. Such terms can often be replaced by “operator” or “person.”

Example:

Avoid: Cleanup for this project is a three-man job.

Use: Cleanup for this project is a three-person job.

1.4.7 Time-sensitive wording—Avoid words and phrases that will become obsolete within a few years, such as, “at the present time,” “currently,” “recently,” or “presently.” A specific time/time frame should be used instead.

Example:

Avoid: At the present time, durability testing is not required.

Use: In the early 2000s, durability testing was not required.

1.5—Lists

Technical documents often contain lists. Whether discussing procedures, materials, characteristics, or precautions, pulling text out from the body of the document and presenting it in a list is sometimes the most direct way of conveying a significant amount of information in a little space.

1.5.1 List phraseology—When listing items, the phrases should always be structured the same way.

Example:

A job supervisor’s duties might include:

- Proportioning the mixture;
- Cleaning the forms;
- Monitoring the batch procedures; and
- Inspecting the finished product.

In this example, a complete sentence is made when you join the phrase “A job supervisor’s duties might include” with each item on the list. “A job supervisor’s duties might include proportioning the mixture.” “A job supervisor’s duties might include cleaning the forms.”

An *incorrect* list would be:

A job supervisor’s duties might include:

- Proportion the mixture;
- Forms are cleaned;
- Monitoring the batch procedures; and
- Inspection of finished product.

1.5.2 List styles—ACI technical documents follow three styles for lists, depending on the content of the list and sometimes on the text to follow. Each line of the list should end

with a semicolon and the final item of the list should end with a period.

1.5.2.1 Style 1: bulleted lists—Bullets are appropriate for a list that does not indicate a progression of activity. If it is necessary to refer back to specific items on a lengthy list later in the text, do not use bullets (see Section 1.5.2.3).

Example:

Consider these items when scheduling a project:

- Weather conditions;
- Availability of materials, equipment, and qualified personnel;
- Quality-control system development and implementation;
- Geographical conditions; and
- Number of required personnel.

1.5.2.2 Style 2: numbered lists—Numbers are appropriate for a sequenced list.

Example:

The steps necessary to fix a problem are:

1. Identify the existing problem;
2. Consider possible options;
3. Design a viable solution;
4. Make provisions for any consequences of a solution; and
5. Correct the problem.

1.5.2.3 Style 3: listing items by lowercase letters—Lower case letters are appropriate for a list that does not indicate a progression of activity and where later text refers to specific items on the list. It is simpler for a reader to refer to Item (p) on the list rather than count down to the sixteenth bulleted item of the preceding list.

Example:

The total water content of concrete is controlled by:

- (a) Maintaining proper slump;
- (b) Reducing as-mixed temperature of the concrete;
- (c) Avoiding placement delay that requires retempering water;
- (d) Increasing the maximum size of coarse aggregate, as well as using coarser sand;
- (e) Reducing sand content; and
- (g) Using a high-range water-reducing admixture.

This would be an acceptable style if followed by text such as: “Item (b) may be accomplished by...; whereas (d) and (e) require...”

1.6—Punctuation and notation

(See also Section 4.1.)

1.6.1 Capitalization

1.6.1.1 When to capitalize—Capitalize any mention of a specific figure, table, or equation (see Section 1.4.5 for details about abbreviations).

Example:

This is shown schematically in Fig. 1.2. The value can be determined using Eq. (2-3). A quick-reference list is provided in Table 4.6.

Specific types, classes, or categories are capitalized.

Example:

Type I, Type II, and Type III cements
Class C or Class F fly ash

The names of ACI certification programs should be capitalized.

Example:

ACI Flatwork Finisher Certification Program

1.6.1.2 When not to capitalize—Do not capitalize words for emphasis and do not capitalize words turned into acronyms that do not include proper nouns.

Example:

Incorrect: The use of Ordinary Portland Cement (OPC) in structures is...

Correct: The use of ordinary portland cement (OPC) in structures is...

(Note: The term “portland cement” is not capitalized.)

1.6.2 Hyphenation

1.6.2.1 When to hyphenate—Three or more compound adjectives should be punctuated with hyphens or commas. Two compound adjectives may be hyphenated if appropriate. Avoid globally inserting hyphens in such phrases, as the same phrases can also appear as nouns, in which case the hyphen is not used.

Example:

- The production of *high-strength* concrete does not always require special materials. (compound adjective)
- *Drying-shrinkage* cracks result from loss of moisture. (compound adjective)
- Adequate moisture can prevent *drying shrinkage*. (noun)

Hyphens are used between whole numbers and fractions that precede a unit abbreviation.

Example:

The bar spacing should be greater than 5-1/2 in.

Note that no hyphens are used between the number and unit of measurement.

1.6.2.2 When not to hyphenate—Do not use a hyphen after an adverb that ends in “ly.”

Example:

Correct: That was a poorly executed plan.

Most prefixes and suffixes should not be separated from a word by a hyphen. Most words beginning with “pre,” “non,”

“un,” “de,” “multi,” “co,” “re,” “post,” “over,” “under,” “micro,” and “macro” do not use a hyphen. Likewise, most words ending with “less” or “proof” do not require a hyphen.

Examples of words that should not be hyphenated:

- Nondestructive testing, pretensioning, pulloff, pullout, sawcut.

Examples of words that should be hyphenated:

- Post-tensioning, saturated surface-dry, strike-off.

OTHER EXCEPTIONS: Hyphenate prefixes that must be distinguished from existing words.

Example:

Re-cover, re-create.

1.6.3 Serial comma—The serial comma is used in ACI technical writing. Therefore, when listing three or more items that are separated by commas, a comma should precede the word “and” or “or” before the last item.

Example:

Proportion the cement, water, and aggregates in accordance with the project specifications.

1.6.4 Footnotes—Footnotes should be used to cite unpublished references (see Section 2.3.3.2). Most other information should be incorporated into the main text by either placing it in parentheses in the place where a footnote call-out would appear or by making it part of the paragraph.

1.6.5 Parentheses and brackets—When it is necessary to set off text that is already within parentheses, brackets are used. In text, brackets are used inside parentheses (see Section A.1.4).

Example:

Correct: Allow for an appropriate gap (no more than 1 in. [25 mm]).

In mathematical expressions, the reverse is true. Parentheses appear inside of brackets.

Example:

32 x [25(3.4 + Y/2)]

Parentheses around a figure, equation, or table number are not switched to brackets when used in a parenthetical expression.

Example:

“...in which case, the compressive strength is adequate (see Table 2(a)).

1.6.6 Equation variables—Variables should be defined in the notation section of Chapter 2. Each variable should be defined with units, or a reference to where an explanation can be found should be provided. See Section 1.2.2 for equation numbering.

