

Specifications for Tolerances for Concrete Construction and Materials and Commentary

An ACI Standard

Reported by ACI Committee 117

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Specification synopsis: This specification provides standard tolerances for concrete construction. This document is intended to be used by specification writers and ACI committees writing standards as the reference document for establishing tolerances for concrete construction.

Commentary synopsis: This report is a commentary on the Specifications for Tolerances for Concrete Construction and Materials (ACI 117). It is intended to be used with ACI 117 for clarity of interpretation and insight into the intent of the committee regarding the application of the tolerances set forth therein.

Keywords: construction; concrete; drilled piers; formwork; foundation; masonry; mass concrete; pier; precast concrete; prestressed concrete; reinforced concrete; reinforcement; specification; splice; tolerances.

Note to Specifier: This Specification is incorporated by reference in the Project Specification using the wording in P3 of the Preface and including information from the Mandatory Requirements and Optional Requirements following the Specification.

PREFACE

P1. ACI Specification 117 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 117 are copied into the Project Specification or any other document, do not refer to them as an ACI Specification because the specification has been altered.

P3. A statement such as the following will serve to make ACI Specification 117 a part of the Project Specification: “Work on (Project Title) shall conform to all requirements of ACI 117-06 published by the American Concrete Institute, Farmington Hills, Michigan, except as modified by these Contract Documents.”

P4. The language in each technical Section of ACI Specification 117 is imperative and terse.

ACI Committee Reports, Guides, and Commentaries are intended for guidance in planning, designing, executing, and inspecting construction. This Commentary 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 commentary shall not be made in contract documents. If items found in this Commentary 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.

ACI 117 Specification and Commentary are presented in a side-by-side column format, with code text placed in the left column and the corresponding commentary text aligned in the right column. To distinguish the specification from the commentary, the specification has been printed in Helvetica, which is the typeface for this paragraph.

The Commentary is printed in Times Roman, which is the typeface for this paragraph. Commentary section numbers are preceded by the letter “R” to distinguish them from specification section numbers. The commentary is not a part of ACI Specification 117-06.

ACI 117-06 supersedes ACI 117-90 and became effective August 15, 2006.
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INTRODUCTION

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This commentary pertains to “Specifications for Tolerances for Concrete Construction and Materials (ACI 117-06).” The purpose of the commentary is to provide an illustrative and narrative complement to the specification.

No structure is exactly level, plumb, straight, and true. Fortunately, such perfection is not necessary. Tolerances are a means to establish permissible variation in dimension and location, giving both the designer and the contractor limits within which the work is to be performed. They are the means by which the designer conveys to the contractor the performance expectations upon which the design is based or that the project requires. Such specified tolerances should reflect design assumptions and project needs, being neither overly restrictive nor lenient. Necessity rather than desirability should be the basis of selecting tolerances.

As the title “Specifications for Tolerances for Concrete Construction and Materials (ACI 117)” implies, the tolerances given are standard or usual tolerances that apply to various types and uses of concrete construction. They are based on normal needs and common construction techniques and practices. Specified tolerances at variance with the standard values can cause both increases and decreases in the cost of construction.

The required degree of accuracy of construction depends on the interrelationship of many factors:

Structural strength and function requirements—It is imperative that structures satisfy the basic code requirement to protect life safety and are constructed in conformance with the contract documents.

Aesthetics—The structure should satisfy the aesthetic requirements of the contract documents.

Economic feasibility—The specified degree of accuracy has a direct impact on the cost of production and the construction method. In general, the higher degree of construction accuracy required, the higher the construction cost.

Relationship of all components—The required degree of accuracy of individual parts can be influenced by adjacent units and materials, joint and connection details, and the possibility of the accumulation of tolerances in critical dimensions.

Construction techniques—The feasibility of a tolerance depends on available craftsmanship, technology, and materials.

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Compatibility—Designers are cautioned to use finish and architectural details that are compatible with the type and anticipated method of construction. The finish and architectural details used should be compatible with achievable concrete tolerances.

Job conditions—Unique job situations and conditions should be considered. The designer should specify and clearly identify those items that require either closer or more lenient tolerances as the needs of the project dictate.

Measurement—Tolerances should be evaluated using control points and benchmarks that have been planned, established, and coordinated prior to execution of the work. Control points and benchmarks should be maintained in an undisturbed condition until final completion and acceptance of the project.

Project document references

ACI specification documents—The following American Concrete Institute standards provide mandatory requirements for concrete construction and can be referenced in the Project Documents:

117	Specifications for Tolerances for Concrete Construction and Materials and Commentary
301	Specifications for Structural Concrete
301M	Specifications for Structural Concrete (metric)
303.1	Standard Specification for Cast-in-Place Architectural Concrete
306.1	Standard Specification for Cold Weather Concreting
308.1	Standard Specification for Curing Concrete
330.1	Specification for Unreinforced Concrete Parking Lots
336.1	Specification for the Construction of Drilled Piers
346	Specification for Cast-in-Place Concrete Pipe
423.6	Specification for Unbonded Single-Strand Tendons and Commentary
503.1	Standard Specification for Bonding Hardened Concrete, Steel, Wood, Brick, and Other Materials to Hardened Concrete with a Multi-Component Epoxy Adhesive
503.2	Standard Specification for Bonding Plastic Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive
503.3	Standard Specification for Producing a Skid-Resistant Surface on Concrete by the Use of a Multi-Component Epoxy System
503.4	Standard Specification for Repairing Concrete with Epoxy Mortars
506.2	Specification for Shotcrete
530.1	Specification for Masonry Structures and Commentary

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548.4 Standard Specification for Latex-Modified
Concrete (LMC) Overlays

ACI informative documents—The documents of the following American Concrete Institute committees cover practice, procedures, and state-of-the-art guidance for the categories of construction as listed:

General buildingACI 302, 304, 305, 311, 315
Special structures..... ACI 307, 313, 325, 332, 334, 343, 358
Materials.....ACI 211, 223

Notes

SECTION 1—GENERAL REQUIREMENTS

STANDARD

COMMENTARY

1.1—Scope

1.1.1 This specification designates standard tolerances for concrete construction.

1.1.2 The indicated tolerances govern unless otherwise specified. Tolerance values affect construction cost. Specific use of a tolerance item may warrant less or more stringent tolerances than contained in the specification. Such variances must be individually designated by the specifier in the contract documents.

Tolerances in this specification are for standard concrete construction and standard construction procedures. Materials that interface with or connect to concrete elements may have tolerance requirements that are not compatible with those contained in this document.

This standard is not intended to apply to special structures not cited in the standard, such as nuclear reactors and containment vessels, bins, prestressed circular structures, and single-family residential construction. It is also not intended to apply to precast concrete or to the specialized construction procedure of shotcrete.

Specialized concrete construction or construction procedures require the specifier to include specialized tolerances. ACI committee documents covering specialized construction may provide guidance on specialized tolerances.

1.1.3 A preconstruction meeting shall be held. All parties shall be given the opportunity to identify any anticipated tolerance questions that are applicable to their work. These questions shall be resolved before the beginning of applicable construction.

1.1.4 Hard conversions were used throughout the document. Use the tolerances specified in inch-pound units if the structure was designed using inch-pound units, and use the tolerances specified in SI units if the structure was designed using SI units. It is not permitted to convert from one system of units to another to obtain larger tolerances.

1.1.5 Values stated in either inch-pound or SI units shall be regarded separately as standard. Values stated in each system might not be exact equivalents; therefore, each system must be used independently from the other, without combining values in any way.

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1.2—Requirements

1.2.1 Concrete construction shall comply with specified tolerances.

1.2.2 Tolerances shall not extend the structure beyond legal boundaries. Tolerances are measured from the points, lines, and surfaces defined in the contract documents. If application of tolerances causes the extension of the structure beyond legal boundaries, the tolerance must be reduced.

R1.2—Requirements

An example of a specific application that uses a multiple of toleranced items that together yield a toleranced result is the location of the face of a concrete wall. The wall has a tolerance on location (Section 4.2.1), measured at the foundation of the wall, and is allowed to deviate from the specified plane (Sections 4.1 and 4.8.2). The application of the location tolerance (Section 4.2.1) cannot be used to increase the plumb tolerance contained in Section 4.1. Similarly, the tolerance on member thickness (Section 4.5) shall not be allowed to increase the tolerance envelope resulting from the application of Sections 4.1, 4.2.1, and 4.8.2. If the base of the wall is incorrectly located by the maximum amount allowed by Section 4.2.1, then the plumb tolerance (Section 4.1) dictates that the face of the wall move back toward the correct location, and at a rate that does not exceed the provisions of Section 4.8.2. Refer to Fig. R1.2.3.

R1.2.2 If the application of tolerances causes the extension of the structure beyond legal boundaries, consideration should be given to reduce the specified dimension to accommodate the tolerances.

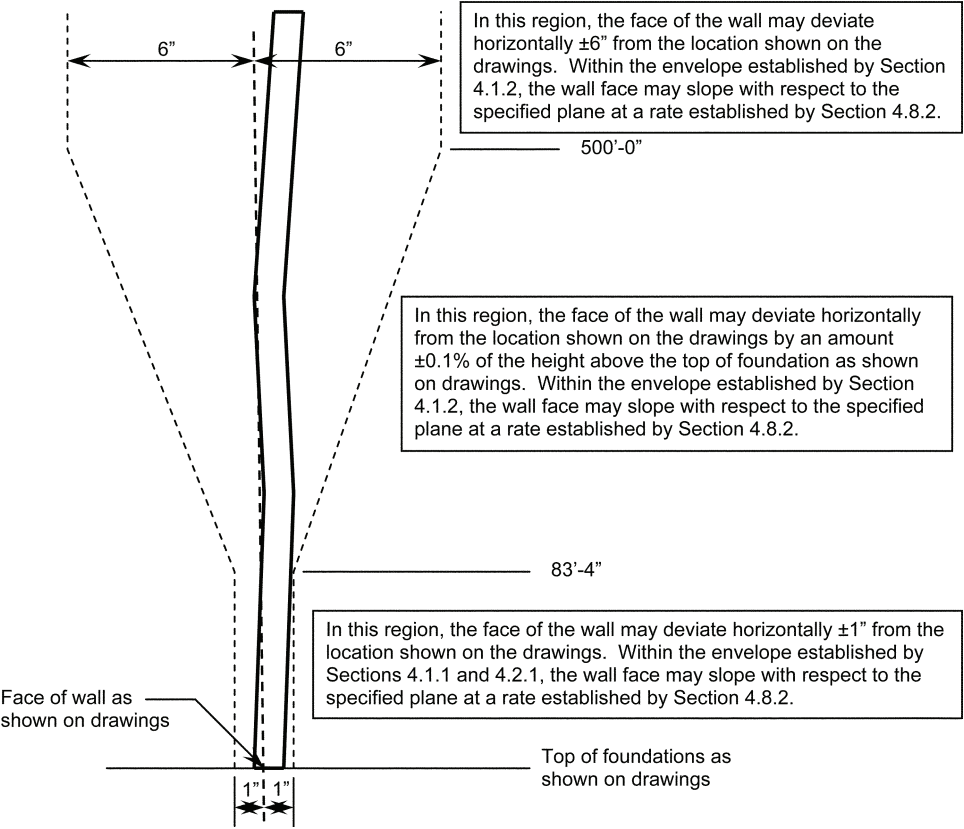


Fig. R1.2.3—Use of multiple of toleranced items to yield toleranced result.

STANDARD

1.2.3 Tolerances are not cumulative. The most restrictive tolerance controls.

1.2.4 Plus (+) tolerance increases the amount or dimension to which it applies, or raises a deviation from level. Minus (–) tolerance decreases the amount or dimension to which it applies, or lowers a deviation from level. Where only one signed tolerance is specified (+ or –), there is no limit in the opposing direction.

1.2.5 If the tolerances for structural concrete in this document are exceeded, refer to ACI 301 for acceptance criteria. For other concrete, the engineer-architect may accept the element if it meets one of the following criteria:

- a. Exceeding the tolerances does not affect the structural integrity, legal boundaries, or architectural requirements of the element.
- b. The element or total erected assembly can be modified to meet all structural and architectural requirements.

1.3—Definitions

arris—the line formed by the intersection of two planar or curved surfaces.

bowing—the deviation of the edge or surface of a planar element from a line passing through any two corners of the element.

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R1.2.3 Accumulations of individual tolerances on a single item should not be used to increase an established tolerance. Individual tolerances are unique to their specific application and should not be combined with other tolerances to form a tolerance envelope. The separately specified tolerances must remain separate and not cumulative. Each tolerance stands alone when evaluating the acceptability of concrete construction. Refer to [Fig. R1.2.3](#).

R1.2.5 For acceptance criteria for structural concrete, refer to ACI 301, Section 1.7.

R1.3—Definitions

arris—refer to Fig. R1.3.1.

bowing—refer to Fig. R1.3.2.

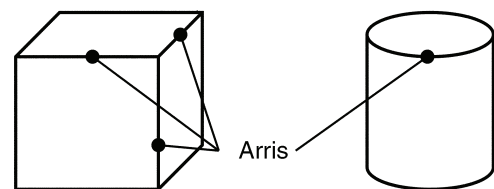


Fig. R1.3.1—Arris.

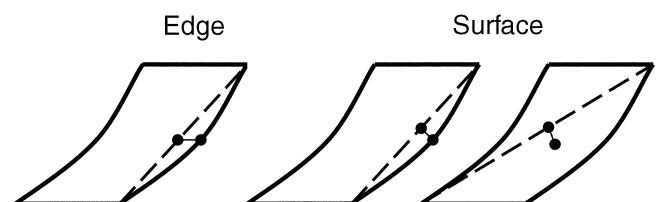


Fig. R1.3.2—Bowing.

STANDARD

bundled bar equivalent area—single bar area derived from the equivalent total area of reinforcing bars contained in the bundle.

clear distance—gap between prescribed elements.

contract documents—the project contract(s), the project drawings, and the project specifications.

cover—in reinforced concrete, the least distance between the surface of the reinforcement and the nearest surface of the concrete.

deviation—departure from an established point, line, or plane. Measurements to reference lines, planes, or surfaces shall be made normal (perpendicular) to the reference line, plane, or surface:

COMMENTARY

clear distance—refer to Fig. R1.3.3.

cover—refer to Fig. R1.3.4.

deviation—refer to Fig. R1.3.5.

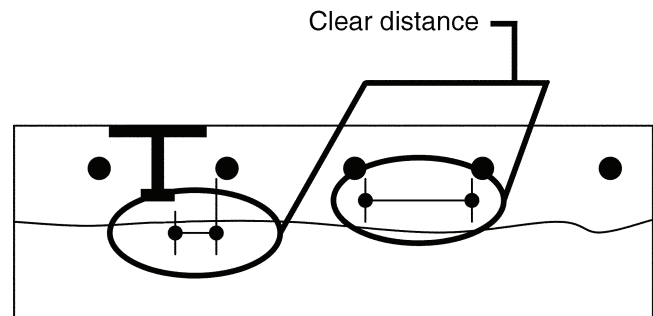


Fig. R1.3.3—Clear distance.

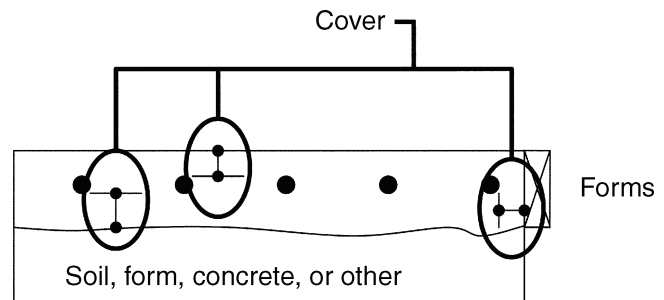


Fig. R1.3.4—Cover.

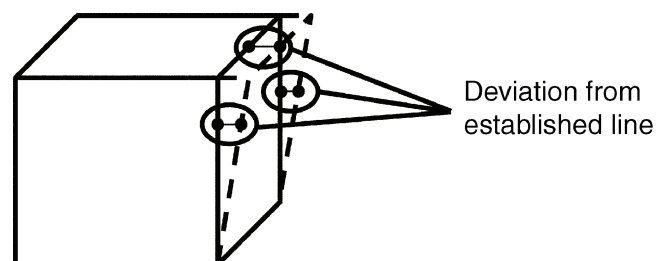


Fig. R1.3.5—Deviation.