When possible, equations should be keyed in as regular text. Complex equations should be generated using MS Word-compatible equation editors, such as Microsoft Equation Editor or Mathtype. When possible, calculations should be shown in symbolic form first so that the reader can easily identify the variables (notation) in the equation.

Example of a simple equation:

$$F = ma \quad (3-1)$$

where F = force, N; m = mass, kg; and a = acceleration, m/s^2 .

Example of a complex equation created using an equation editor:

$$bf_{a1} = xy \left(\sqrt{\frac{1}{f_c}} + rx \right) \quad (3-2)$$

Note the following style formats when keying equations:

- Variables that are letters should be italicized (for example, b_w , P_n)
- Numbers within variables are not italicized (for example, c_{w1} , r_{c1}^2)
- Variables that are not from the standard alphabet (for example, Greek letters) should not be italicized. In addition, they should be keyed in as a “Symbol” font to reduce the likelihood of being shown differently on other computers (for example, ρ , ϵ_t).

Units should be shown on measured values. For multiplication, a “x” is preferred over an “x” or “.” as the “x” can be confused with a symbol, and is sometimes difficult to see.

Example:

$$M_{eccentricity} = 500 \text{ N} \times 0.1 \text{ m} = 50 \text{ Nm}$$

CHAPTER 2—REFERENCES

2.1—Introduction

ACI has adopted styles for references in the text of a document and for the reference section listing the details for each reference. See Section 1.4.1 of this style manual and Chapter 3 of the *TCM* for an explanation of the various types of ACI documents and whether they use mandatory or nonmandatory language.

2.2—Mandatory-language documents

Mandatory-language documents may only cite other mandatory-language documents as references, and must reference a specific edition. When referencing technical documents of a standards-producing organization, such as ACI or ASTM, in the text of a document, titles are omitted and only serial designations appear.

Example:

Correct: ...as specified in ACI 301.

Correct: Follow the procedure in ASTM C 39/C 39M to measure compressive strength.

In codes and specifications, referenced standards are listed in a section within the document.

Example:

Referenced standards

Standards of ACI and ASTM referred to in this standard are listed with serial designation, including year of adoption or revision, and are part of this standard.

American Concrete Institute

301-05 Specifications for Structural Concrete

318-05 Building Code Requirements for Structural Concrete

ASTM

C 150-04 Specification for Portland Cement

C 94-04 Specification for Ready-Mixed Concrete

This list is followed by the addresses of all sponsoring organizations cited. Addresses for some commonly referenced organizations are given in Section B.3.

2.3—Nonmandatory-language documents

2.3.1 Documents of standards-producing organizations—

When referencing technical documents of a standards-producing organization, such as ACI or ASTM, in the text of a document, titles are omitted, and only serial designations appear (without a year designation).

Example:

Correct: For further details on hot-weather concreting, refer to ACI 305R.

Correct: The procedure given in ASTM C 39/C 39M to measure compressive strength should be followed.

2.3.2 Document references—Cited references are individually authored references, such as journal papers, books, or magazine articles. Individually authored references should be cited in the author-date format in the text and as an alphabetical list of references by author in the reference section. The use of superscripts in the text and a numbered list in the reference section is discouraged because it makes it cumbersome to update the references for subsequent versions of the document.

When citing publications by author-date in parentheses in the text, do not place a comma between the last author's name and the year of publication.

Use these formats in the text:

- (Smith 1998)..... one author
- (Smith and Jones 1998) two authors
- (Smith et al. 1998)three or more authors
- (Smith 1998; Jones and Johnson 1998)...separate works by different authors with a semicolon
- (Smith 1994, 1998; Jones et al. 1998)...separate works by same author with a comma
- (Smith et al. 1998a, b; Jones 1998)...if an author or group of authors has two works with the same year, designate them "a" and "b" (and so on, as necessary).

2.3.3 Reference section format—The reference section of a nonmandatory-language technical document (a commentary falls into this category as well) should have two subsections within the reference chapter: "Referenced standards and reports" and "Cited references." Each of these subsections has its own format. The reference section should be placed at the end of the document but before the appendices (if any).

2.3.3.1 Referenced standards and reports—Documents of standards-producing organizations and technical societies are listed under "Referenced standards and reports," and year designations are not listed. These references are generally updated periodically, and reference to the most recent edition of any referenced standard or report should be indicated (see the example in Section 2.3.3.2). This list is followed by the addresses of all sponsoring organizations cited. Addresses for some commonly referenced organizations are given in Section B.3.

EXCEPTION: If a reference to a specific edition of a standard or report is made for historical or other purposes that are essential to the discussion being presented, these references may be cited with their year designations in "Cited references."

Example (in text):

The strength design method appeared for the first time in ACI 318-77 (ACI Committee 318 1977).

This would appear in "Cited references" as:

ACI Committee 318, 1977, "Building Code Requirements for Reinforced Concrete (ACI 318-77)," American Concrete Institute, Farmington Hills, MI, 103 pp.

2.3.3.2 Cited references—When listing cited references, place the titles of articles inside quotation marks and the titles of books or periodicals in italics. For articles from technical journals, provide the volume (V.) and number (No.) of the journal issue, month (see Section 2.3.3.2.1), year of publication, and page numbers. When listing a cited reference with more than two authors, separate their names with semicolons.

Generally, the more information provided for a listed reference, the better. The object is to enable the reader to locate the listed reference.

Do not list unpublished (unavailable to the public) work in the reference list. If an unpublished reference is referred to in the text, use a footnote to provide all publication information available to date.

Do not list references that are not cited in the body of the text; documents should not include “Additional references” or “Suggested references.”

2.3.3.2.1 Month abbreviations for references—Use the following:

January	Jan.
February	Feb.
March	Mar.
April	Apr.
May	May
June	June
July	July
August	Aug.
September	Sept.
October	Oct.
November	Nov.
December	Dec.

2.3.3.2.2 State and province abbreviations in references—Use two-letter capitalized abbreviations. (See Appendix C for a list of state abbreviations.)

2.3.3.2.3 Website references—When possible, printed publications should be referenced. For original content available only from electronic sources, however, include as much information as possible: author, title of page, title or owner of site, URL, and date that the site was accessed.

Example:

Whitmore, D., *Installation of Embedded Galvanic Anodes*, American Concrete Institute, <http://www.concrete.org/general/RAP-1.pdf> (accessed June 10, 2007).

If there is no author, the owner of the site may be substituted for the author.

Example:

American Concrete Institute, *Concrete: A Century of Innovation*, American Concrete Institute, <http://www.concrete.org/staffreport/concrete.html> (accessed June 7, 2004).

For electronic journals, follow the same format for paper journals, and add the URL.