STANDARD

deviation from plane—the distance between a point on a reference plane and the corresponding point on the actual plane.

deviation, horizontal—the location relative to specified vertical plane or a specified vertical line or from a line or plane reference to a vertical line or plane. When applied to battered walls abutments, or other nearly vertical surfaces, horizontal deviation is defined as the horizontal location of the surfaces relative to the specified profile.

COMMENTARY

deviation from plane—refer to Fig. R1.3.6(a) and (b).

deviation, horizontal—refer to Fig. R1.3.7(a), (b), and (c).

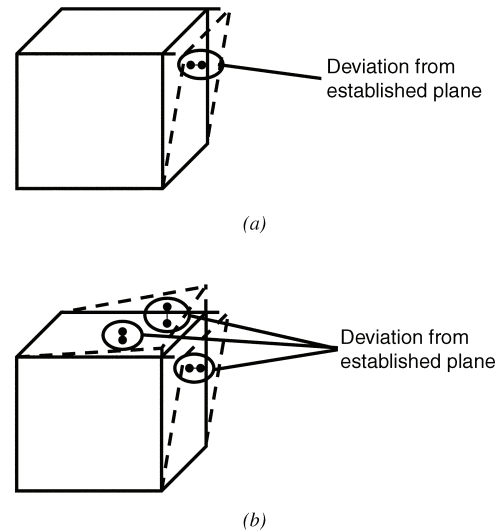


Fig. R1.3.6—Deviation from plane.

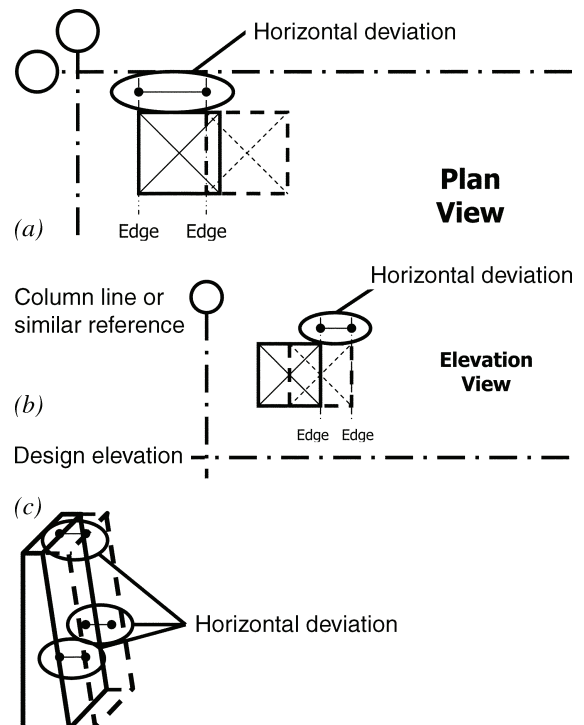


Fig. R1.3.7—Horizontal deviation.

STANDARD

deviation, vertical—the location relative to specified horizontal plane or a specified horizontal line. When applied to nearly horizontal surfaces, vertical deviation is defined as the vertical location of the surface relative to the specified profile.

COMMENTARY

deviation, vertical—refer to Fig. R1.3.8(a) and (b).

Vertical deviation, horizontal deviation, and deviation from plumb are used to establish a tolerance envelope within which permissible variations can occur. Deviation from plane, in addition to designating allowable relative displacements of elements, is used to determine the rate of change of adjacent points (slope tolerance) occurring within the tolerance envelope. In this fashion, the slope and smoothness of surfaces and lines within a tolerance envelope are controlled. Abrupt changes such as offsets, saw-toothing, and sloping of lines and surfaces properly located within a tolerance envelope may be objectionable when exposed to view. The acceptable relative alignment of points on a surface or line is determined by using a slope tolerance. Effective use of a slope tolerance requires that the specifier establish the specific distance over which the slope is to be measured, and that the surface between measurement points does not influence the measurement device.

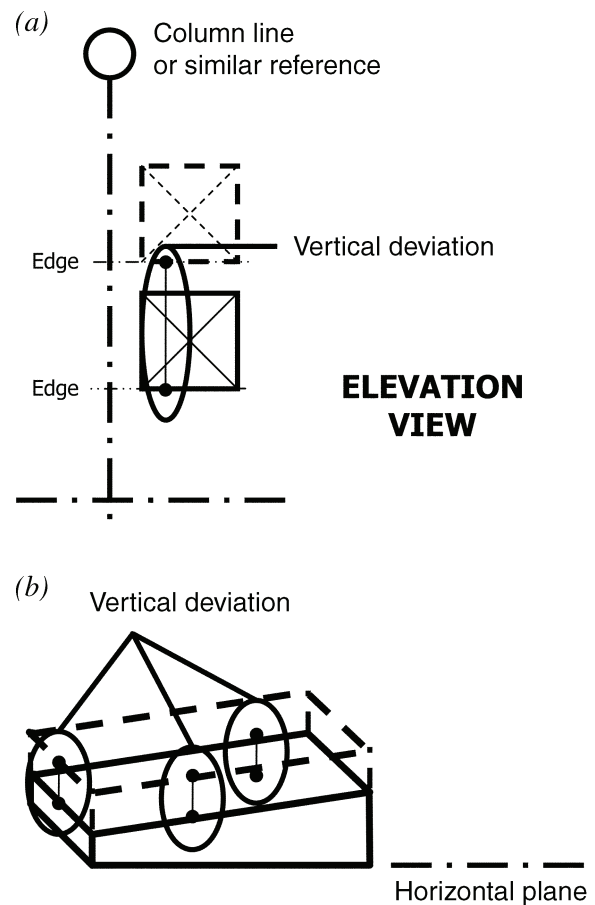


Fig. R1.3.8—Vertical deviation.

STANDARD

flatness—the degree to which a surface approximates a plane.

levelness—the degree to which a line or surface is horizontal.

COMMENTARY

flatness—refer to Fig. R1.3.9.

levelness—refer to Fig. R1.3.9.

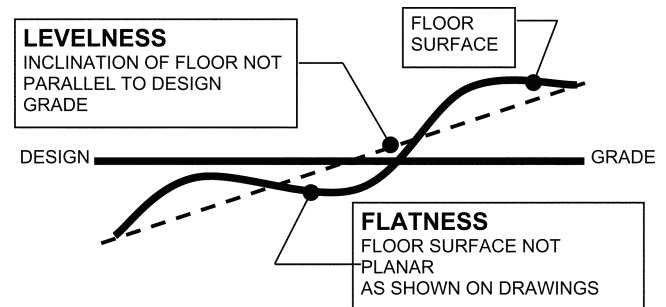


Fig. R1.3.9—Flatness and levelness.

project specifications—the specifications of a specific project that employ ACI 117 by reference. Project specifications are the instrument for making the mandatory and optional selections available under ACI 117 applicable and for specifying items not covered in ACI 117.

specified point, line, plane, surface, or dimension—a point, line, plane, surface, or dimension specified by the contract documents. Specified lines and planes may slope and specified surfaces may have curvature.

spiral—as used in circular stave silo construction, a spiral is defined as the distortion that results when the staves are misaligned so that their edges are inclined while their outer faces are vertical. The resulting assembly appears twisted, with the vertical joints becoming long-pitch spirals.

tolerance—the permitted deviation from a specified dimension, location, or quantity.

1.4—Referenced standards

ASTM International

- C 94-04 Standard Specification for Ready-Mixed Concrete
- C 174-97 Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
- C 1383-98a Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method

R1.4—Recommended references

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

- 301 Specifications for Structural Concrete
- 318 Building Code Requirements for Structural Concrete and Commentary

STANDARD

- E 1155-96 Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers
- E 1486-98 Standard Test Method for Determining Floor Tolerances Using Waviness, Wheel Path and Levelness Criteria

COMMENTARY*ASTM International*

- D 1196-93 Standard Test Method for Nonrepetitive Static (97) Plate Load Tests of Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements
- E 1155-96 Standard Test Method for Determining F_F Floor (01) Flatness and F_L Floor Levelness Numbers
- E 1486-98 Standard Test Method for Determining Floor Tolerances Using Waviness, Wheel Path and Levelness Criteria

American Society of Concrete Contractors

Position Statement #14—Anchor Bolt Tolerances

American Institute of Steel Construction

Steel Design Guide Series, No. 1

Concrete Reinforcing Steel Institute

MSP-1-01 Manual of Standard Practice (27th Edition)

Prestressed Concrete Institute

MNL-135-00 Tolerance Manual for Precast and Prestressed Concrete Construction

MNL 116 Manual for Quality Control for Plants and Production of Structural Precast Concrete Products

These publications may be obtained from:

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SECTION 2—MATERIALS

STANDARD

2.1—Reinforcing steel fabrication

For bars No. 3 through 11 (No. 10 through 36) in size, refer to Fig. 2.1(a).

For bars No. 14 and 18 (No. 43 and 57) in size, refer to Fig. 2.1(b).

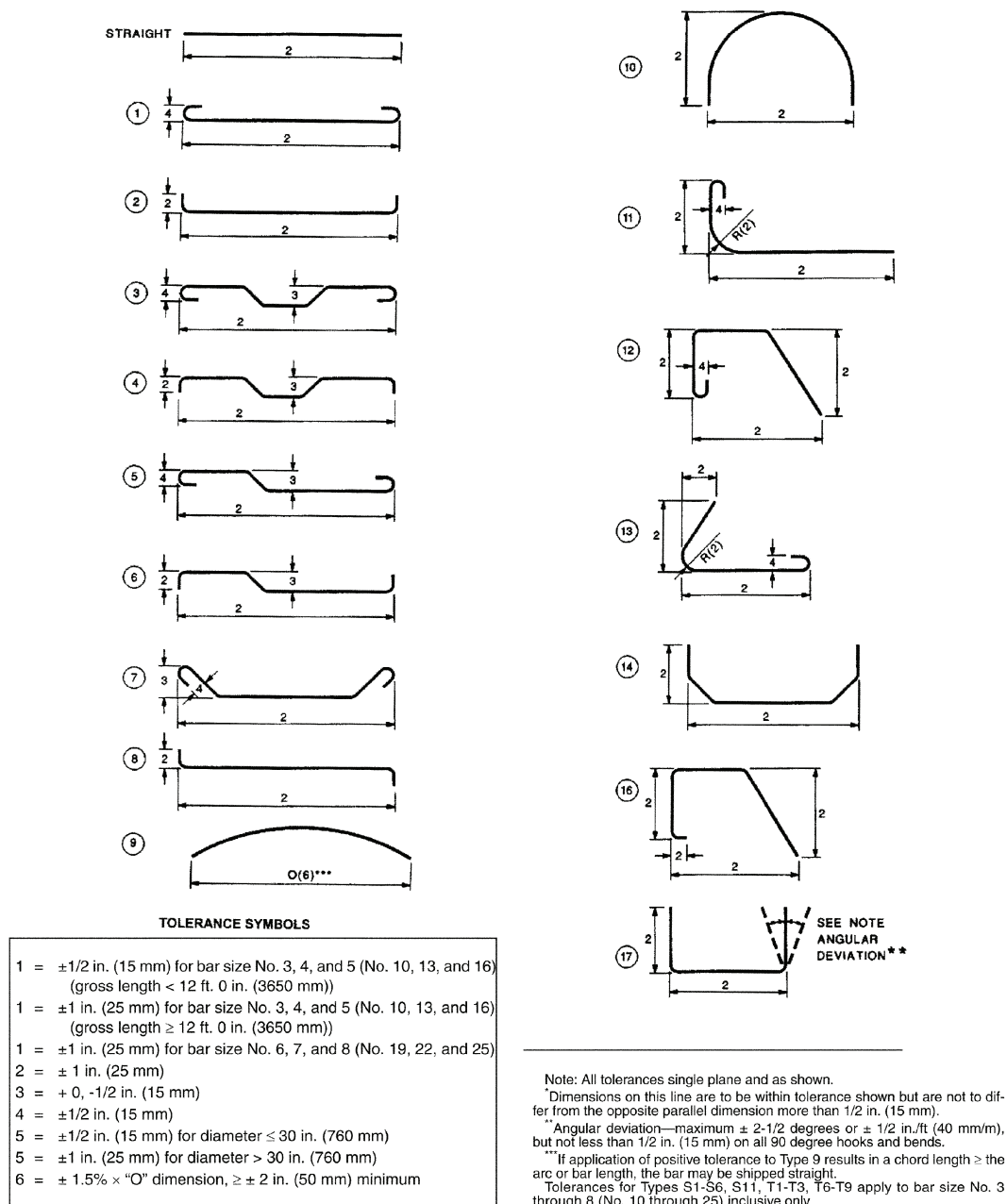
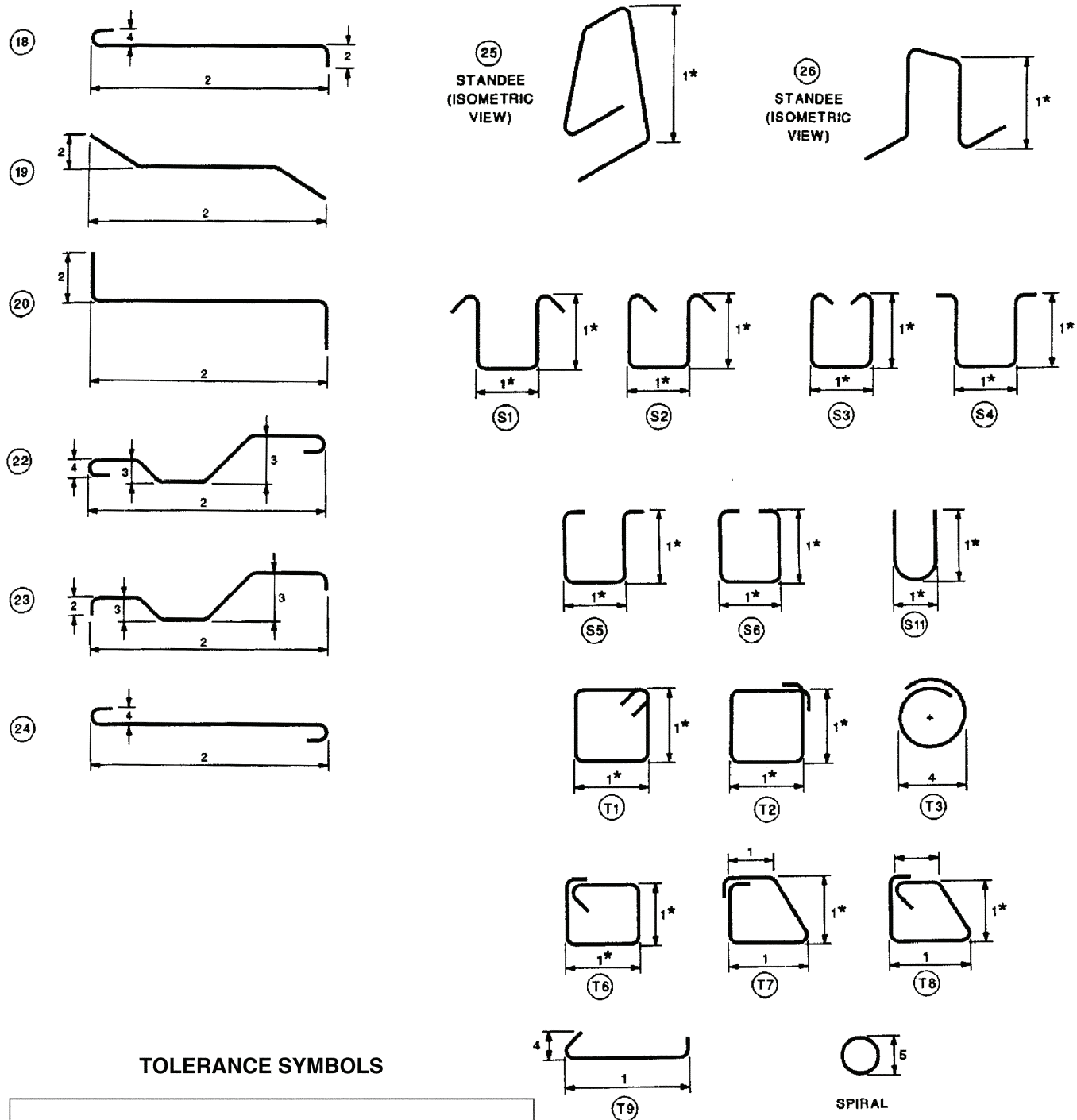


Fig. 2.1(a)—Standard fabricating tolerances for bar sizes No. 3 through 18 (No. 10 through 57).

STANDARD



Note: All tolerances single plane and as shown.