Example:

Suryavanshi, A. K., “Cementitious Adhesive for Ceramic Tiles,” *Concrete International*, V. 26, No. 8, 2004, http://www.concreteinternational.com/Pages/Featured_Article.ASP?ID=13347.

2.3.3.3 Sample reference chapter for a nonmandatory-language document—This example uses the author-date format for citing references in the text; therefore, it is alphabetical by first author’s last name.

CHAPTER 10—REFERENCES

10.1—Referenced standards and reports

The standards and reports listed below were the latest editions at the time this document was prepared. Because these documents are revised frequently, the reader is advised to contact the proper sponsoring group if it is desired to refer to the latest version.

American Concrete Institute

- 116R Cement and Concrete Terminology
- 305R Hot Weather Concreting

ASTM

- C 33 Specification for Concrete Aggregates
- C 150 Specification for Portland Cement

These publications may be obtained from these organizations:

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

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428
www.astm.org

10.2—Cited references

ACI Committee 212, 2004, "Chemical Admixtures for Concrete (ACI 212.3R-04)," American Concrete Institute, Farmington Hills, MI, 31 pp.

Doe, J. L., and Frost, J., 1997, "Concrete Structures," *Proceedings of the First Concrete Conference*, University Press, Boulder, CO, pp. 120-146.

Frost, J. M., 1993, "Corrosion of Metals in Concrete," Master's thesis, Michigan Technological University, Houghton, MI, 200 pp.

Kosmatka, S. H.; Kerkhoff, B.; and Panarese, W. C., 2002, *Design and Control of Concrete Mixtures*, EB001, 14th Edition, Portland Cement Association, Skokie, IL, 372 pp.

Mathur, R.; Lee, H.; and Orsolini, G., 1999, "Two-Level Design Spectrum for Highway Bridges," *Seismic Response of Concrete Bridges*, SP-187, K. Krishnan, ed., American Concrete Institute, Farmington Hills, MI, pp. 345-360.

Monfore, G. E., and Ost, B., 1964, "Corrosion of Aluminum Conduit in Concrete," *Engineering News Record*, V. 172, No. 26, June 25, pp. 6-8.

Neeley, B. D., 1988, "Evaluation of Concrete Mixtures for Use in Underwater Repairs," *Technical Report REMR CS-18*, U.S. Army Engineers Waterways Experiment Station, Vicksburg, MS, 124 pp.

Neeley, B. D., and Wickersham, J., 2002, "Repair of Red Rock Dam," *Concrete International*, V. 11, No. 10, Oct., pp. 36-39.

CHAPTER 3—ACCEPTABLE TERMINOLOGY

3.1—Terms and phrases

Certain terms and phrases should typically not be used in ACI documents. Some terms to be avoided are listed below along with their acceptable alternatives. Terms that can have more than one meaning should also be avoided.

<u>AVOID</u>	<u>USE</u>
<i>a</i> and/or <i>b</i>	<i>a</i> , <i>b</i> , or both
air-entraining agent	air-entraining admixture
chairman	chair
compared to.....	compared with
concrete block and cmu.....	concrete masonry unit
conform with	conform to
constructability.....	constructibility
control joint	contraction joint
cost (when referring to monetary cost)	price
designer/engineer or architect/engineer	these terms should not be used interchangeably throughout a document. If referring to the design engineer, do not use “the engineer” in one paragraph and “the designer” in the next. Be consistent. The term “architect/engineer” should be used when referring to the architect, engineer, architectural firm, or engineering firm issuing project drawings or specifications or administering work under contract specifications or drawings, or both (<i>CCT</i>). Reference an individual whenever possible.
e.g.	for example
epoxy (as a verb)	apply epoxy
etc.	avoid ending lists with “etc.” If the remaining items are obvious, the “etc.” is superfluous. Any item that is not obvious should be listed.
form streaking	formstreaking
form work.....	formwork
freeze/thaw	freezing and thawing
freezing and thawing durability	resistance to freezing and thawing
ground-granulated blast-furnace slag	slag cement
high performance concrete	high-performance concrete
i.e.	that is
in order to	to
in situ	in place
is dependent on.....	depends on
lateral force resisting system.....	lateral-force-resisting system
may/is permitted/should	(do not use in mandatory-language documents)
microsilica	silica fume
must/shall	(do not use in nonmandatory-language documents)
NPC	OPC (ordinary portland cement)
optimal/ideal.....	(avoid use in nonmandatory-language documents)
percent	% (use symbol)
PFA	fly ash
Portland cement.....	portland cement
pour concrete	place concrete
prior to	before
rebar.....	reinforcing bar
referred to as.....	called
registered engineer	licensed design professional
self compacting concrete.....	self-consolidating concrete
since (when not referring to time).....	as, because
slab(s)-on-grade.....	slab(s)-on-ground
superplasticizer	high-range water-reducing admixture

<u>AVOID</u>	<u>USE</u>
utilize	use
water tightness	watertightness
water cementitious ratio.....	water-cementitious material ratio
water to cementitious material ratio.....	water-cementitious material ratio
$w/(c+m)$	w/cm
water reducer.....	water-reducing admixture
water to cement ratio.....	water-cement ratio (w/c)
wet concrete or plastic concrete.....	fresh concrete
while (when not referring to time).....	whereas

3.2—Creating definitions/terminology

The online *CCT* provides acceptable concrete-related terminology and definitions. When a committee creates a new definition, the following apply:

1. Each definition shall be stated in one sentence;
2. Each definition shall consist of the term printed in bold-face, a dash, and the definition statement;
3. The definition statement shall not repeat the term and should state the class or group and identify the features unique to the term; as “**mathematics**—the science of numbers and spaces”;
4. Verbs should be stated in the infinitive rather than the participle; for example, the term to be defined should be “**abrade**”, not “**abrading**”;
5. Notes may be appended to definition statements;

6. Cross references may take the place of a definition, as “**green concrete**—see **concrete, green**.” They may also call attention to related items, as “**flint**—a variety of chert. (See also **chert**).” Where the committee has found two or more terms with the same meaning, the definition is given where the preferred term appears, the synonyms are cross referenced to the preferred term, and in many cases, the fact is stated;

7. Generally, where there are a number of terms, the last word of which is the same, the definitions are given where the terms are listed in the inverted form, as “**cement, low-heat**” rather than “**low-heat cement**,” but under the latter entry, there will be a cross-reference “see **cement, low-heat**”; and

8. The creation of definitions should be coordinated with the terminology subcommittees of ASTM Committees C-1 on Cement, and C-9 on Concrete and Concrete Aggregates.

CHAPTER 4—UNITS OF MEASUREMENT

4.1—General

4.1.1 Rules for usage of unit names and abbreviations

- A unit name is its full written name, such as kilogram or microgram. Its abbreviation is the letters used to shorten it, such as kg or μg (Section 4.2).
- When spelling out the full name of a unit, print the unit name in lower case, even those derived from a proper name, such as newton, kelvin, or pascal.
- Print unit abbreviations in upright type, nonitalic text. See IEEE/ASTM SI 10 to determine whether a symbol should be upper or lower case. In general, symbols are lower case text, unless the name is derived from a proper name, such as N, K, or Pa. Also, SI decimal prefixes greater than 10^6 are upper case: M, G, T, P, E, Z, and Y. Therefore, the abbreviation for megapascals is MPa.
- Leave a space between a numeral and an abbreviation (except for percentages)—45 kg or 37 °C, not 45kg or 37°C.
- Do not leave a space between a unit abbreviation and its decimal prefix—kg, not k g.
- Do not use a plural of unit abbreviations—45 kg, not 45 kgs.
- Use the plural of written unit names—“several kilograms.”
- Use abbreviations in conjunction with numerals (the area is 10 m²); write out names if numerals are not used, such as “area is measured in square meters.”
- Indicate the product of two or more units in abbreviated form by using a dot positioned above the line—kg·m·s⁻².
- Do not mix names and abbreviations—write N·m or newton meter, not N·meter or newton·m.
- Do not use a period after an abbreviation except when it occurs at the end of a sentence, with the exception of “in.” and “gal.” which use the period to differentiate them from the actual words “in” and “gal”.
- Use decimals, not fractions—0.75 g, not 3/4 g.

4.1.2 Percent versus percentage point—Do not confuse “percentage point” with “percent.”

Example:

Correct: An increase in volume fraction of entrained air from 4 to 5% is an increase of 1 percentage point, but also a 25% increase in the volume of air.

4.1.3 Hyphenation—See Section 1.6.2.

4.1.4 Degrees—Do not abbreviate the word “degree.” When using Fahrenheit or Celsius, the word is replaced with the ° symbol, such as 38 °C. When referring to an angle, spell out the word, such as a 90-degree angle. In the SI system, use radian (rad) for angle measurement.

Example:

Correct: Maintain a slope of 60 degrees.

Correct: The temperature of the concrete should not exceed 40 °C.

4.1.5 Mass versus weight: pounds, kilograms, and newtons—In the inch-pound system, pound (lb) is always a unit of force, unless explicitly stated otherwise. In SI, a kilogram is a unit of mass, and a newton is a unit of force. Newtons are obtained by multiplying kilograms by 9.81 m/s², which is the gravitational acceleration g (this is from force = mass \times acceleration). In the inch-pound system, g is 32.2 ft/s², and is included automatically when measuring in pounds, as it is always a force; in concrete construction measurements or calculations, it is unlikely to ever need to divide pounds by g to obtain pounds as a unit of mass (known as slug).

The SI system, however, commonly uses units of mass to express the amount of a substance or object. When converting weight from inch-pound to mass in SI, be sure to convert to the appropriate units, either kilograms or newtons. For instance, pounds of cement in a mixture would be converted to kilograms, while a dead or live load in pounds per foot would be converted to newtons per meter.

Keep in mind that the conversion multiplier from pounds to kilograms, 0.45359237, has dividing by g built in, so the result is units of mass, the kilogram. The conversion multiplier from pounds to newtons, 4.448222, leaves g in, so it is a straight conversion from units of force to units of force. (Note that $0.45359237 \cdot g = 4.448222$.)

4.1.6 Density versus unit weight—When referring to mass of a substance per unit volume, such as kg/m³, use “density” instead of “unit weight.” When referring to force per unit volume, such as lb/ft³, use “unit weight” instead of “density.”

Confusion can arise when calculating forces (horizontal or vertical) from density or unit weight. When given an inch-pound unit weight (lb/ft³), multiplying by the member depth (ft) gives a distributed load in psf directly because pounds are a unit of force. When given a density in SI units (kg/m³), you must also multiply by gravity to obtain the distributed load in kPa.

Because of terminology commonly used by the U.S. concrete industry, ACI allows the use of the terms lightweight and normalweight concrete as opposed to low-density or normal-density concrete.

4.1.7 Verb agreement—Use singular words when subjects express a total amount. When a subject represents a number of individual units, use plural verbs.

Example:

Correct: The 40 gal. of water was added to the mixture.

Correct: Many gallons of water were added to the mixture.

4.2—Unit abbreviations

Units should be abbreviated only when accompanied by a numeral. Do not add an “s” to the end of a unit abbreviation to make it plural.

4.2.1 Acceptable abbreviations for inch-pound units—Use the following:

degrees Fahrenheit = °F

foot = ft

gallon = gal. (note period)

inch = in. (note period)
 kips per square inch = ksi or kip/in.²
 ounce = oz
 pound = lb (see Section 4.1.5)
 pounds per cubic foot = lb/ft³
 pounds per square inch = psi or lb/in.²
 pounds per square foot = psf or lb/ft²
 speed = mph
 ton = (no symbol)
 yard = yd

4.2.2 Acceptable abbreviations for SI units—Use the following:

centimeter (avoid use of centimeter)
 degrees Celsius* = °C
 gram = g
 kilogram = kg
 kilopascal = kPa
 liter = L
 megagram = Mg
 megapascal = MPa
 meter = m
 millimeter = mm
 newton = N
 newton-meter = N·m
 pascal = Pa
 speed = km/h

*The SI unit of temperature is kelvin (K). Degrees Celsius is widely used and accepted, however. °C = K – 273.15.

4.2.3 Time—(Abbreviate as shown in mathematical expressions; spell out in sentences.)

hour = (no abbreviation)
 minute = min
 second = (no abbreviation)
 year = (no symbol)
 day = (no abbreviation)
 week = (no abbreviation)
 month = (no abbreviation)

For time of day, use am or pm (lowercase).

4.3—Metrication

ACI technical documents must adhere to the ACI policy on metrication given in Section 4.3.1. IEEE/ASTM SI 10 cited in the Board policy is available as a separate publication from ASTM headquarters.

4.3.1 ACI policy on metrication—The ACI Board of Direction, at their November 2006 meeting, approved the following policy on metrication:

The general policy of ACI shall be that all new and revised ACI codes and specifications shall be published in two separate versions, one using inch-pound units and one using hard-converted SI units. Exceptions to this policy will depend upon industry needs and TAC approval. All new and revised ACI standards and other publications shall use dual units. Nonarchival information, such as visual materials used at convention sessions, shall use units of measurements selected by the author. All conversions shall conform to the latest version of IEEE/ASTM SI 10, supplemented where applicable by ASTM E 621. In hard conversions, due consideration shall

be given to uniformity among Institute documents and to availability of metric products for concrete construction.

ACI Board Committees shall establish provisions to implement this policy.