*Dimensions on this line are to be within tolerance shown but are not to differ from the opposite parallel dimension more than 1/2 in. (15 mm).

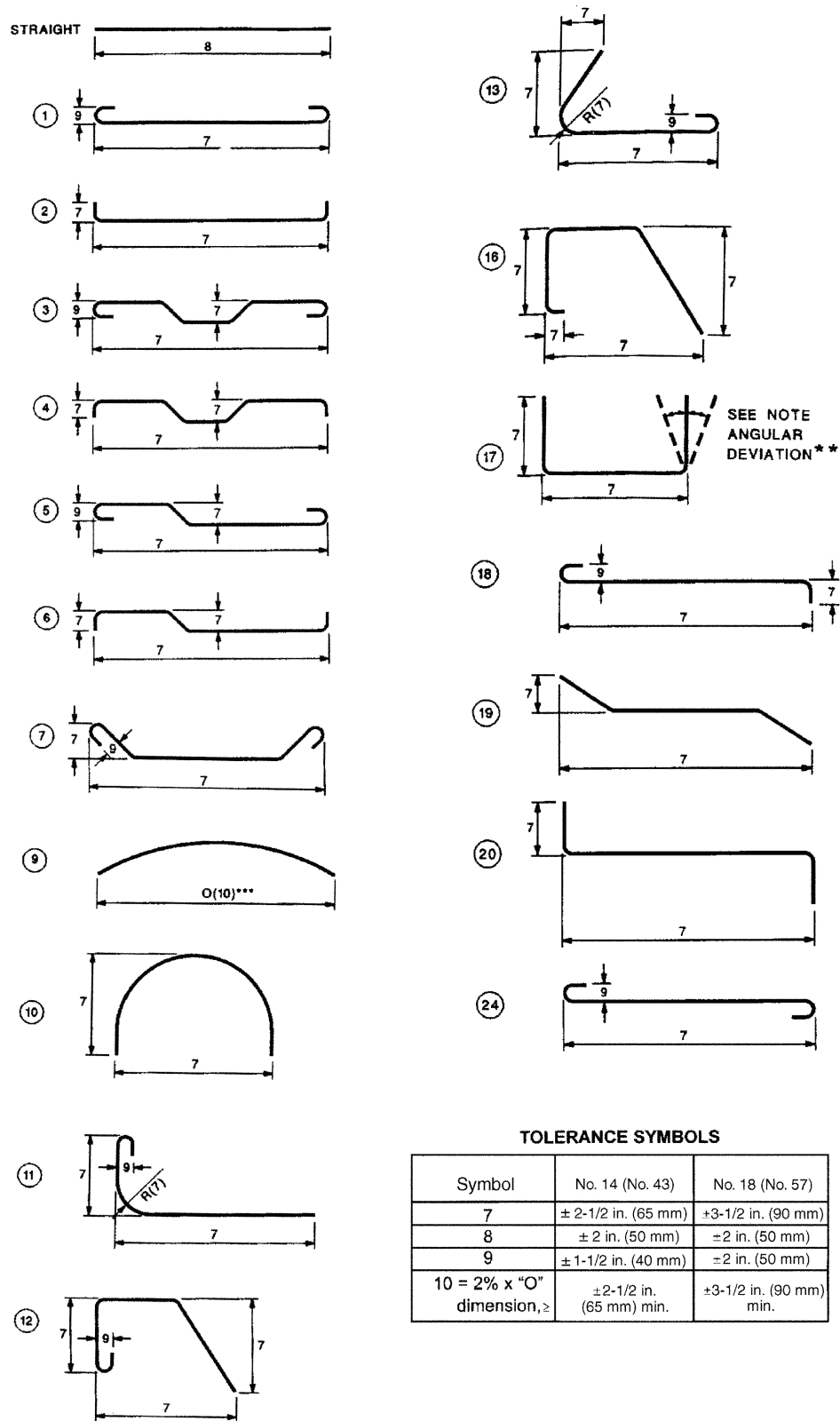
**Angular deviation—maximum $\pm 2-1/2$ degrees or $\pm 1/2$ in./ft. (40 mm/m), but not less than 1/2 in. (15 mm) on all 90 degree hooks and bends.

***If application of positive tolerance to Type 9 results in a chord length \geq the arc or bar length, the bar may be shipped straight.

Tolerances for Types S1-S6, S11, T1-T3, T6-T9 apply to bar size No. 3 through 8 (No. 10 through 25) inclusive only.

Fig. 2.1(a) (cont.)—Standard fabricating tolerances for bar sizes No. 3 through 11 (No. 10 through 36).

STANDARD



Note: All tolerances single plane as shown.

*Saw-cut both ends—Overall length ± 1/2 in. (15 mm).

**Angular deviation—Maximum ± 2 1/2 degrees or ± 1/2 in./ft (40 mm/m) on all 90 degree hooks and bends.

***If application of positive tolerance to Type 9 results in a chord length ≥ the arc or bar length, the bar may be shipped straight.

Fig. 2.1(b)—Standard fabricating tolerances for bar sizes No. 14 and 18 (No. 43 and 57).

STANDARD

2.2—Reinforcement location

2.2.1 Placement of nonprestressed reinforcement, measured from form surface

When member depth (or thickness) is 4 in. (101 mm) or less.....±1/4 in. (6 mm)

When member depth (or thickness) is over 4 in. (101 mm) and not over 12 in. (305 mm)±3/8 in. (10 mm)

When member depth (or thickness) is over 12 in. (305 mm).....±1/2 in. (13 mm)

2.2.2 Concrete cover measured perpendicular to concrete surface

When member depth (or thickness) is 12 in. (305 mm) or less.....–3/8 in. (10 mm)

When member depth (or thickness) is over 12 in. (305 mm).....–1/2 in. (13 mm)

Reduction in cover shall not exceed 1/3 the specified concrete cover.

Reduction in cover to formed soffits shall not exceed–1/4 in. (6 mm)

2.2.3 Vertical deviation for slab-on-ground reinforcement.....± 3/4 in. (19 mm)

COMMENTARY

R2.2—Reinforcement location

In the absence of specific design details shown or specified on the contract documents, CRSI MSP-I, Appendix C, should be followed by estimators, detailers, and placers. The tolerance for *d* as stated in ACI 318, is a design tolerance and should not be used as a placement tolerance for construction.

R2.2.1, R2.2.2, and R2.2.3 Tolerances for fabrication, placement, and lap splices for welded wire reinforcement are not covered by ACI 117 and, if required, should be specified by the specifier. There is an inherent conflict in the measurement of tolerances relating to reinforcing steel. During placement of reinforcing steel, tolerances are measured from formwork or the intended future concrete finish. After a structure is complete, tolerances are measured against hardened concrete. Refer to Fig. R2.2.1(a),(b), and (c). An absolute limitation on one side of the reinforcement placement is established by the limit on the reduction in cover. Refer to Fig. R2.2.2(a) to (d) and Fig. R2.2.3.

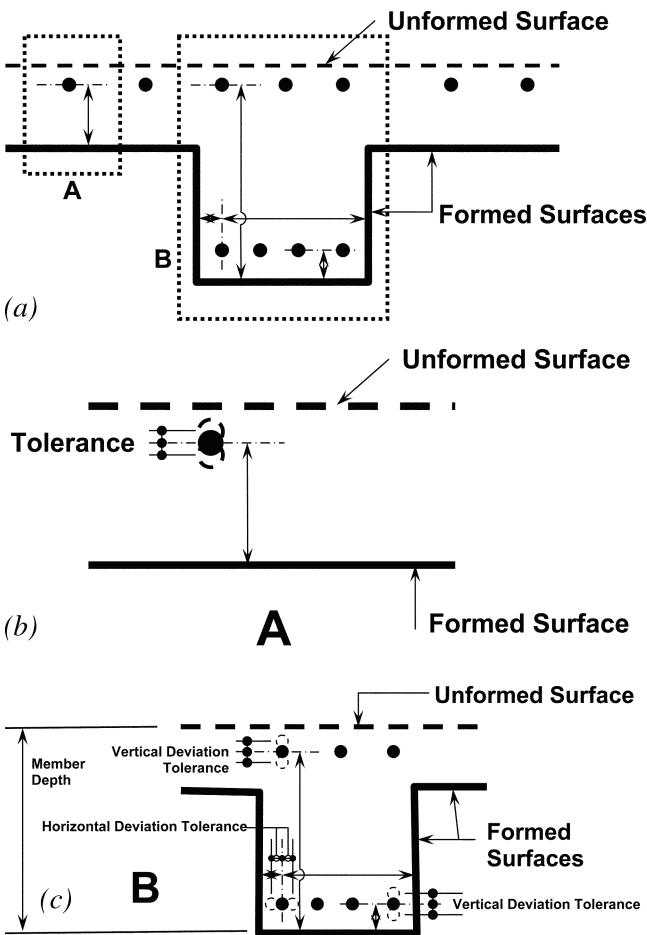


Fig. R2.2.1—Placement.

STANDARD

COMMENTARY

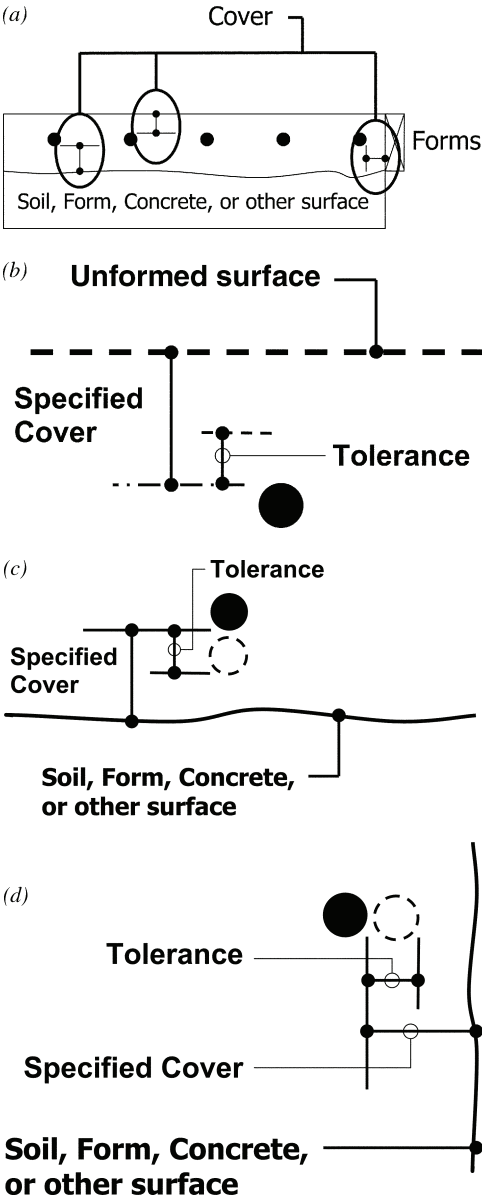


Fig. R2.2.2—Cover.

Vertical Placement

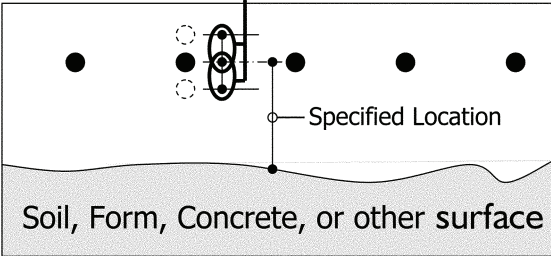


Fig. R2.2.3—Vertical placement.

STANDARD

2.2.4 Clear distance between reinforcement or between reinforcement and embedment

One-quarter specified distance not to exceed
.....±1 in. (25 mm)

Distance between reinforcement shall not be less than the greater of the bar diameter or 1 in. (25 mm) for unbundled bars.

For bundled bars, the distance between bundles shall not be less than the greater of 1 in. (25 mm) or 1.4 times the largest individual bar diameter for two-bar bundles, 1.7 times the largest individual bar diameter for three-bar bundles, and two times the largest individual bar diameter for four-bar bundles.

2.2.5 Spacing of nonprestressed reinforcement, measured along a line parallel to the specified spacing

In slabs and walls, except as noted below
.....±3 in. (76 mm)

Stirrups.....the lesser of ±3 in. (76 mm) or ±1 in. per ft of beam depth (83 mm per 1 m)

Ties.....the lesser of ±3 in. (76 mm) or ±1 in. per ft of least column width (83 mm per 1 m)

The total number of bars shall not be less than that specified.

COMMENTARY

R2.2.4 and R2.2.5 The spacing tolerance of reinforcement consists of an envelope with an absolute limitation on one side of the envelope determined by the limit on the reduction in distance between reinforcement. In addition, the allowable tolerance on spacing should not cause a reduction in the specified number of reinforcing bars used. Designers are cautioned that selecting a beam width that exactly meets the placement tolerance. This sometimes happens when lap-spliced bars take up extra space and cannot accommodate the placement tolerance. Where reinforcement quantities and available space are in conflict with spacing requirements of these sections, the contractor and designer might consider bundling a portion of the reinforcement. Bundling of bars requires approval of the designer. Refer to Fig. R2.2.4(a) to (e) and **R2.2.5**.

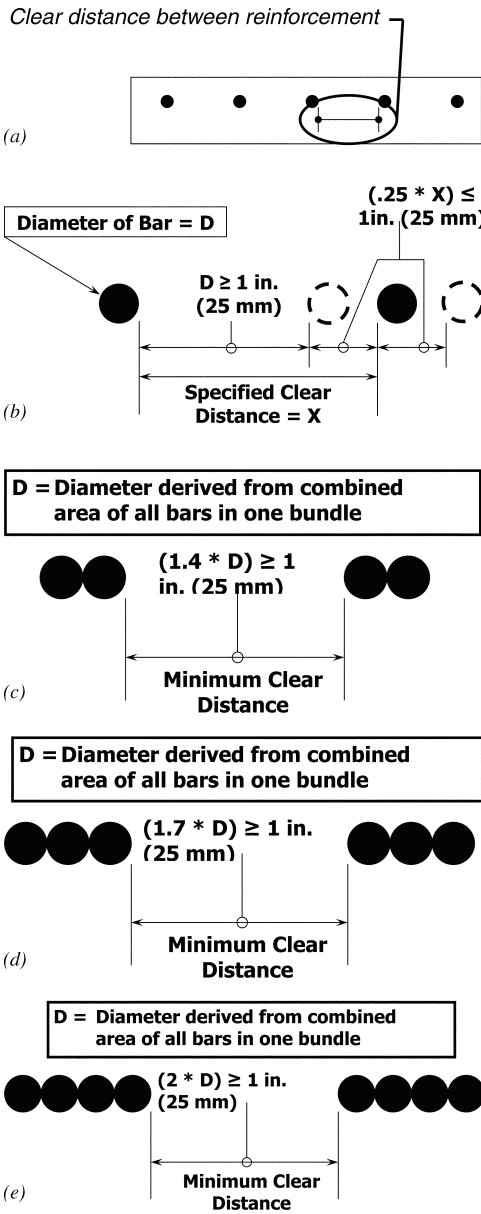


Fig. R2.2.4—Clear distance.

STANDARD

COMMENTARY

Note: Total Number of bars shall not be less than that specified

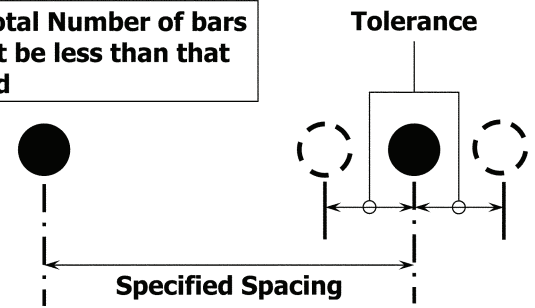


Fig. R2.2.5—Reinforcement spacing.

2.2.6 Placement of prestressing reinforcement or prestressing ducts

2.2.6.1 Horizontal deviation

Element depth (or thickness) 24 in. (0.6 m) or less
..... $\pm 1/2$ in. (13 mm)

Element depth (or thickness) over 24 in. (0.6 m)
..... ± 1 in. (25 mm)

2.2.6.2 Vertical deviation

Element depth (or thickness) 8 in. (203 mm) or less
..... $\pm 1/4$ in. (6 mm)

Element depth (or thickness) over 8 in. (203 mm) and
not over 24 in. (0.6 m)..... $\pm 3/8$ in. (10 mm)

Element depth (or thickness) more than 24 in. (0.6 m)
..... $\pm 1/2$ in. (13 mm)

R2.2.6 The vertical deviation tolerance should be considered in establishing minimum prestressing tendon covers, particularly in applications exposed to deicer chemicals or salt water environments where use of additional cover is recommended to compensate for placing tolerances. Slab behavior is relatively insensitive to horizontal location of tendons. Refer to Fig. R2.2.6(a) and (b).