TAC shall review and recommend revisions to this policy to the Board on an as-needed basis to meet the demand for metrication of ACI documents.

4.3.2 What is SI?—“Metric” is a somewhat generic term, as there are a number of different metric systems in use worldwide. For example, many countries use kgf/cm² instead of Pa for stress. The International System of Units (SI) is the metric system adopted in the United States. SI comprises seven base and two supplementary units and a large number of derived units. Prefixes are used with the base units and derived units to indicate powers of ten. Several other units that are not actually part of SI are included in ACI documents. Each of these items is discussed as follows.

4.3.2.1 Base and supplementary units—The seven base units are defined in terms of accepted standards or reproducible phenomena. The two supplementary units are dimensionless derived quantities, which have not officially been defined as base or derived units. These units are shown in Table 4.1.

4.3.2.2 Derived units—Derived units are formed by combining base units, supplementary units, and other derived units according to the algebraic relations linking the corresponding quantities. Several examples of derived units are shown in Table 4.2. Note that some of the derived units have been given special names.

4.3.2.3 Decimal prefixes—Prefixes used in SI to indicate multiples of the units are listed in Table 4.3. Note that multiples of the mass unit are formed by adding prefixes to the word “gram,” not to the base unit kilogram. Also note that prefixes are typically used to represent multiples or submultiples of 1000.

4.3.2.4 Other units—There are a number of units that are not strictly SI, but are widely used. Some of these are shown in Table 4.4.

4.4—Conversion of units

Converting from one system of units to another requires two steps: 1) multiplying or dividing by the appropriate conversion factor; and 2) rounding off to an appropriate number of significant digits.

4.4.1 Conversion factors—Table 4.5 lists conversion factors for measurements commonly used in the concrete industry.

4.4.2 Significant digits—The most difficult part of conversions is selecting the appropriate number of significant digits to use after making a conversion. Given the number of digits in the conversion factors and that conversions are usually made on a calculator, it is possible to end up with impractical converted values. In all conversions, the number of significant digits retained should be such that accuracy is neither sacrificed nor exaggerated.

For example, consider a concrete with a 6 in. slump.

$$(6 \text{ in.}) \times \left(\frac{25.4 \text{ mm}}{1 \text{ in.}} \right) = 152.4 \text{ mm}$$

Table 4.1—Base and supplementary units

Quantity	Unit	Abbreviation
Base SI units		
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Thermodynamic temperature	Kelvin	K
Amount of substance	Mole	mol
Luminous intensity	Candela	cd
Supplementary units		
Plane angle	Radian	rad
Solid angle	Steradian	sr

Table 4.2—Derived units

Quantity	Unit (name)	Abbreviation	Derivation
Area	Square meter	m ²	—
Density, mass	Kilogram per cubic meter	kg/m ³	—
Velocity	Meter per second	m/s	—
Volume	Cubic meter	m ³	—
Electrical potential	Volt	V	m ² ·kg/(s ³ ·A)
Force	Newton	N	m·kg/s ²
Frequency	Hertz	Hz	1/s
Pressure or stress	Pascal	Pa	(m·kg/s ²)/m ² = kg/(m·s ²)
Quantity of electricity	Coulomb	C	s·A

Table 4.3—Decimal prefixes

Multiplication factor	Prefix	Abbreviation
10 ¹²	tera	T
10 ⁹	giga	G
10 ⁶	mega	M
10 ³	kilo	k
10 ²	hecto*	h
10 ¹	deka*	da
10 ⁻¹	deci*	d
10 ⁻²	centi*	c
10 ⁻³	milli	m
10 ⁻⁶	micro	μ
10 ⁻⁹	nano	n
10 ⁻¹²	pico	p

*To be avoided when possible.

The converted value implies that the slump was measured to the nearest 0.1 mm. To avoid this, significant digits and proper rounding techniques must be considered.

Significant digits are any digits necessary to define a value or quantity. Generally, leading zeros are not significant; trailing zeros may or may not be significant.

Example:

6 = one significant digit

0.0037 = two significant digits

1.297 = four significant digits

1000 = one, two, three, or four significant digits, depending upon the precision of the original measurement; if measurement is to the nearest unit, there are four significant units.

4.4.3 Rounding

- After considering the precision of a value, the converted value should be rounded to the minimum number of significant digits such that a unit of the last place is equal to or smaller than the converted precision.
- If the inch-pound measurement is expressed as a

Table 4.4—Other units

Quantity	Unit	Abbreviation
Time	Minute	min
Volume	Liter (0.001 m ³)	L
Mass	Metric ton (1000 kg)	t
Area	Hectare (10,000 m ²)	ha
Temperature	Degree Celsius	°C

Table 4.5—Conversion factors for commonly used values in the concrete industry*

From	Multiply by	To get
Area		
1 square yard (yd ²)	0.8361274	square meter (m ²)
1 square foot (ft ²)	0.0929034 (exact)	square meter (m ²)
1 square inch (in. ²)	645.16 (exact)	square millimeter (mm ²)
Area per volume (coverage)		
1 square foot per gallon (ft ² /gal.)	0.02454	square meter per liter (m ² /L)
Energy		
BTU	1055.87	joule (J)
Heat		
thermal conductivity (<i>k</i> value) (BTU / (ft·h·°F))	1.730735	watt per (meter-kelvin) (W/(m·K))
thermal resistance (<i>R</i> value) (ft ² ·h·°F/BTU)	0.176110	square meter-kelvin per watt ((m ² ·K)/W)
specific heat (BTU / (lb·°F))	4186.800	joule per (kilogram-kelvin) (J/(kg·K))
Force		
1 pound (lb)	4.448222	newton (N)
1 kip (1000 lb)	4.448222	kilonewton (kN)
Length		
1 inch (in.)	25.4 (exact)	millimeter (mm)
1 foot (ft)	0.3048 (exact)	meter (m)
1 yard (yd)	0.9144 (exact)	meter (m)
1 mile (mile)	1.609 44	kilometer (km)
Mass		
1 pound (lb)	0.4535924	kilogram (kg)
1 ton (=2000 lb)	0.9071847	metric ton (t)
kip (=1000 lb)	435.924	kilogram (kg)
ton, long (=2240 lb)	1016.047	kilogram (kg)
ton, short (=2000 lb)	907.1847	kilogram (kg)
Mass per volume [†]		
1 pound per cubic foot (lb/ft ³)	16.018846	kilogram per cubic meter (kg/m ³)
1 pound per cubic yard (lb/yd ³)	0.5932764	kilogram per cubic meter (kg/m ³)
1 pound per gallon (lb/gal.)	0.1198264	kilogram per liter (kg/L)
Pressure (stress)		
1 pound per square inch (psi, lb/in. ²)	6.894757	kilopascal (kPa)
1 pound per square foot (psf, lb/ft ²)	47.88026	pascal (Pa)
1 kip per square inch (ksi, kip/in. ²)	6.894757	megapascal (MPa)
Temperature		
Fahrenheit (°F)	(°F - 32)/1.8 (exact)	Celsius (°C)
Celsius (°C)	1.8 °C + 32 (exact)	Fahrenheit (°F)
Temperature difference		
Fahrenheit (°F)	Δ _F /1.8 (exact)	Celsius (°C)
Δ _F	5/9	Δ _C
Volume per mass and volume per volume		
1 fluid ounce per cubic yard (oz/yd ³)	38.68071	milliliter per cubic meter (mL/m ³)
1 fluid ounce per 100 pounds (fl oz/100 lb)	65.19847	milliliter per 100 kilogram (mL/100 kg)
1 gallon per cubic yard (gal./yd ³)	4.951132	liter per cubic meter (L/m ³)