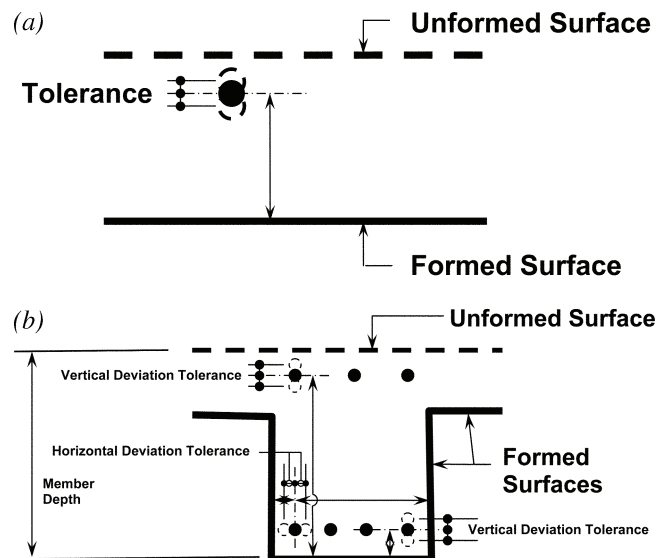


Fig. R2.2.6—Prestressing reinforcement placement.

2.2.7 Longitudinal location of bends in bars and ends of bars

At discontinuous ends of corbels and brackets
..... $\pm 1/2$ in. (13 mm)

At discontinuous ends of elements ± 1 in. (25 mm)

At other locations ± 2 in. (51 mm)

R2.2.7 and R2.2.8 The tolerance for the location of the ends of reinforcing steel is determined by these two sections.

STANDARD

COMMENTARY

2.2.8 Embedded length of bars and length of bar laps

- No. 3 through 11 (No. 10 through 36) bar sizes
.....–1 in. (25 mm)
- No. 14 and 18 (No. 43 and 57) bar sizes
.....–2 in. (51 mm)

2.2.9 Bearing plate for prestressing tendons, deviation from specified planeThe lesser of $\pm 1/8$ in. (3 mm) or $\pm 1/4$ in. per ft (20 mm per 1 m)

R2.2.9 The tolerance for conformance of prestressing tendon bearing plates to the specified plane is established by this section. Refer to Fig. R2.2.9.

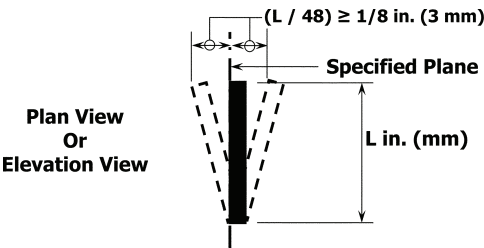


Fig. 2.2.9—Bearing plate for prestressing tendons.

2.2.10 Placement of smooth dowels in slabs-on-ground

2.2.10.1 Centerline of dowel, vertical deviation measured from bottom of concrete slab at the joint
..... $\pm 1/2$ in. (13 mm)

When element dimension is over 2 ft (0.6 m)
..... ± 1 in. (25 mm)

2.2.10.2 Spacing of dowels..... ± 3 in. (76 mm)

The total number of dowels shall not be less than that specified.

2.2.10.3 Centerline of dowel with respect to a horizontal line that is perpendicular to the plane established by the joint

Horizontal deviation..... $\pm 1/4$ in. (6 mm)

Vertical deviation $\pm 1/4$ in. (6 mm)

R2.2.10 The tolerance for placement of dowels is determined by this section. Refer to Fig. R2.2.10.1, R2.2.10.2, and R2.2.10.3.

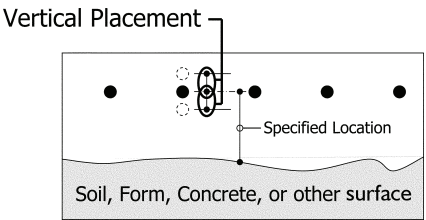


Fig. R2.2.10.1—Dowel placement.

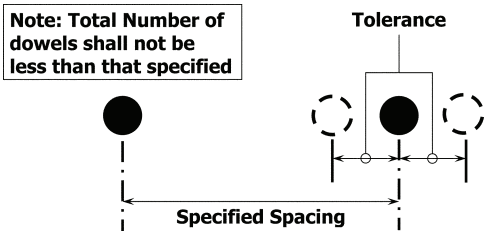


Fig. R2.2.10.2—Dowel spacing.

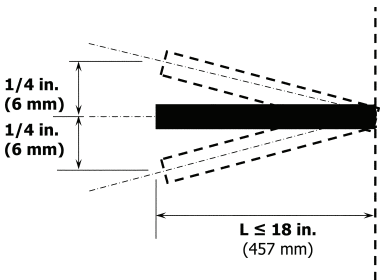


Fig. R2.2.10.3—Dowel deviation from line.

STANDARD**2.3—Placement of embedded items, excluding dowels in slabs-on-ground**

2.3.1 Clear distance to nearest reinforcement shall be the greater of the bar diameter or 1 in. (25 mm)

COMMENTARY**R2.3—Placement of embedded items, excluding dowels in slabs-on-ground**

R2.3.1 The tolerance for clear distance between reinforcement and embedded items is determined by this section. Refer to Fig. R2.3.1(a) and (b).

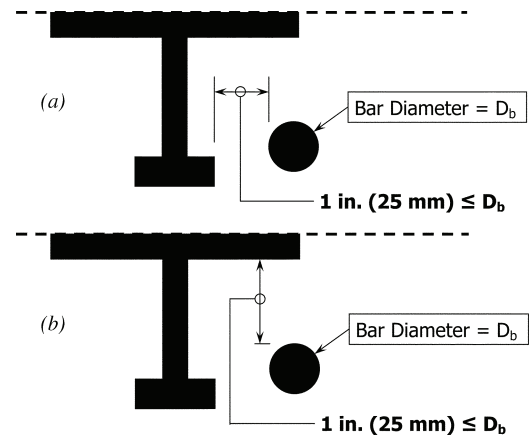


Fig. R2.3.1—Clear distance.

2.3.2 Centerline of assembly from specified location

Horizontal deviation ± 1 in. (25 mm)

Vertical deviation ± 1 in. (25 mm)

2.3.3 Surface of assembly from specified plane

Assembly dimension 12 in. (305 mm) or smaller
..... $\pm 1/2$ in. per 12 in. (40 mm per m)

Assembly dimension greater than 12 in. (305 mm)
..... $\pm 1/2$ in. (13 mm)

R2.3.3 The tolerance for the elevation of the top of anchor bolts is consistent with that contained in the American Institute of Steel Construction's Code of Standard Practice. The tolerance for the location of anchor bolts is based on using oversized holes per the *AISC Steel Design Guide Series 1, Column Base Plates*, recommendations of the Structural Steel Educational Council, and concrete contractor anchor bolt placement techniques. Refer to the American Society of Concrete Contractor's *Position Statement No. 14*.

2.3.4 Anchor bolts in concrete**2.3.4.1 Top of anchor bolt from specified elevation**

Vertical deviation $\pm 1/2$ in. (13 mm)

2.3.4.2 Centerline of individual anchor bolts from specified location

Horizontal deviation
for 3/4 in. (19 mm) and 7/8 in. (22 mm) bolts
..... $\pm 1/4$ in. (6 mm)

for 1 in. (25 mm), 1-1/4 in. (32 mm), and 1-1/2 in. (38 mm) bolts $\pm 3/8$ in. (10 mm)

for 1-3/4 in. (44 mm), 2 in. (51 mm), and 2-1/2 in. (64 mm) bolts $\pm 1/2$ in. (13 mm)

STANDARD

2.4—Concrete batching

Refer to Table 2.4.

Table 2.4

Material	Tolerance
<i>Cementitious materials</i> 30% of scale capacity or greater	±1% or required mass
Less than 30% of scale capacity	–0 to +4% of the required mass
<i>Water</i> Added water or ice, and free water on aggregates	±1% of the total water content (including added water, ice, and water on aggregates)
Total water content (measured by weight or volume)	±3% of total water content
<i>Aggregates</i> Cumulative batching: Over 30% of scale capacity	±1% of the required mass
30% of scale capacity or less	±0.3% of scale capacity or 3% of the required mass, whichever is less
Individual material batching	±2% of the required mass
<i>Admixtures</i>	±3% of the required amount or plus or minus the amount of dosage required for 100 lb (50 kg) of cement, whichever is greater

2.5—Concrete properties

2.5.1 Slump

Where slump is specified as “maximum” or “not to exceed” (Refer to ASTM C 94)

For all values+0 in. (0 mm)

Specified slump 3 in. (76 mm) or less
..... –1-1/2 in. (38 mm)

Specified slump more than 3 in. (76 mm)
.....– 2-1/2 in. (64 mm)

Where slump is specified as a single value

Specified slump 2 in. (51 mm) and less
.....±1/2 in. (13 mm)

Specified slump more than 2 in. (51 mm) through 4 in. (102 mm)±1 in. (25 mm)

Specified slump more than 4 in. (102 mm)
.....±1-1/2 in. (38 mm)

Where slump is specified as a range no tolerance

2.5.2 Air content: where no range is specified, the air content tolerance is ±1-1/2%

COMMENTARY

R2.4—Concrete batching

Refer to ASTM C 94 for additional information regarding concrete batching.

R2.5—Concrete properties

R2.5.1 Where the specification has specified slump as a maximum, the project specifications should provide for one addition of water at the job site for slump adjustment, per ASTM C 94, Section 6. Concrete slump should include a tolerance that allows for both plus or minus deviations so that concrete slumps are not underdesigned to avoid rejection. The water added at the job site should be within the water-cementitious material ratio (*w/cm*) limitations of the specifications or approved mixture proportions.

Flowing concrete achieved by the incorporation of high-range water-reducing admixtures (HRWRs) (also called superplasticizers) are regularly used at specified slumps of 7-1/2 in. (190 mm) or greater. In addition, it is difficult to measure high slumps accurately. Consideration should be given to eliminating a maximum slump when a HRWR is used to achieve flowing concrete. When HRWR admixtures are used, concrete slump should be specified for the concrete mixture prior to the addition of the HRWR.

The slump specified should always be evaluated to determine if it is suitable for delivery, placing, and reinforcement clearance.

R2.5.2 When an air content range is specified, care should be given to address aggregate size and job-site requirements. The range should be adequately wide to accommodate the preceding.

SECTION 3—FOUNDATIONS

STANDARD

3.1—Deviation from plumb

3.1.1 Category A—For unreinforced piers extending through materials offering no or minimal lateral restraint (for example, water, normally consolidated organic soils, and soils that might liquefy during an earthquake)— $\pm 12.5\%$ of shaft diameter.

3.1.2 Category B—For unreinforced piers extending through materials offering lateral restraint (soils other than those indicated in Category A)— $\pm 1.5\%$ of shaft length.

3.1.3 Category C—For reinforced concrete piers— $\pm 2.0\%$ of shaft length.

COMMENTARY

R3.1—Deviation from plumb

Refer to Fig. R3.1.1, R3.1.2, and R3.1.3.

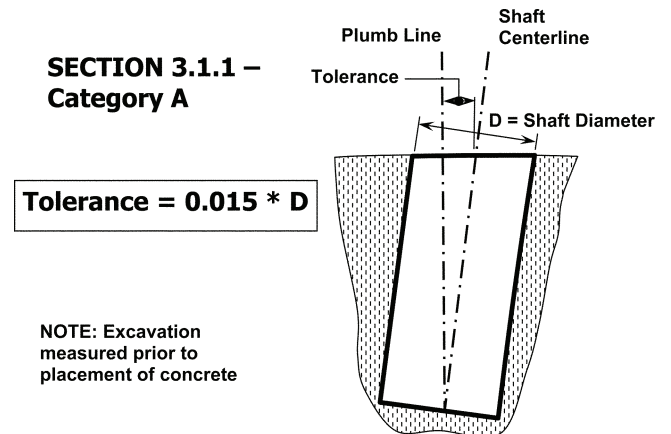


Fig. R3.1.1—Category A.

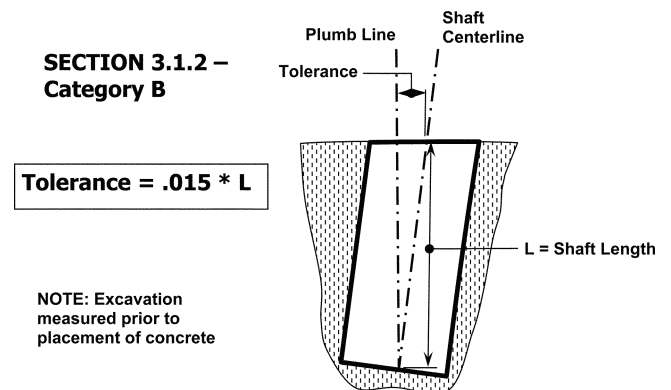


Fig. R3.1.2—Category B.

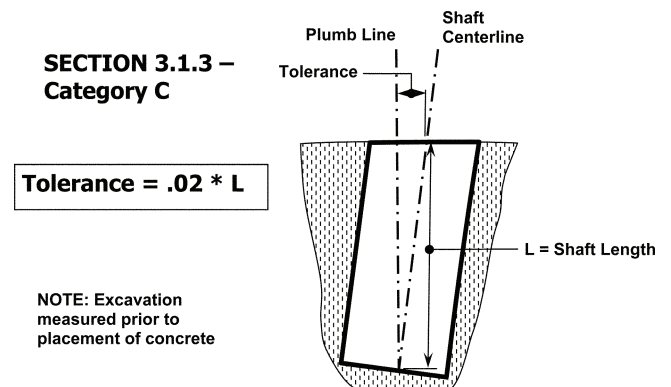


Fig. R3.1.3—Category C.

STANDARD

3.2—Deviation from location

3.2.1 Foundations, unless noted otherwise in this section

Horizontal deviation of the as-cast edge shall be the lesser of ±2% of the foundation’s width or ±2 in. (51 mm).

COMMENTARY

R3.2—Deviation from location

R3.2.1 Determines the permissible location of foundations or piers. The allowable deviation for the location of foundations or piers is governed by the dimension of the foundations or piers with an absolute limit, depending on whether the foundations or piers support concrete or masonry. Refer to Fig. R3.2.1(a) and (b).

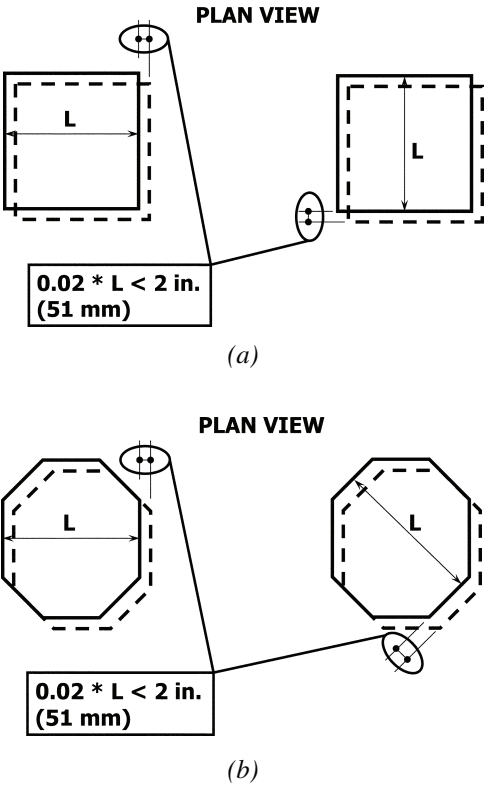


Fig. R3.2.1—Foundations, unless otherwise noted.

3.2.2 Foundations supporting masonry

Horizontal deviation of the as-cast edge shall be the lesser of ±2% of the foundation’s width or ±1/2 in. (13 mm).

R3.2.2 Foundations supporting masonry

Refer to Fig. R3.2.2(a) and (b).