*To convert from an SI unit to the indicated inch-pound unit, divide by the given conversion factor, except for temperature, as an equation is also given for converting from °C to °F.

†The inch-pound system uses force (lb) per volume. The conversion factors convert to mass (kg) per volume for the SI system (see Section 4.1.5).

combination of units, convert to the smaller unit and then multiply by the appropriate conversion factor. For example, 5 ft 6 in. should be converted to 66 in. before converting.

- Do not round off either the unit or conversion factor before multiplying.
- After multiplying by the conversion factor, round off to a number of significant digits to represent the accuracy of the original measurement.
- After rounding off, move the decimal point as necessary to express the converted value using one of the preferred prefixes. The numerical value should be between 1 and 999. For example, use 1.2 km, not 1200 m.

Going back to the example of 6 in. slump in Section 4.4.2, the implied precision of the measurement is to the nearest 1/4 in. The appropriate conversion would be 150 mm.

4.4.4 Hard versus soft conversion—“Soft” conversions are exact mathematical conversions, rounded to an appropriate number of significant digits. “Hard” conversions are measurements in one system converted to a standard dimension in the other system that would be used in design and construction.

Note that the Board policy statement requires ACI codes and specifications be published in two separate versions, one using hard-converted SI units and the other inch-pound units. Other ACI documents must be published using dual units.

Except for the codes and specifications, conversions may be either hard or soft, as appropriate. Soft conversions are generally appropriate for reporting measured values such as test data or dimensions of existing structures. Hard conversions are appropriate for codes and specifications and for making recommendations, setting requirements, or discussing products that are available in that system of measurement. If manufacturers have elected to make only soft conversions of their products, use their soft-converted values to describe or reference the product.

Sections 4.4.5 and 4.4.6 show how to do both soft and hard conversions.

4.4.5 Soft metric conversion—To make soft metric conversions, apply the conversion factor from IEEE/ASTM SI 10 (Table 4.5), then round to the number of significant digits that gives an accuracy equivalent to that of the original value. Show the resulting soft converted value in parentheses following the original value. Note that either the inch-pound or SI system could be the document’s primary units, as logic dictates, with the conversion to the other system appearing in parentheses. Either way, be consistent throughout the document.

Example 1:

Make a soft metric conversion of the ASTM C 39/C 39M test result of 4030 psi.

Use the conversion factor of 1 psi = 6.894757 kPa:

$4030 \text{ psi} \times 6.894757 \text{ kPa/psi} = 27785.87071 \text{ kPa} = 27.78587071 \text{ MPa}$

In ASTM C 39/C 39M, compression strength is reported to the nearest 10 psi, which is approximately 70 kPa. Thus, it would be appropriate to report the strength to the nearest

0.1 MPa. You would show the soft conversion in your document as:

ASTM C 39 test result of 4030 psi (27.8 MPa)

Example 2:

Make a soft conversion of a distance of 125 ft.

First, use the exact conversion of 0.3048 m = 1 ft:

$125 \text{ ft} \times 0.3048 \text{ m/ft} = 38.100 \text{ m}$

Assuming three figures are significant, that is, distance was reported to the nearest foot, you would show the soft conversion as “a distance of 125 ft (38.1 m).”

If, however, the distance of 125 ft was obtained by rounding to the nearest 5 ft so that the value could have been anywhere between 123 and 127 ft, only two significant figures are justified, and you would write the conversion as “a distance of 125 ft (38 m).”

If you do not know the precision of the measurement, make a reasonable estimate. Ideally the number of significant digits retained should be such that precision is neither sacrificed nor exaggerated. See the documents of ACI Committee 304 for an example of soft conversion.

4.4.6 Hard conversion in one dual-dimension document—Apply the appropriate conversion factor from IEEE/ASTM SI 10 (Table 4.5), and then round to the standard dimension that would be used when design and construction are in the other system of units. Show the original value followed by the hard conversion and separated by the word “or.” Note that either the inch-pound or SI system could be the document’s primary units, as logic dictates, with the conversion to the other system appearing second. Either way, be consistent throughout the document.

Example:

For hard conversion of bar spacing of 16 in., first multiply by the conversion factor:

$16 \text{ in.} \times 25.4 \text{ mm/in.} = 406.4 \text{ mm}$

The 406.4 mm value could be rounded to 410 mm, to have the same precision as the original 16 in. But for hard conversion, it would be more appropriate to use further rounding that reflects actual field practice: “bar spacing of 16 in. **or** 400 mm.”

Using the word “or” indicates that 400 mm is an alternative to, but not necessarily an exact equivalent of, 16 in. Always consider using actual dimensions or products and equipment that are available and manufactured to SI dimensions when making a hard metric conversion, and vice-versa when going from SI to inch-pound units.

All ACI documents containing both inch-pound and SI units, with one as a hard conversion of the other, shall include the following statement in the first chapter:

“The paired values stated in inch-pound and SI units are usually not exact equivalents. Therefore, each system is to be used independently of the other. Combining values from the two systems may result in nonconformance with this document [or standard, guide, specification, as appropriate].”

4.4.7 Hard conversion in two documents—When a document is published in two separate versions, perform

conversions as in Section 4.4.6, but use only inch-pound units in one document and only SI units in the other document. See ACI 318 and ACI 318M for an example of how this is done.

4.4.8 Miscellaneous conversion issues

4.4.8.1 Numerical examples—In dual-unit documents, numerical examples should not be shown in dual units. Instead, one example should be given in inch-pound units, followed by a similar example in SI units, or vice-versa. Tables and figures should be in dual units, unless that would result in a table or figure that was difficult to read. In that case, appropriate conversion factors should be given in the caption of a figure or in a footnote to the table.