STANDARD

COMMENTARY

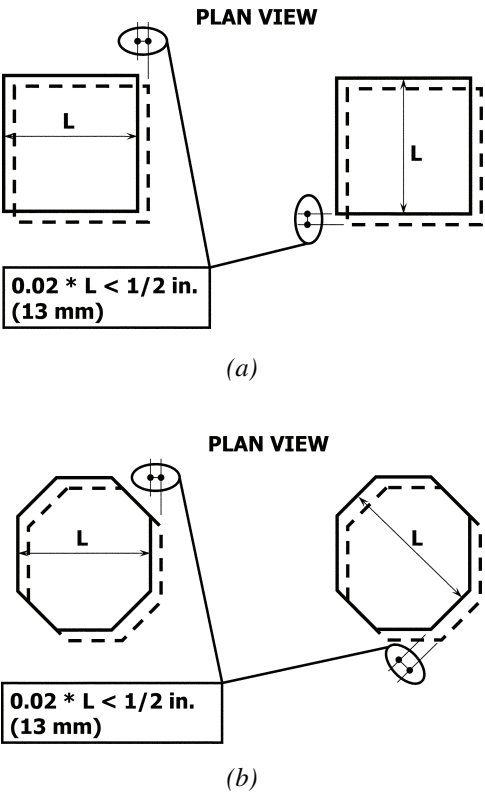


Fig. R3.2.2—Foundations supporting masonry.

3.2.3 Top of drilled piers

Horizontal deviation of the as-cast center shall be the lesser of 4.2% of the shaft diameter or ± 3 in. (76 mm).

R3.2.3 Top of drilled piers

Refer to Fig. R3.2.3.

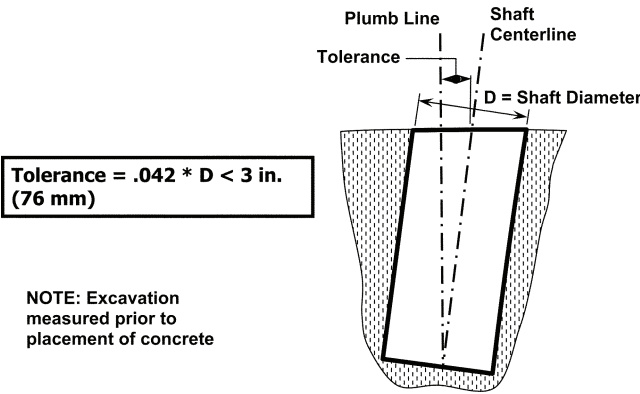


Fig. R3.2.3—Top of drilled piers: horizontal deviation.

STANDARD

3.3—Deviation from elevation

3.3.1 Top surface of foundations

Vertical deviation+1/2 in. (13 mm)
.....-2 in. (51 mm)

3.3.2 Top surface of drilled piers

Vertical deviation+1 in. (25 mm)
.....-3 in. (76 mm)

3.4—Deviation from plane

3.4.1 Base of bell pier

The lesser of 10% of the bell diameter or ±3 in. (76 mm).

COMMENTARY

R3.3—Deviation from elevation

Determines the location of any point on the top surface of a footing relative to the specified plane. Refer to Fig. R3.3.1 and R3.3.2.

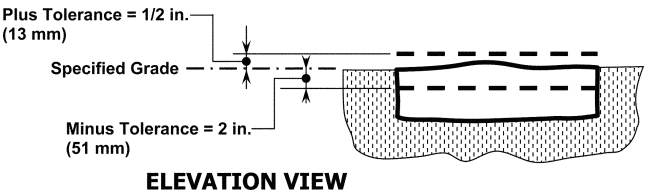


Fig. R3.3.1—Top surface of foundations: vertical deviation.

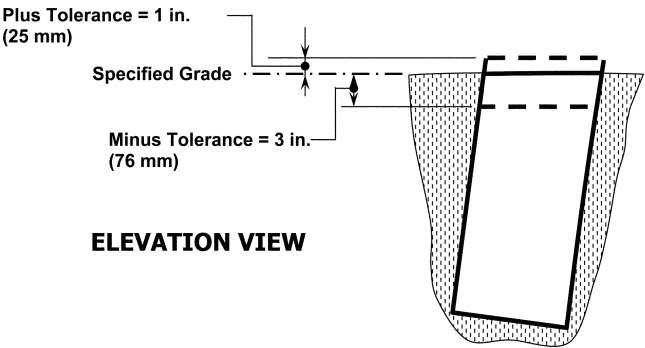


Fig. R3.3.2—Top surface of drilled piers: vertical deviation.

R3.4—Deviation from plane

Determines the allowable slope of the base of a bell pier. Refer to Fig R3.4.1.

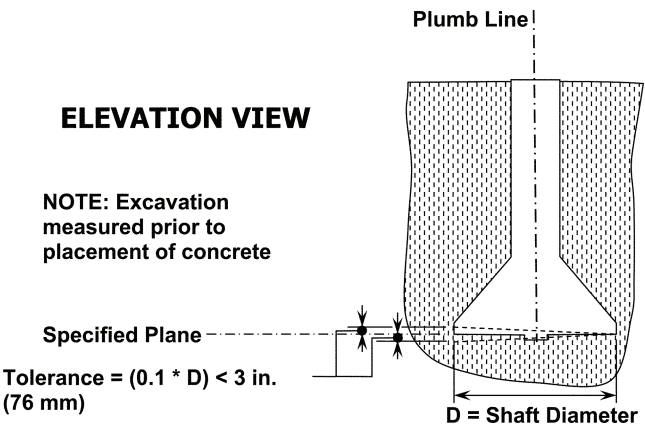


Fig. R3.4.1—Base of bell pier.

STANDARD**3.5—Deviation from cross-sectional dimensions of foundations****3.5.1 Formed footings**

Horizontal deviation +2 in. (51 mm)

..... -1/2 in. (13 mm)

3.5.2 Unformed footings cast against soil

Horizontal deviation from plan dimension

Where dimension is 2 ft (0.6 m) or less

..... +3 in. (76 mm)

..... -1/2 in. (13 mm)

Where dimension is more than 2 ft (0.6 m)

..... +6 in. (152 mm)

..... -1/2 in. (13 mm)

3.5.3 Deviation from footing thickness -5%**COMMENTARY****R3.5—Deviation from cross-sectional dimension of foundations**

Determines the permissible size of a footing. Refer to Fig. R3.5.1, R3.5.2(a) and (b), and R3.5.3.

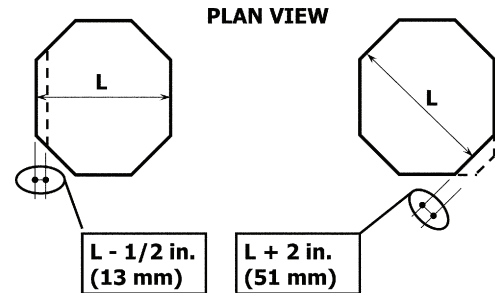
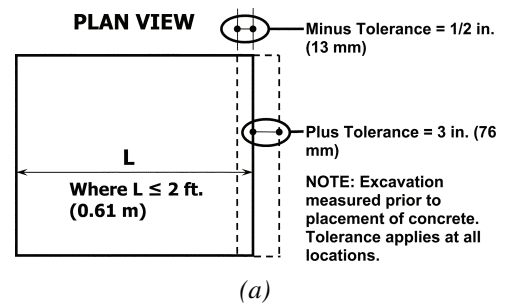
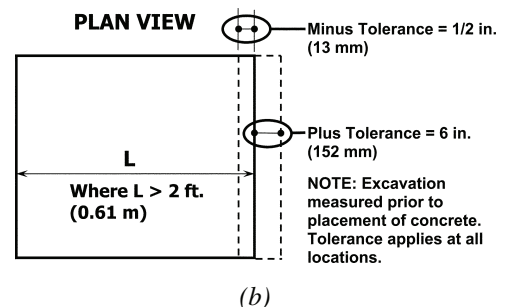


Fig. R3.5.1—Formed foundations: cross-sectional dimensions.



(a)



(b)

Fig. R3.5.2—Unformed footings cast against soil.

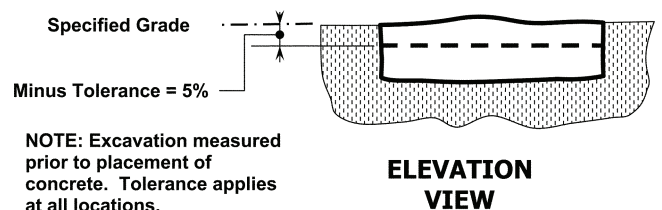


Fig. R3.5.3—Deviation from footing thickness.

Notes

SECTION 4—CAST-IN-PLACE CONCRETE FOR BUILDINGS

STANDARD

4.1—Deviation from plumb

4.1.1 For heights less than or equal to 83 ft 4 in. (25.4 m)

For lines, surfaces, corners, arises, and elements: the lesser of 0.3% times the height above the top of foundations as shown on structural drawings or ± 1 in. (25 mm).

For the outside corner of an exposed corner column and contraction joint grooves in concrete exposed to view: the lesser of 0.2% times the height above the top of foundations as shown on structural drawings or $\pm 1/2$ in. (13 mm).

COMMENTARY

R4.1—Deviation from plumb

R4.1.1 The tolerance for plumb varies with the height above the top of foundation of the structure. Between the top of foundation and a height of 83 ft 4 in. (25.4 m), the tolerance is 0.3% of the height until a maximum dimension of 1 in. (25 mm) is reached. Refer to Fig. R4.1.1(a) and (b). The tolerance for the outside corner of exposed corner columns and for contraction joint grooves in exposed concrete is more stringent.

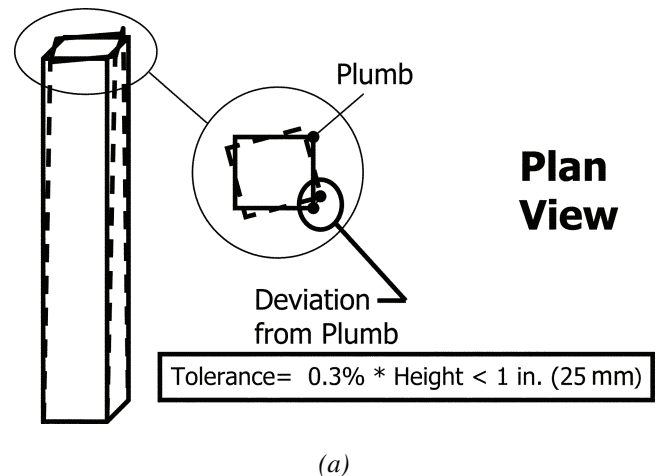
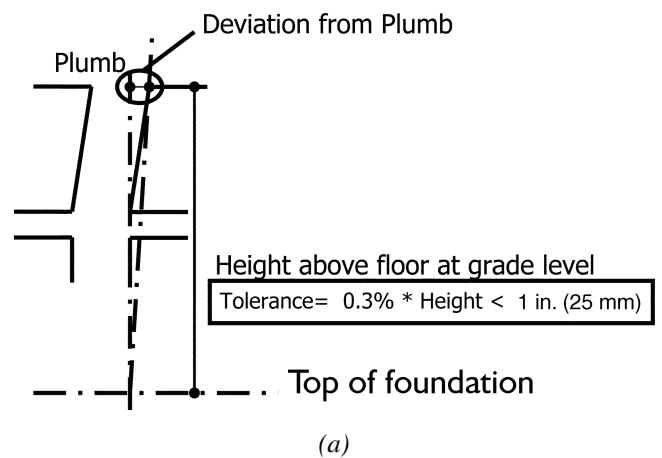


Fig. R4.1.1—Deviation from plumb.

STANDARD

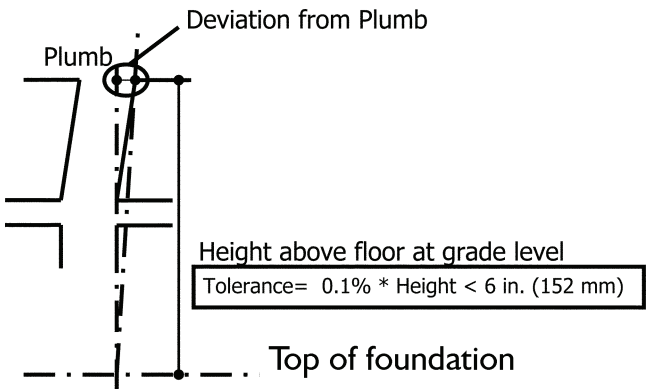
4.1.2 For heights greater than 83 ft 4 in. (25.4 m)

For lines, surfaces corners, arises, and elements: the lesser of 0.1% times the height above the top of foundations as shown on structural drawings or ±6 in. (152 mm).

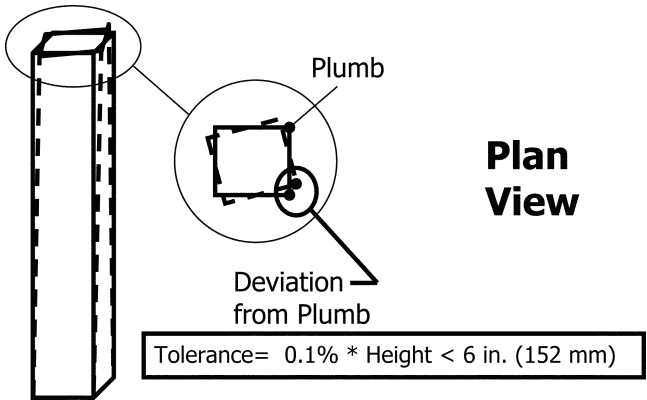
For the outside corner of an exposed corner columns and contraction joint grooves in concrete exposed to view: the lesser of 0.05% times the height above the top of foundations as shown on structural drawings or 3 in. (76 mm).

COMMENTARY

R4.1.2 From 83 ft 4 in. (25.4 m) to 500 ft (152.4 m) above the top of foundation, the tolerance for plumb is 1/1000 (0.1%) times the height. The maximum tolerance is 6 in. (152 mm) at heights more than 500 ft (152.4 m) above the top of foundation of the structure. The structure and exterior cladding should not extend beyond legal boundaries established by the contract documents. Refer to Fig. R4.1.2(a) and (b).



(a)



(b)

Fig. R4.1.2—Deviation from plumb.

4.1.3 Vertical edges of openings larger than 12 in. (305 mm), measured over the full height of the opening.....±1/2 in. (13 mm)

R4.1.3 The plumb tolerance for edges of openings larger than 12 in. (305 mm) is established by this section. Refer to Fig. R4.1.3.

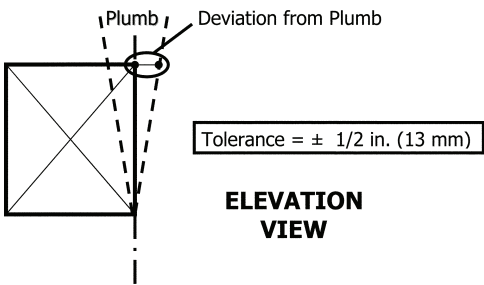


Fig. R4.1.3—Deviation from plumb.

STANDARD**4.2—Deviation from location****4.2.1 Horizontal deviation**

Vertical elements, measured at the top of element foundation ± 1 in. (25 mm)

Other elements ± 1 in. (25 mm)

Edge location of all openings $\pm 1/2$ in. (13 mm)

Sawcuts, joints, and weakened plane embedments in slabs $\pm 3/4$ in. (19 mm)

COMMENTARY**4.2—Deviation from location**

R4.2.1 Horizontal deviation is defined in [Section 1.3](#). The tolerance for horizontal deviation would apply to the plan location of items such as the vertical edge of a floor opening or of a wall, beam, or column. The tolerance for horizontal deviation would also apply to items such as the vertical edges of openings in walls, beams, or columns. Refer to Fig. R4.2.1(a) to (c).