4.4.8.2 Reinforcing bar designations—Converting reinforcing bar designations is complicated by the various schemes used to designate bar sizes and properties. The best approach is to fully describe the bars in terms of physical dimensions such as diameter or cross-sectional area rather than using a national designation. Also, different countries use different standards in which the tensile properties of the steel may differ from those in the United States. Report the properties of the steel used such that the reader can understand the reinforcement without detailed knowledge of a particular country's design standard.

4.4.8.3 Converting temperature—Sometimes mistakes are made when converting temperatures, differences in temperature, and temperature tolerances. For example, a Fahrenheit temperature may be converted directly into Celsius using $t_C = (t_F - 32)/1.8$.

A temperature difference of 10 °F or a tolerance of ± 2 °F, however, should not be converted in the same direct manner. Differences and tolerances must be converted using $\Delta_C = (\Delta_F)/1.8$.

4.4.9 Precision and accuracy—Following are definitions of precision and accuracy.

Precision:

- The degree of refinement with which a measurement is stated.
- The number of decimal places or significant figures used to report a measurement.
- The degree of agreement between individual measurements, namely repeatability and reproducibility.

Accuracy:

- The degree of conformity of a measurement to a standard or to a true value.

It is not appropriate to report or require more precision in measurements than is appropriate for the values being discussed. Recommended degrees of precision for different measurements used in the concrete industry are presented in Table 4.6.

The values shown in Table 4.6 are recommended for:

- Reporting new research work;
- Preparing project specifications;
- Writing general technical papers; and
- Making recommendations regarding concrete practice.

Note that the same degree of precision may not be appropriate for reporting measured values and for use in a specification.

Table 4.6—Recommended degrees of precision for common measured quantities

What	Current practice in United States	Soft-converted value	Recommendations for SI units
Specified/reported admixture dosage	Air-entraining admixture: 0.1 fl oz	6.5 mL	10 mL
	Water-reducing admixture: 0.5 fl oz	33 mL	25 mL
	High-range water-reducing admixture: 1.0 fl oz	65 mL	50 mL
	Per 100 lb of cement or cementitious material	Per 44.5 kg of cement or cementitious material	per 100 kg of cement or cementitious material
Concrete volume	0.5 yd ³ (no standard exists)	0.4 m ³	0.5 m ³
Measured density (unit weight)	Nearest 0.1 lb/ft ³	1.6 kg/m ³	Nearest 5 kg/m ³
Batch quantities	1 lb/yd ³	0.6 kg/m ³	1 kg/m ³
Tolerances for specified slump	Less than 2 in.: $\pm 1/2$ in.	± 13 mm	50 mm and less: ± 10 mm
	2 to 4 in.: ± 1 in.	± 25 mm	50 to 100 mm: ± 30 mm
	More than 4 in.: $\pm 1-1/2$ in.	± 38 mm	More than 100 mm: ± 40 mm
Measured slump	Nearest 1/4 in.	6 mm	Nearest 10 mm
Specified compressive strength	500 psi increments	3.4 MPa	5 MPa increments
Measured compressive strength	Nearest 10 psi	0.069 MPa	Nearest 0.1 MPa
Specified flexural strength	50 psi increments	0.34 MPa	0.5 MPa increments
Measured flexural strength	Nearest 5 psi	0.03 MPa	Nearest 0.1 MPa

Note: The recommended values are appropriate for most concretes. It may be appropriate to modify the recommendations for special cases, such as very-high-strength concrete or lightweight or heavyweight concretes.

APPENDIX A—GENERAL GRAMMAR, PUNCTUATION, AND WORD USAGE

A.1—Rules of grammar and punctuation

Please refer to an appropriate grammar textbook for complete rules on proper English usage. Items included in this appendix are commonly misused, and are provided as a “watch list” for committees writing technical documents.

A.1.1 *Apostrophes*

A.1.1.1 *When to use apostrophes*—Use apostrophes only to show possession.

Example:

Correct: Technical document approval is left to TAC’s discretion.

Correct: This is a productive use of members’ time.

A.1.1.2 *When not to use apostrophes*—Do not use an apostrophe when referring to decades or when making acronyms plural.

Example:

Correct: This was not a popular technique in the 1950s.

Correct: A lower level outlet (LLO) was constructed. LLOs are used frequently.

A.1.2 *Dangling modifiers*—A dangling modifier does not refer clearly to what it modifies. Make sure that the phrase or clause logically agrees with the subject of the sentence. Rewrite so that the subject of the sentence is the doer of the action expressed by the modifier. If that is not possible, use a different construction.

Example:

Incorrect: Before finishing lunch, the carpenter left.

Correct: The carpenter left before I finished my lunch.

A.1.3 *Infinitives/split infinitives*—An infinitive consists of “to” plus a verb, for example, “to break.” When a word appears between “to” and a verb, it is called a split infinitive, for example, “to carefully paint.”

Example:

Incorrect: The candidate decided to formally launch her campaign.

Correct: The candidate decided to launch her campaign formally.

When a split infinitive is more natural and less awkward than not splitting the infinitive, it is acceptable to split the infinitive.

Example:

Awkward: We decided actually to enforce the law.

Better: We decided to actually enforce the law.

A.1.4 *Parentheses and brackets*—When setting text off in parentheses, keep the thought brief. If the phrase can be set

off by commas instead, that is preferable. Text in parentheses is a distraction to the reader that can draw attention away from the point of the main sentence.

Example:

Correct: The contractor (or person designated by the contractor) should perform this task.

Incorrect: The contractor (or person designated by the contractor, like John, who worked on the last bridge project that Acme Construction completed last summer even though there were horrible storms that year and it was nearly impossible to maintain a schedule) should perform this task.

A.1.5 *Semicolons*—Use semicolons to separate complete clauses of compound sentences. Bear in mind that the clause before the semicolon and the clause after the semicolon must both be able to stand as independent sentences or else the semicolon is misplaced. It is always correct to rewrite the clauses as two complete sentences.

Example:

Correct: Do not pump concrete through aluminum pipe; this can ultimately cause irregular expansion.

Also correct: Do not pump concrete through aluminum pipe. This can ultimately cause irregular expansion.

Use semicolons to separate items listed within a sentence that are complex or contain internal punctuation. Use semicolons when more than three items are listed in text. When three or fewer items are listed and are uncomplicated expressions, commas are usually sufficient to separate them.

Example:

Correct: Successful concrete construction depends on careful planning and execution of all procedures; experienced, available personnel; effective on-site troubleshooting; agreeable weather conditions or proper provisions to accommodate unfavorable conditions; and proper materials.

Use semicolons to end punctuation for all but the last item in a bulleted, numbered, or lettered list. See Section 1.5 for details and examples of acceptable styles for lists.

Use semicolons to separate the keywords of the document.

A.2—Commonly misused terms

A.2.1 *Alternate/alternative*—Alternate usually means “an action by turns or step-by-step.” Alternative usually means “one or the other.”