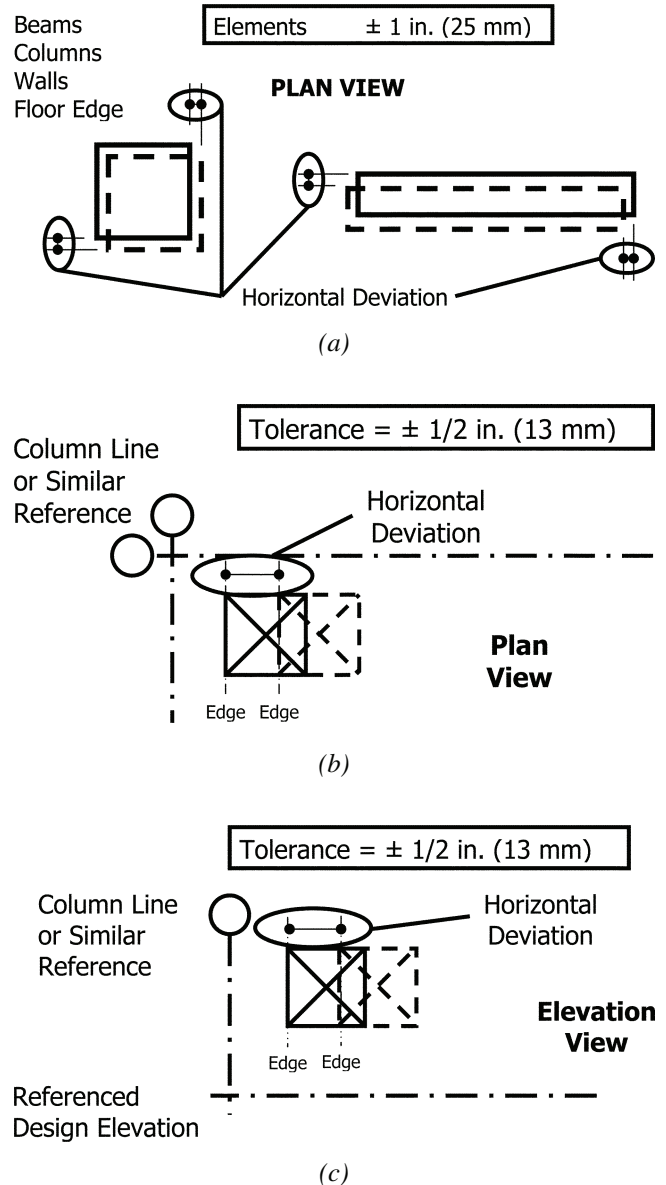


Fig. R4.2.1—Horizontal deviation.

STANDARD

4.2.2 Vertical deviation

Elements	± 1 in. (25 mm)
Edge location of all openings	$\pm 1/2$ in. (13 mm)

COMMENTARY

R4.2.2 Vertical deviation is also defined in [Section 1.3](#). The tolerance for vertical deviation would apply to the location of items such as the horizontal edges of a wall or column opening. The tolerance for vertical deviation would also apply to items such as the horizontal edges of openings in walls, beams, or columns. Refer to Fig. R4.2.2(a) and (b).

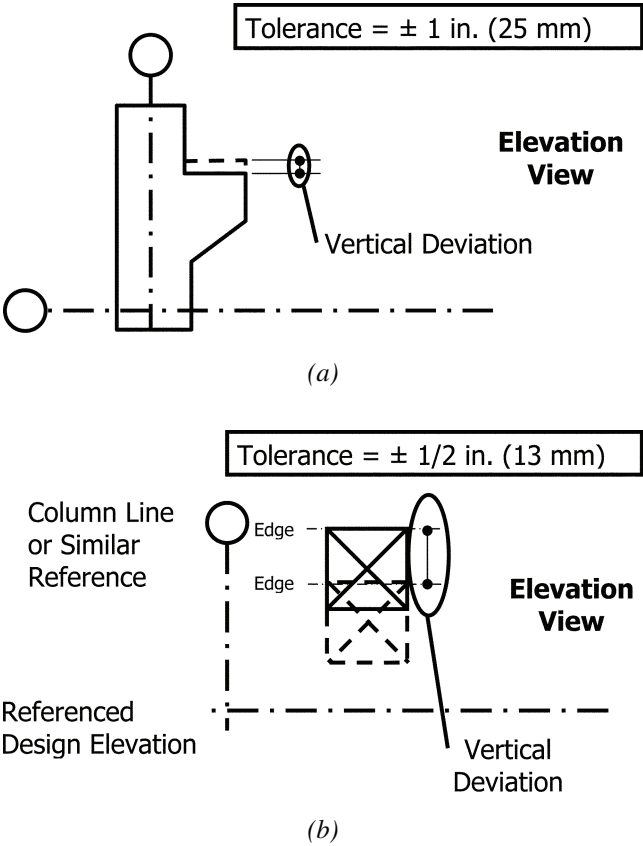


Fig. R4.2.2—Vertical deviation.

4.3—Distance between adjacent elements sectioned by a vertical plane

4.3.1 Where specified width is 2 in. (51 mm) or less
..... $\pm 1/8$ in. (3 mm)

Where specified width is more than 2 in. (51 mm) but not more than 12 in. (305 mm) $\pm 1/4$ in. (6 mm)

4.3.2 All other elements..... ± 1 in. (25 mm)

R4.3—Distance between adjacent elements sectioned by a vertical plane

R4.3.2 Refer to [Fig. R4.3.2](#).

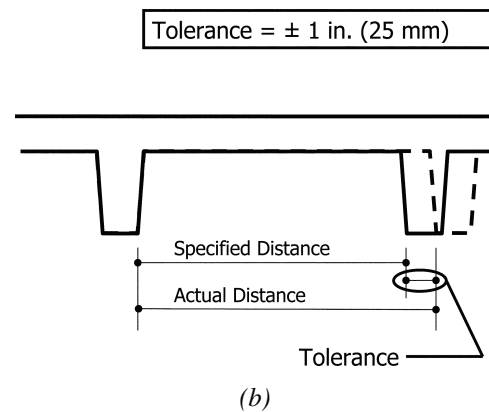
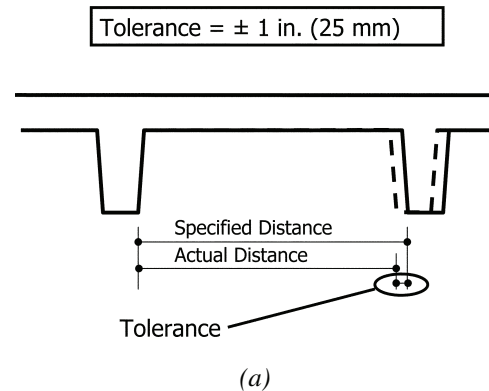
STANDARD**COMMENTARY**

Fig. R4.3.2—Distance between adjacent elements sectioned by a vertical plane.

4.4—Deviation from elevation**4.4.1 Top surface of slabs**

Slabs-on-ground..... $\pm 3/4$ in. (19 mm)

Formed suspended slabs, before removal of supporting shores $\pm 3/4$ in. (19 mm)

Slabs on structural steel or precast concrete
..... no requirement

4.4.2 Formed surfaces before removal of shores
..... $\pm 3/4$ in. (19 mm)

4.4—Deviation from elevation

R4.4.1 The top elevation for slabs on structural steel or precast concrete will be determined by elevation of the supporting steel or precast concrete, plus or minus variations in slab thickness, as specified in [Section 4.5.3](#). In situations where this procedure may result in unsatisfactory slab elevations (for example, unshored beams that deflect or supporting steel or precast set with large deviations from specified elevation), the architect/engineer should specify, or the contractors involved should agree on, a satisfactory procedure. The concrete flooring contractor cannot control elevations of steel or precast concrete members upon which concrete slabs are cast. In the instance of slabs cast on metal deck, there is also a practical limitation on the increase of slab thickness to accommodate differential elevations or deflections. If the specifier requires the concrete slab to be placed level on deflecting or cambered supporting steel or precast, the plus tolerance is likely to be exceeded.

STANDARD

4.4.3 Lintels, sills, parapets, horizontal grooves, and other lines exposed to view±1/2 in. (13 mm)

4.4.4 Top of walls.....±3/4 in. (19 mm)

4.4.5 Fine grade of soil immediately below slabs-on-ground±3/4 in. (20 mm)

4.5—Deviation from cross-sectional dimensions

4.5.1 Thickness of elements, except slabs, where specified dimension is

12 in. (305 mm) or less.....+3/8 in. (10 mm)
.....–1/4 in. (6 mm)

More than 12 in. (305 mm), and not more than 36 in. (0.90 m)+1/2 in. (13 mm)
.....–3/8 in. (10 mm)

More than 36 in. (0.90 m)+1 in. (25 mm)
.....–3/4 in. (19 mm)

4.5.2 Unformed beams and walls cast against soil

4.5.2.1 Deviation from thickness–5%

COMMENTARY

R4.4.3 The term “exposed to view” refers to areas that will be readily apparent to the public in normal use of the structure. In multistory construction, for example, the tolerance would apply to conditions that are visible with the unaided eye from the ground surrounding the structure or from a balcony, floor, or similar building element that is subject to routine access by the public. A stair tower would not be classified as “exposed to view” because stairs are typically intended for use only as an emergency exit route. The committee considers a viewing distance of 20 ft (6 m) to be consistent with the intent of this tolerance.

R4.4.5 The elevation of the soil upon which a slab-on-ground is to be placed is generally more difficult to control than that of the concrete surface. The intent of establishing an elevation tolerance of ±3/4 in. (20 mm) for fine grading below slabs-on-ground is to provide an environment in which a slab-on-ground installation can successfully comply with the thickness requirements established in Section 4.5.4. If more stringent tolerance requirements are deemed necessary by the specifier, consider a fine grade elevation tolerance of ±1/2 in. (13 mm). This tolerance is reasonable for industrial applications because more sophisticated equipment is normally used to establish the fine grade elevation and because of the performance requirements for industrial slabs.

R4.5—Deviation from cross-sectional dimensions

Cross-sectional dimensions determine the permissible thickness of concrete members, variation in opening width, or the depth of sawcut joints.

STANDARD**4.5.3** Thickness of suspended slabs.... –1/4 in. (6 mm)**4.5.4** *Thickness of slabs-on-ground*

Average of all samples..... –3/8 in. (10 mm)

Individual sample –3/4 in. (19 mm)

4.5.4.1 Minimum number of samples shall be one per 10,000 ft² (929 m²).**4.5.4.2** Samples shall be taken within 7 days of placement.**4.5.4.3** Samples shall be randomly located over the test area and shall be taken by coring of the slab or by using an impact-echo device.**4.5.4.3.1** Where concrete core samples are taken, the length of each core sample shall be determined using ASTM C 174.**4.5.4.3.2** An impact-echo device, when used, shall be calibrated using a minimum of three random locations within the test area where the actual concrete thickness is known. The impact-echo test shall be conducted in accordance with ASTM C 1383.**4.5.4.4** Location of the samples shall be identified and results recorded in a manner that will allow an independent third party to verify the accuracy of the data.**COMMENTARY****R4.5.3** Suspended (elevated) slabs require only that a tolerance for elevation and cross-sectional dimension be established. Thickness of suspended slabs is of primary concern because insurance carriers establish a fire rating of the structure, depending on the occupancy. The fire rating is derived in part from the insulating properties of concrete and the thickness of the concrete slab. Achieving the minimum period of fire separation between floors depends in part on achieving a minimum thickness. Variations in the elevation of erected steel or precast concrete and in deflections of the supporting metal deck and frame under weight of concrete often make it necessary to provide additional slab thickness in local areas to produce a relatively level slab. Care should be taken to ensure that providing additional concrete in local areas does not overload the supporting formwork or metal deck.**R4.5.4** Specifiers should anticipate localized occurrences of reduced thickness for slabs-on-ground. The slab-on-ground thickness tolerance has been set with respect to both average thickness for all the samples measured and a minimum thickness for individual samples.Where the specifier determines requirements of this section are inadequate for a particular application, the specifier should incorporate within the project specifications specific sampling procedures and acceptance criteria for all elements impacting thickness of slabs-on-ground (**Sections R4.4.1, R4.4.5, and R4.5.4**). In such an instance, consideration might be given to statistical control of the subgrade, elevation of the concrete surface, and slab thickness.**R4.5.4.2** There are circumstances where it is not practical to take samples within 7 days. Sampling after the specified 7-day period will not adversely affect the measured values; however, it may affect the ability to take corrective action.

STANDARD

COMMENTARY

4.5.4.5 When computing the average of all samples, samples with a thickness more than 3/4 in. (19 mm) above the specified thickness shall be assumed to have a thickness 3/4 in. (19 mm) more than the specified thickness.

4.5.4.6 When corrective action is required, additional samples shall be taken in the vicinity of unacceptable results to establish the extent of corrective action.

4.6—Deviation from sawcut depth or formed opening width or height

4.6.1 Depth of sawcut joints±1/4 in. (6 mm)

4.6.2 Opening width or height–1/2 in. (13 mm)
.....+1 in. (25 mm)

4.7—Deviation from relative elevations or widths

4.7.1 *Stairs, measured along a line parallel to the stair axis*

Elevation of consecutive risers at the nosing
.....±3/16 in. (5 mm)

Width of consecutive treads or within one tread
..... ±3/16 in. (5 mm)

4.8—Deviation from slope or plane

4.8.1 Stair tread from back to nosing ...±1/4 in. (6 mm)

4.8.2 *Formed surfaces over distances of 10 ft (3 m)*

All conditions, unless noted otherwise in this section
.....±0.3%

Outside corner of exposed corner column±0.2%

Contraction joint grooves in concrete exposed to view
.....±0.2%

4.8.3 *Formed surface irregularities (gradual or abrupt)*

Abrupt irregularities shall be measured within 1 in. (25 mm) of the irregularity. Gradual surface irregularities shall be measured by determining the gap between concrete and near surface of a 5 ft (1.5 m) straight-edge, measured between contact points.

R4.6.1 Specifiers are cautioned that a tighter tolerance should be specified where there is a potential for cutting reinforcement.

R4.8.2 This is one of several paragraphs that addresses the proper location of formed surfaces. Local departure of the formed surface from the specified slope or plane is addressed in this section. A departure of 0.3% is approximately 3/8 in. (10 mm) over a distance of 10 ft (3.0 m). Tolerances are based on a 10 ft (3.0 m) measured length. Interpolation or extrapolation of tolerances for dimensions greater than or less than 10 ft (3.0 m) are not permitted. Other sections, such as 4.1 and 4.4.2, establish a global tolerance for elements.

R4.8.3 Specifiers should anticipate local irregularities in formed surfaces. The purpose of establishing different classes of surface is to define the magnitude of irregularities in a manner that is consistent with the exposure of the concrete when in service. As stated in Section R4.4.3, the term “exposed to view” is primarily an aesthetic consideration and this tolerance is properly applied to conditions that are readily apparent to the public in normal use of the structure.

STANDARD

Class A Surface	+1/8 in. (3 mm)
Class B Surface	+1/4 in. (6 mm)
Class C Surface	+1/2 in. (13 mm)
Class D Surface	+1 in. (25 mm)

4.8.4 Random traffic floor surface finish tolerances shall meet the requirements of **Section 4.8.5** or **4.8.6**.

COMMENTARY

Within a commercial structure, for example, the inside face of a concrete exit stair or the face of a concrete wall in an area, such as a mechanical or electrical room, would not be considered exposed to view. The specifier should also anticipate abrupt transitions at the surface of members where segmental steel void forms are used to form floor framing members.

R4.8.4 The purpose of establishing floor surface tolerances is to define surface characteristics that are of importance to those who will be using the surface. The two surface characteristics thought to be of greatest importance for concrete floors are flatness and levelness. Flatness can be described as bumpiness of the floor, and is the degree to which a floor surface is smooth or plane. Levelness is the degree to which a floor surface parallels the slope established on the project drawings. Two methods are identified for use in the evaluation of floor surface finish tolerances. The F-Number System uses data taken at regular intervals along lines located in random locations on the test surface. The described methods use different criteria to evaluate the as-constructed data. Therefore, it is important that the specifier select the method most applicable to the end user of the floor. The Waviness Index may be used instead of the two methods identified in **Section 4.8** by specifying parameters established in the Optional Checklist. Before contracting to build to any floor tolerance specification, it is suggested the constructor evaluate data from tests of its own floors. Data should be processed using the proposed floor tolerance specification to confirm an understanding of the specific approach and its implications on proposed construction means and methods. Specifiers may require the constructor to demonstrate proven ability by testing an existing floor slab installed by the constructor.

Each of the methods described herein will yield a slightly different result. Each of the described approaches uses a different method to evaluate flatness. The F-Number System uses only 2 ft (0.6 m) slope changes (center offset from a 2 ft [0.6 m] chord). The manual straightedge and computerized simulation of the manual straightedge methods both use maximum offsets from chords of varying lengths up to 10 ft (3.0 m).

To develop an understanding of the relationship among these approaches, the committee undertook a study of six groups of 100 individual profiles each (600 total). The profiles included all quality levels likely to be produced using current construction techniques; each of the profiles was 100 ft (30 m) long. **Table R4.8.4** shows partial results of that study. Evaluation of the results resulted in the tolerance values contained in **Sections 4.8.5** and **4.8.6**.