A.2.2 *Assure/insure/ensure*—The verb “assure” must always take a person as its direct object. Therefore, you can assure people that certain events will take place.

Example:

Correct: The designer should assure the owner that the plans are accurate.

The verb “insure” refers to protection against financial loss.

Example:

Correct: To protect the owner’s investment, the building should be insured.

The verb “ensure” means “to make certain.”

Example:

Correct: Ensure that mixture proportions are correct.

Be careful in the use of “ensure” in mandatory-language documents. Used improperly, “ensure” could legally imply a guarantee that should be avoided. For example, do not state, “Use of this equation will ensure crack control.” Also, “ensure” should be used only if the party required “to make certain” is typically assigned that responsibility and if the requirement is practicable.

A.2.3 Criterion/criteria—Criterion is singular; criteria are plural.

A.2.4 However—A sentence should not begin with “however” when the meaning is “nevertheless.”

Example:

Correct: “The roads were almost impassable. At last, however, we succeeded in reaching camp.”

Incorrect: “The roads were almost impassable. However, we at last succeeded in reaching camp.”

When “however” comes first, it means “in whatever way” or “to whatever extent.”

Example:

Correct: However you advise him, he will probably do as he thinks best.

A.2.5 Per versus “/”—Typically, a slash (solidus) should be used between unit abbreviations when one unit is being

measured per the other. The exceptions are units commonly expressed as acronyms, such as mph and psi.

Example:

Correct: For best results, 3 gal./lb or 9 L/kg should be added.

Use the word “per” to separate units that are not abbreviated.

Example:

Correct: Many ounces of water per pound of cement are needed.

A.2.6 Practical/practicable—“Practical” applied to persons means sensible and businesslike and applied to things it means efficient and workable, as contrasted with theoretical. “Practicable” means possible or feasible, able to be done, capable of being put into practice or of being used.

Example:

Correct: The use of ice is a practical approach for reducing the temperature of fresh concrete.

Correct: It is not practicable to consolidate cylindrical specimens of zero-slump concrete by rodding.

A.2.7 That/which—The general rule of thumb is if the clause can be deleted without changing the meaning of the sentence, then “which” should be used. If deleting the clause changes the meaning, then “that” should be used.

Example:

Correct: The book that I borrowed is on the shelf. (Identifies the book in question.)

Correct: The book, which I borrowed, is on the shelf. (Offers detail about the book.)

APPENDIX B—QUICK REFERENCE

B.1—Document searches and replacements

B.1.1 Global replacements—Once the document is complete, these suggested global replacements help to ensure the document conforms to ACI style as closely as possible.

In nonmandatory-language documents, search for all occurrences of “shall” and “must” and replace with “should” and “may” accordingly (Section 1.4.1).

In mandatory-language documents, search for all occurrences of “should” and “may” and replace with “shall” and “must” accordingly (Section 1.4.1).

Search for all occurrences of “which” and verify that each use is correct. When it is not, replace with “that” (Section A.2.7).

Search for words that do not conform to ACI style. Replace unacceptable terms such as microsilica, superplasticizer, and rebar (Chapter 3).

Search for first mention of any abbreviations or acronyms. Make sure abbreviations and acronyms are defined at first mention.

Search for “Fig.” (and “Figure,” if it was used to begin a sentence) and “Table” and verify that all artwork is cited somewhere in the text. (Make sure citations of artwork that have been removed are deleted or updated accordingly.)

Run a spell-check program on the entire document.

B.2—Last-minute verifications

Perform a final check of these often-overlooked items on the final draft:

- Do all section headings match the table of contents?
- Have sections been renamed, deleted, or moved?
- Are all pages numbered?
- Do line numbers appear on each page?
- Does the correct roster appear (Section 1.1.3)?
- Are references up-to-date and cited appropriately?
- Is text double-spaced?
- Is revised text distinguished from unrevised text (for revisions to existing documents) (Section 1.1)?
- Are originals of figures and tables (or photocopies, if originals are already at headquarters from a previous printing) included?
- Did the equations and symbols print properly?

B.3—Addresses of commonly referenced organizations

American Association of State Highway
& Transportation Officials
444 N. Capitol Street NW
Suite 249
Washington, DC 20001
www.transportation.org

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

American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, VA 20191
www.asce.org

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428
www.astm.org

British Standards Institution
389 Chiswick High Road
London W4 4AL
United Kingdom
www.bsi-global.com

Canadian Standards Association
5060 Spectrum Way
Mississauga, ON
L4W 5N6
Canada
www.csa.ca

Concrete Reinforcing Steel Institute
933 N. Plum Grove Road
Schaumburg, IL 60173
www.crsi.org

International Organization for Standardization (ISO)
1, rue de Varembe
Case postale 56
CH-1211 Genève 20
Switzerland
www.iso.org

National Ready-Mixed Concrete Association
900 Spring Street
Silver Spring, MD 20910
www.nrmca.org

The Masonry Society
3970 Broadway, Suite 201-D
Boulder, CO USA 80304-1135
www.masonrysociety.org

Portland Cement Association
5420 Old Orchard Road
Skokie, IL 60077
www.cement.org

Post-Tensioning Institute
8601 North Black Canyon Highway, Suite 103
Phoenix, AZ 85021
www.post-tensioning.org

Precast/Prestressed Concrete Institute
209 W. Jackson Blvd. #500
Chicago, IL 60606
www.pci.org

U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180
www.erd.c.usace.army.mil/

RILEM
157 rue des Blains
F-92220 Bagneux
France
www.rilem.org

APPENDIX C—STATE ABBREVIATIONS

Alabama	AL	Montana	MT
Alaska	AK	Nebraska	NE
Arizona	AZ	Nevada	NV
Arkansas	AR	New Hampshire	NH
California	CA	New Jersey	NJ
Colorado	CO	New Mexico	NM
Connecticut	CN	New York	NY
Delaware	DE	North Carolina	NC
District of Columbia	DC	North Dakota	ND
Florida	FL	Ohio	OH
Georgia	GA	Oklahoma	OK
Hawaii	HI	Oregon	OR
Idaho	ID	Pennsylvania	PA
Illinois	IL	Puerto Rico	PR
Indiana	IN	Rhode Island	RI
Iowa	IA	South Carolina	SC
Kansas	KS	South Dakota	SD
Kentucky	KY	Tennessee	TN
Louisiana	LA	Texas	TX
Maine	ME	Utah	UT
Maryland	MD	Vermont	VT
Massachusetts	MA	Virgin Islands	VI
Michigan	MI	Virginia	VA
Minnesota	MN	Washington	WA
Mississippi	MS	West Virginia	WV
Missouri	MO	Wisconsin	WI
		Wyoming	WY

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