STANDARD

COMMENTARY

Table R4.8.4—Methods to evaluate flatness

Floor classification	F_F flatness ($SOFF_F$)	10 ft (3.0 m) manual straightedge maximum gap, in. (mm)
Conventional	20	0.628 to 0.284 (16 to 7)
Moderately flat	25	0.569 to 0.254 (15 to 6)
Flat	35	0.359 to 0.163 (9 to 4)
Very flat	45	0.282 to 0.144 (7 to 4)
Super flat	60	0.253 to 0.135 (6 to 3)
Floor classification	10 ft (3.0 m) manual straightedge maximum gap, in. (mm)	$SOFF_F$ range
Conventional	1/2 (13)	17.4 to 27.7
Moderately flat	3/8 (16)	20.3 to 34.9
Flat	1/4 (6)	24.0 to 45.9
Very flat	3/16 (5)	31.7 to 64.3
Super flat	1/8 (3)	37.7 to 109.3

Floor surface classifications shown in Sections 4.8.5 and 4.8.6 vary from conventional at the low end to super flat at the high end of the flatness/levelness spectrum. Although there is no direct correlation among the described tolerancing methods, similarly classified floors in Sections 4.8.5 and 4.8.6 should provide the user with floor surfaces of approximately the same flatness and levelness.

Floor surfaces in the conventional category can be routinely produced using strikeoff and finishing techniques that include no restraighening operations after initial strikeoff. This classification of floor surface is generally not compatible with floor coverings such as carpeting and vinyl flooring. Conventional floor surface tolerances are appropriately applied to areas such as mechanical rooms, nonpublic areas, or surfaces under raised computer flooring or thick-set tile.

The moderately flat classification of surface tolerances will routinely require the use of float dish attachments to the power float machines or some restraighening of the concrete surface during finishing operations to consistently achieve flatness requirements. The moderately flat surface can routinely be produced by using a wide bull float (8 to 10 ft [2.4 to 3.0 m]) to smooth the concrete and a modified highway straightedge to restraighen the surface after completion of the initial power float pass. The use of a rider with float dishes attached to the trowel blades can reduce the amount of restraighening required by the modified highway straightedge. An appropriate use of floor surfaces with this classification would be carpeted areas of commercial office buildings or industrial buildings with low-speed vehicular traffic.

Flat floor tolerances are appropriate for concrete floors under thin-set ceramic, vinyl tile, or similar coverings. Flat floor tolerances are also appropriate for use in warehouses employing conventional lift trucks and racks. The flat classification requires restraighening after floating and is the highest feasible tolerance level for suspended slabs.

STANDARD

COMMENTARY

Very flat floor tolerances are generally restricted to high-end industrial applications, such as might be required for successful operation of high-speed lift trucks, air pallets, or similar equipment. Multiple restraightenings in multiple directions following both the floating and initial finishing phases are required to produce floors conforming to very flat tolerances. The use of a laser screed or rigid edge forms up to 30 ft (9.1 m) apart can achieve the required degree of levelness.

The super flat category is the highest quality random traffic floor surface classification that can be routinely produced using current technology. Only skilled contractors, using sophisticated equipment, will be able to achieve this level of quality. Restraightening operations for this floor category are more rigorous than that described for the very flat category. The super flat random traffic category is only appropriate for limited applications, such as TV production studios.

Another type of super flat floor surface, one that falls outside the scope of random traffic specifications, is that which is required for defined traffic applications, such as narrow aisle industrial warehouse floors. The aisle width in these installations is typically about 5 ft (1.5 m) wide, and the narrow clearance between the vehicles and racks requires construction of an extremely smooth and level surface. The tolerance requirements normally dictate strip placement of concrete using closely spaced rigid forms (approximately 15 ft [4.6 m] on center), but they can occasionally be achieved without narrow strip placement by skilled contractors using sophisticated equipment.

The evaluation of the super-flat-defined traffic surface classification requires specialized techniques that should be agreed on by all parties before construction. The test method should measure:

- 1) The maximum transverse elevation difference between wheel tracks;
- 2) The maximum elevation difference between front and rear axle; and
- 3) The maximum rate of change per foot (meter) for 1) and 2) as the vehicle travels down the aisle.

Flatness of defined traffic wheel tracks can also be specified by reference to ASTM E 1486, Section 4.9.

The remedy for noncompliance with specified defined flatness tolerances should be included in specification language. For random traffic slabs-on-grade, the remedy can range from liquidated damages, to localized grinding, to application of a topping, to removal and replacement, depending on the purpose for which the slab is being installed. The remedy for defined traffic installations is generally grinding of high spots.

STANDARD

4.8.4.1 Floor test surfaces shall be measured and reported within 72 hours after completion of slab concrete finishing operations and before removal of any supporting shores.

4.8.4.2 Floor surface test measurements shall not cross planned changes in floor surface slope.

4.8.4.3 Test results shall be reported in a manner that will allow reproduction of the test data.

4.8.5 Random traffic floor finish tolerances as measured in accordance with the “Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers (ASTM E 1155).”

4.8.5.1 Specified overall values for flatness (SOF_F) and levelness (SOF_L) shall conform to one of the following floor surface classifications, unless noted otherwise.

Floor surface classification	Specified overall flatness SOF_F	Specified overall levelness SOF_L
Conventional	20	15
Moderately flat	25	20
Flat	35	25
Very flat	45	35
Super flat	60	40

COMMENTARY

R4.8.4.1 The purpose for establishing a default 72-hour time limit on the measurement of floor surfaces is to avoid any possible conflict over the acceptability of the floor and to alert the contractor of the need to modify finishing techniques on subsequent placements, if necessary, to achieve compliance. All slabs will shrink; joints and cracks in slabs-on-ground will curl with time, resulting in a surface that is less flat with the passage of time. If the needs of the user are such that a delay in testing is necessary to allow successful installation of subsequent work, this requirement for delayed testing should be clearly stated in the specifications.

R4.8.4.2 Ramped (sloped) surfaces can be toleranced by reference to ASTM E 1486 or the average slope of 15 ft (4.6 m) least squares fit of each survey line calculated in accordance with ASTM E 1486, Section 4.11 and Eq. (21), (22), and (23). Survey lines should be parallel to the direction of slope. In instances where the specifier chooses to provide a tolerance at construction joints, specific provisions for data collection should be included in the project specifications.

R4.8.5 The F-Number System evaluates the flatness of a floor surface by measuring slope changes over a distance of 2 ft (0.6 m). Specifics of the test procedure are dictated by ASTM E 1155. The 2 ft (0.6 m) slope change data are evaluated to develop an estimate of the floor’s flatness. The system evaluates the levelness of a floor surface by measuring elevation changes relative to a horizontal plane and between points separated by a distance of 10 ft (3.0 m). These 10 ft (3.0 m) elevation differences are evaluated to develop an estimate of the floor’s levelness. Higher numbers indicate better quality in the surface characteristic being reported.

STANDARD

4.8.5.2 The SOF_F and SOF_L values shall apply to the test surface as defined in ASTM E 1155, unless noted otherwise.

4.8.5.3 Minimum local values for flatness (MLF_F) and levelness (MLF_L) shall equal 3/5 of the SOF_F and SOF_L values, respectively, unless noted otherwise. The MLF_F and MLF_L values shall apply to the minimum areas bounded by the column lines and half-column lines, or the minimum areas bounded by the construction and contraction joints, whichever are the smaller areas.

4.8.5.4 The SOF_L and MLF_L levelness tolerances shall apply only to level slabs-on-ground or to level suspended slabs that are shored when tested.

4.8.6 Random traffic floor finish tolerances as measured by manually placing a freestanding (unleveled) 10 ft (3 m) straightedge anywhere on the slab and allowing it to rest naturally upon the test surface shall conform to the following requirements:

COMMENTARY

R4.8.5.2 The specified overall values SOF_F and SOF_L are the F_F and F_L numbers to which the completed project floor surface must conform viewed in its entirety. Daily F_F/F_L results may vary above and below SOF_F/SOF_L without consequence, provided: a) that the cumulative results ultimately equal or exceed SOF_F/SOF_L , and b) that the specified MLF_F and MLF_L values are satisfied at all locations. The F-Number System provides daily running totals of the aggregate in-place areas that are less than, equal to, and better than SOF_F and SOF_L . Consequently, after the entire floor has been installed, the system permits the immediate calculation of liquidated damages based on the final aggregate areas defective relative to either SOF_F or SOF_L F_F (whichever yields the larger penalty).

R4.8.5.3 Some local variation in floor surface quality should be anticipated by the specifier, much as one should anticipate variations in results of concrete compressive tests. These variations can be caused by normal occurrences, such as inconsistent setting time of concrete, changes in ambient conditions, or delays in delivery or placement of the concrete. The specified MLF_F and MLF_L values establish the minimum surface quality that will be acceptable anywhere on any of the concrete placements. Experience has shown that the use of tools and techniques that will generally meet specific SOF_F/SOF_L requirements for the overall concrete placement are also sufficient to meet the associated MLF_F/MLF_L requirements in the minimum local areas. Acceptance or rejection of a minimum local area requires that data collection within the minimum local area in question meet the requirements of ASTM E 1155. Because MLF_F and MLF_L , in theory, define the minimum usable floor, MLF_F/MLF_L defects normally require physical modification (that is, grinding, topping, or removal and replacement) of the entire affected minimum local area.

R4.8.5.4 Initial camber, curling, and deflection all adversely affect the conformance of a floor surface to a plane. Limiting the use of F_L to evaluation of level slabs-on-ground and level suspended slabs before shores or forms are removed ensures that the floor's levelness is accurately assessed.

R4.8.6 The manual straightedge approach evaluates the flatness of a floor surface by placing a 10 ft (3.0 m) long straightedge on the floor surface and measuring the maximum gap that occurs under the straightedge and between the support points.

STANDARD

4.8.6.1 The gap under the straightedge and between the support points shall not exceed one of the following:

Floor surface classification	Maximum gap 90% compliance Samples not to exceed	Maximum gap 100% compliance Samples not to exceed
Conventional	1/2 in. (13 mm)	3/4 in. (19 mm)
Moderately flat	3/8 in. (10 mm)	5/8 in. (16 mm)
Flat	1/4 in. (6 mm)	3/8 in. (10 mm)
Very flat	N/A	N/A
Super flat	N/A	N/A

4.8.6.2 The following minimum sampling requirements shall apply for test surfaces evaluated using this tolerance method:

4.8.6.2.1 A test surface is deemed to meet specified tolerances if it complies with the limitations imposed by the 90% and 100% columns above. Maximum gap between a taut string stretched between ends of the straightedge and the straightedge shall not exceed 1/32 in. (0.8 mm) at any point.

4.8.6.2.2 The minimum number of samples = (0.01) area for floor areas measured in ft² or (0.1) area for floor areas measured in m². A sample is a single placement of the straightedge.

4.8.6.2.3 Orientation of straightedge shall be parallel, perpendicular, or at a 45-degree angle to longest construction joint bounding the test surface.

4.8.6.2.4 An equal number of samples shall be taken in perpendicular directions.

4.8.6.2.5 Samples shall be evenly distributed over the test surface.

4.8.6.2.6 Straightedge centerpoint locations for samples shall not be closer than 5 ft (1.5 m).

4.8.6.2.7 Test results shall be reported in a manner that will allow reproduction of the test data, such as a key plan showing straightedge centerpoint location and straightedge orientation.

4.8.6.3 A computerized simulation of a freestanding 10 ft (3 m) straightedge test shall be permitted to be used as an alternative to the test procedure established in the contract documents or the previous paragraph. Data collection procedures and evaluation of data shall comply with the requirements established in the contract documents or 4.8.6.2.

COMMENTARY

R4.8.6.1 Measurements should be taken between straight-edge support points and perpendicular to its base. Smaller gaps between the straightedge and supporting surface are indicative of higher flatness quality. The use of this approach requires that 90% of the data samples should comply with values in the second column, and 100% of the data samples should comply with values in the third column. This method is not sufficiently precise to evaluate very flat and super flat categories.

R4.8.6.2 At the time the document was prepared, no nationally accepted standard has been developed to govern evaluation of a floor surface using this procedure, so minimum sampling requirements have been established in this section. The specifier may provide alternative procedures as long as specific testing requirements and acceptance criteria are established. Test results should be reproducible. When using this approach to evaluate floor surfaces, levelness is subject to the provisions of [Section 4.4.1](#); the manual straightedge approach does not directly measure levelness.

R4.8.6.3 A computerized simulation of a manual straight-edge approach can be used to evaluate the flatness of a floor surface. Data are taken using an instrument other than a straightedge and processed using a computer to produce results similar to that achieved using a manual straightedge. This method requires that data be collected along lines in a manner similar to that described by ASTM E 1155 or

STANDARD**COMMENTARY**

4.8.7 Root mean square (RMS) levelness tolerance in in./ft (mm/m) for floors purposely pitched in one direction shall be obtained per the requirements of Paragraph 4.11 of ASTM E 1486. Each survey line used in the RMS levelness calculation shall be parallel with the others and all lines shall be in the direction of the pitch or tilt.

ASTM E 1486. The flatness is evaluated by moving a simulated 10 ft (3.0 m) long straightedge along each data line at 1 ft (3.0 m) intervals. No ASTM standard has been developed to govern evaluation of a floor surface using this procedure, so the specifier should provide specific testing requirements and acceptance criteria as described in the Mandatory Checklist. Results should be reproducible. When using this approach to evaluate floor surfaces, levelness is subject to the provisions of [Section 4.4.1](#); the computerized simulation of a manual straightedge approach does not directly measure levelness. The specifier is advised that current available software for computerized simulation of a free-standing 10 ft (3 m) straightedge does not meet the requirements of [4.8.6.2](#).

Notes

SECTION 5—PRECAST CONCRETE

STANDARD

This section has been removed.

COMMENTARY

For guidance and recommended tolerances for precast elements, the specifier should refer to “Tolerance Manual for Precast and Prestressed Concrete Construction,” Prestressed Concrete Institute, MNL 135.

Notes

SECTION 6—MASONRY

STANDARD

This section has been removed.

COMMENTARY

For guidance and tolerances for masonry, the specifier should refer to the most recent edition of “Specification for Masonry Structures (ACI 530.1).”

Notes

SECTION 7—CAST-IN-PLACE, VERTICALLY SLIPFORMED BUILDING ELEMENTS

STANDARD

7.1—Deviation from plumb for buildings and cores

7.1.1 *Translation and rotation from a fixed point at the base of the structure*

Heights 100 ft (30 m) or less.. $\pm 1/2$ in. (13 mm) per level

..... ± 2 in. (51 mm) maximum

Heights greater than 100 ft (30 m)

..... $\pm 1/600$ times the height

..... $\pm 1/2$ in. (13 mm) per level

..... ± 6 in. (152 mm) maximum

COMMENTARY

R7.1—Deviation from plumb for buildings and cores

Refer to Fig. R7.1.

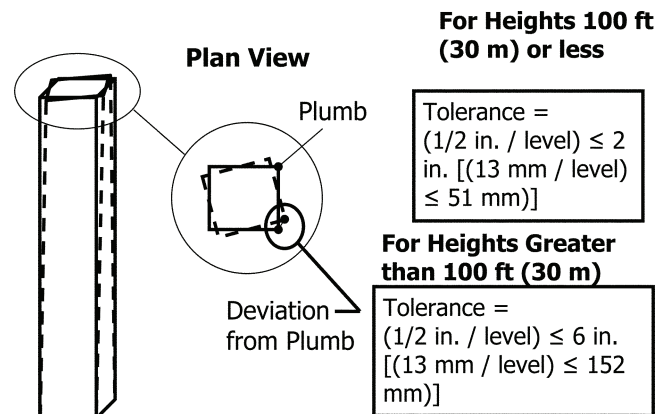


Fig. R7.1—Deviation from plumb for buildings and cores.

7.2—Horizontal deviation

7.2.1 Between adjacent elements ± 1 in. (25 mm)

7.2.2 Horizontal elements

Edges of openings, sleeves, and embedments 12 in. (305 mm) or smaller ± 1 in. (25 mm)

Edges of openings, sleeves, and embedments greater than 12 in. (305 mm) ± 2 in. (51 mm)

R7.2—Horizontal deviation

Refer to Fig. R7.2.1 and R7.2.2.

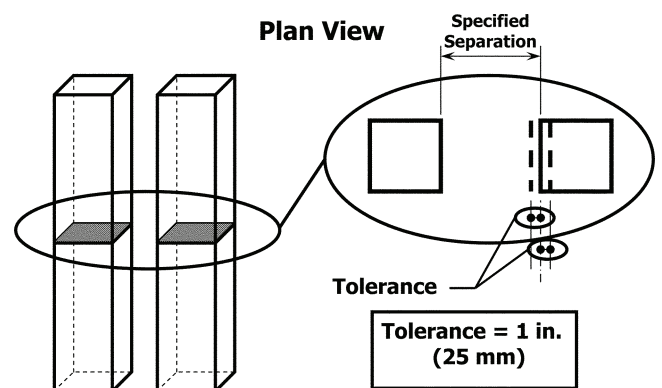


Fig. R7.2.1—Horizontal deviation.

Column Line
or Similar
Reference

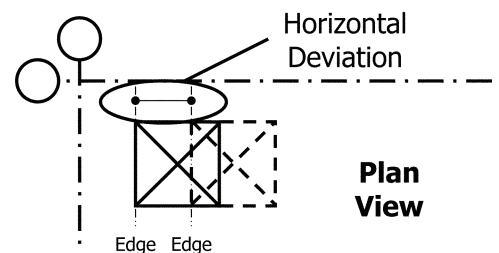


Fig. R7.2.2—Edges of openings, sleeves, and embedments.

STANDARD

COMMENTARY

7.3—Cross-sectional dimensions

R7.3—Cross-sectional dimensions

7.3.1 Columns and walls

Refer to Fig. R7.3.1.

12 in. (300 mm) or less.....	+3/8 in. (10 mm)
.....	−1/4 in. (6 mm)
More than 12 in. (300 mm) and less than 36 in.(910 mm)	
.....	+1/2 in. (13 mm)
.....	−3/8 in. (10 mm)
More than 36 in. (910 mm)	+1 in. (25 mm)
.....	−3/4 in. (19 mm)

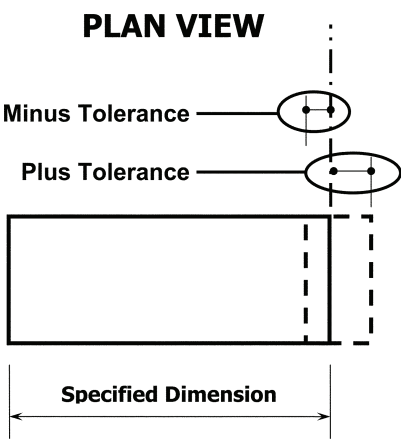


Fig. R7.3.1—Cross-sectional dimensions.

7.4—Openings through elements

7.4.1 Door openings or walk-through type openings

7.4.1.1 Length or width of opening ..	+1-1/2 in. (38 mm)
.....	−1/4 in. (6 mm)

7.4.2 Other openings and sleeves

7.4.2.1 Length or width of opening	+1 in. (25 mm)
.....	−0 in. (0 mm)

7.5—Embedded plates

7.5.1 Length or width of plate	+ 2 in. (51 mm)
.....	−0 in. (0 mm)

7.6—Deviation from plumb for slipformed and jumpformed silos

7.6.1 Deviation from plumb

Translation of silo centerline, or rotation (spiral) of silo wall from a fixed point at the base of the structure

100 ft (30 m) or less	±3 in. (76 mm)
More than 100 ft (30 m)	±1/400 of height

STANDARD**COMMENTARY****7.6.2** *Inside diameter or distance between walls*

Horizontal deviation $\pm 1/2$ in. per 10 ft (13 mm per 3 m)

..... ± 3 in. (76 mm)

7.6.3 *Cross-sectional dimensions of component*

..... $+1$ in. (25 mm)

..... $-3/8$ in. (10 mm)

7.6.4 *Location of openings, embedded plates and anchors*

Vertical deviation..... ± 3 in. (76 mm)

Horizontal deviation ± 1 in. (25 mm)

Notes

SECTION 8—MASS CONCRETE STRUCTURES OTHER THAN BUILDING ELEMENTS

STANDARD

COMMENTARY

8.1—Deviation from plumb

R8.1, R8.2, R8.3, R8.4, and R8.5

8.1.1 Surfaces

Refer to commentary Sections R4.1.1, R4.2.1, R4.2.2, R4.5, and R4.8.2, respectively.

Visible surfaces..... $\pm 1\text{-}1/4$ in. (32 mm)

Concealed surfaces $\pm 2\text{-}1/2$ in. (64 mm)

8.1.2 Side walls for radial gates and similar watertight joints $\pm 3/16$ in. (5 mm)

8.2—Horizontal deviation

Visible surfaces..... $\pm 1\text{-}1/4$ in. (32 mm)

Concealed surfaces $\pm 2\text{-}1/2$ in. (64 mm)

8.3—Vertical deviation

8.3.1 General

Visible flatwork and formed surfaces $\pm 1/2$ in. (13 mm)

Concealed flatwork and formed surfaces ± 1 in. (25 mm)

8.3.2 Sills of radial gates and similar watertight joints $\pm 3/16$ in. (5 mm)

8.4—Cross-sectional dimension

Thickness..... +1 in. (25 mm)

..... $-3/4$ in. (19 mm)

8.5—Deviation from plane

8.5.1 Slope of formed surfaces with respect to the specified plane shall not exceed the following amounts:

8.5.1.1 Slopes, vertical deviation

Visible surfaces..... $\pm 0.2\%$

Concealed surfaces $\pm 0.4\%$

8.5.1.2 Slopes, horizontal deviation

Visible surfaces..... $\pm 0.4\%$

Concealed surfaces $\pm 0.8\%$

Notes

SECTION 9—CANAL LINING

STANDARD

COMMENTARY

9.1—Horizontal deviation

R9.1, R9.2, and R9.3

9.1.1 *Surfaces*

Refer to commentary [Sections R4.2.1, R4.2.2, and R4.5](#), respectively.

Visible surfaces..... $\pm 1\text{--}1/4$ in. (32 mm)

9.1.2 Alignment of curves ± 4 in. (101 mm)

9.1.3 Width (W) of section at any height
..... $\pm 0.0025W + 1$ in. ($\pm 0.0025W + 25$ mm)

9.2—Vertical deviation

9.2.1 Profile grade ± 1 in. (25 mm)

9.2.2 Surface of invert $\pm 1/2$ in. (13 mm)

9.2.3 Surface of side slope $\pm 1/2$ in. (13 mm)

9.2.4 Height (h) of lining
..... $\pm 0.005h + 1$ in. ($\pm 0.005h + 25$ mm)

9.3—Cross-sectional dimensions

Thickness of lining cross section
..... $\pm 10\%$ of specified thickness

Thickness shall be determined by calculating an average as determined by daily batch volumes when compared to calculated theoretical volumes.

Notes

SECTION 10—MONOLITHIC WATER-CONVEYING TUNNELS, SIPHONS, CONDUITS, AND SPILLWAYS

STANDARD

COMMENTARY

10.1—Horizontal deviation

R10.1, R10.2, R10.3, and R10.4

10.1.1 Centerline alignment..... $\pm 1/2$ in. (13 mm)

Refer to commentary [Sections R4.2.1, R4.2.2, R4.5, and 4.8.2](#), respectively.

10.1.2 Inside dimensions
..... $\pm 0.5\%$ times inside dimension

10.2—Vertical deviation

10.2.1 Profile grade $\pm 1/2$ in. (13 mm)

10.2.2 Surface of invert..... $\pm 1/4$ in. (6 mm)

10.2.3 Surface of side slope $\pm 1/2$ in. (13 mm)

10.3—Cross-sectional dimensions

10.3.1 *Cross section thickness at any point*

Increase thickness: greater of 5% of thickness, or
..... $+ 1/2$ in. (13 mm)

Decrease thickness: greater of 2.5% of thickness, or
..... $- 1/4$ in. (6 mm)

10.4—Deviation from plane

10.4.1 Slope of formed surfaces with respect to the specified plane shall not exceed the following amounts when measured with a 10 ft (3 m) straightedge:

10.4.1.1 *Vertical deviation*

Visible surfaces..... $\pm 0.2\%$

Concealed surfaces $\pm 0.4\%$

10.4.1.2 *Horizontal deviation*

Visible surfaces..... $\pm 0.4\%$

Concealed surfaces $\pm 0.8\%$

Notes

SECTION 11—CAST-IN-PLACE BRIDGES

STANDARD

COMMENTARY

11.1—Deviation from plumb

11.1.1 Exposed surfaces $\pm 3/4$ in. (19 mm)

11.1.2 Concealed surfaces $\pm 1-1/2$ in. (38 mm)

11.2—Horizontal deviation

11.2.1 Centerline alignment..... $\pm 1/2$ in. (13 mm)

11.2.2 Centerline of bearing $\pm 1/8$ in. (3 mm)

11.2.3 Abrupt form offset at barrier rail... $\pm 1/8$ in. (3 mm)

11.2.3.4 Location of openings through concrete elements $\pm 1/2$ in. (13 mm)

11.3—Vertical deviation

11.3.1 Profile grade ± 1 in. (25 mm)

11.3.2 *Top of other concrete surfaces and horizontal grooves*

Exposed..... $\pm 3/4$ in. (19 mm)

Concealed..... ± 1 in. (25 mm)

11.3.3 Location of openings through concrete elements $\pm 1/2$ in. (13 mm)

11.4—Length, width, or depth of specified elements

11.4.1 Bridge slab thickness..... $+1/4$ in. (6 mm)

..... $-1/8$ in. (3 mm)

11.4.2 Elements such as columns, beams, piers, and walls

..... $+1/2$ in. (13 mm)

..... $-1/4$ in. (6 mm)

11.2—Horizontal deviation

R11.2.2 Centerline of bearing refers to the primary girders or stringers. On highway plans, dimensions are usually given in hundredths of a foot. Inches are used here to conform to the rest of this document.

R11.3—Vertical deviation

R11.3.1 Profile grade refers to the upper surface of an overpass. If the structure creates a highway underpass, then the clearance from the profile grade to the bottom of the lowest structural element should be $+1$ in. (25 mm), 0 in. (0 mm).

STANDARD

COMMENTARY

11.4.3 Openings through concrete elements
.....±1/2 in. (13 mm)

11.5—Deviation from plane

11.5.1 Slope of formed and unformed surfaces with respect to the specified plane shall not exceed the following amounts in 10 ft (3 m):

Watertight joints±1/8 in. (3 mm)

Other exposed surfaces±1/2 in. (13 mm)

Concealed surfaces.....±1 in. (25 mm)

11.6—Deck reinforcement cover

.....+1 in. (25 mm)

.....–0 in. (0 mm)

11.7—Bearing pads

11.7.1 Horizontal deviation of centerline ..±1 in. (25 mm)

11.7.2 Edge dimensions in plan±1 in. (25 mm)

11.7.3 Deviation from plane.....±0.10%

SECTION 12—PAVEMENTS AND SIDEWALKS

STANDARD

12.1—Horizontal deviation

12.1.1 Placement of dowels..... $\pm 1\text{--}1/4$ in. (32 mm)

12.1.2 *Alignment of dowels, relative to centerline of pavement*

18 in. (0.45 m) or less projection $\pm 1/4$ in. (6 mm)

Greater than 18 in. projection (0.45 m)not established

12.2—Vertical deviation of surface

12.2.1 Mainline pavements in longitudinal direction, the gap below a 10 ft (3 m) unleveled straightedge resting on highspots shall not exceed $+1/8$ in. (3 mm)

12.2.2 Mainline pavements in transverse direction, the gap below a 10 ft (3 m) unleveled straightedge resting on highspots shall not exceed $+1/4$ in. (6 mm)

12.2.3 Ramps, sidewalks, and intersections, in any direction, the gap below a 10 ft (3 m) unleveled straightedge resting on highspots shall not exceed $+1/4$ in. (6 mm)

COMMENTARY

Smoothness tolerances are not addressed within this document. Engineers and contractors should refer to the regional and local highway and roadway departments, including the American Association of State Highway and Transportation Officials (AASHTO).

Notes

SECTION 13—CHIMNEYS AND COOLING TOWERS

STANDARD

13.1—Deviation from plumb

Translation, rotation, or variance from the vertical axis shall not exceed the greater of $\pm 0.1\%$ times the height at time of measurement or ± 1 in. (25 mm).

In any 10 ft (3 m) of height, the geometric center of the chimney or cooling tower element shall not change more than..... ± 1 in. (25 mm)

13.2—Outside shell diameter

Outside shell diameter $\pm 1\%$ of the specified diameter plus 1 in. (25 mm).

13.3—Wall thickness

The average of four wall thickness measurements taken over a 60-degree arc.

Specified wall thickness 10 in. (254 mm) or less

..... $+1/2$ in. (13 mm)

..... $-1/4$ in. (6 mm)

Specified wall thickness greater than 10 in. (254 mm)

..... $+1$ in. (25 mm)

..... $-1/2$ in. (13 mm)

COMMENTARY

Tolerance requirements for openings and items embedded within concrete chimneys must be established on an individual basis depending on the specific nature of their use.

Notes

SECTION 14—CAST-IN-PLACE NONREINFORCED PIPE

STANDARD

COMMENTARY

14.1—Wall thickness

Minimum wall thickness at any point shall be 1/12 times the specified internal diameter of the pipe plus 1/2 in. (13 mm), and in no case less than +2 in. (51 mm)

Cast-in-place concrete pipe tolerances relate to the accuracy of construction that can be achieved using machinery and equipment consistent with the standard practice for local soil types.

14.2—Pipe diameter

The internal diameter at any point shall not be less than 98% of the design diameter.

14.3—Offsets

At form laps and horizontal edges shall not exceed:

For pipe with an internal diameter not less than 42 in. (1.07 m) $\pm 1/2$ in. (13 mm)

For pipe with an internal diameter greater than 42 in. (1.07 m) or less than or equal to 72 in. (1.8 m) $\pm 3/4$ in. (19 mm)

For pipe with an internal diameter greater than 72 in. (1.8 m) ± 1 in. (25 mm)

14.4—Surface indentations

Maximum allowable $\pm 1/2$ in. (13 mm)

14.5—Grade and alignment

14.5.1 Vertical deviation from grade ± 1 in. per 10 ft (25 mm per 3 m)

..... $\pm 1-1/2$ in. (38 mm) maximum

14.5.2 Horizontal deviation from alignment ± 2 in. per 10 ft (50 mm per 3 m)

..... ± 4 in. (102 mm) maximum

14.6—Concrete slump

For pipe with an internal diameter less than 42 in. (1.07 m) $\pm 1-1/2$ in. (38 mm)

For pipe with an internal diameter from 42 in. (1.07 m) up to 72 in. (1.83 m) ± 1 in. (25 mm)

For pipe with an internal diameter greater than 72 in. (1.83 m) $\pm 1/2$ in. (13 mm)

Notes

COMMENTARY

FOREWORD TO CHECKLISTS

F1. This Foreword is included for explanatory purposes only; it does not form a part of Specification ACI 117.

F2. ACI Specification 117 may be referenced by the specifier in the project specification for any building project, together with supplementary requirements for the specific project. Responsibilities for project participants must be defined in the project specification. The ACI specification cannot and does not address responsibilities for any project participant other than the contractor.

F3. Checklists do not form a part of ACI Specification 117. Checklists assist the specifier in selecting and specifying project requirements in the project specification.

F4. Building codes set minimum requirements necessary to protect the public. ACI Specification 117 may stipulate requirements more restrictive than the minimum. The specifier shall make adjustments to the needs of a particular project by reviewing each of the items in the checklists and including those the specifier selects as mandatory requirements in the project specification.

F5. The Mandatory Requirements Checklist indicates work requirements regarding specific qualities, procedures, materials, and performance criteria that are not defined in ACI Specification 117.

F6. The Optional Requirements Checklist identifies specifier choices and alternatives. The checklists identify the Sections, Parts, and Articles of the reference specification and the action required or available to the specifier.

MANDATORY REQUIREMENTS CHECKLIST

Section/Part/Article	Notes to the specifier
Section 1—General requirements	
1.1.2 Scope	Tolerance values affect construction cost. Specific use of a tolerance item may warrant less or more stringent tolerances than contained in the specification. The specifier is responsible for identifying, in the contract documents, any tolerances that the specifier expects the contractor to achieve but are not addressed in ACI 117.
1.1.2 Scope	Specifier is responsible for coordinating tolerances for concrete construction and those of any materials that interface with, or attach to, the concrete structure.
1.2.3 Requirements	Where a specific application uses multiple toleranced items that together yield a toleranced result, the specifier must analyze the resulting tolerance envelope with respect to practical limits and design assumptions and specify a tolerance envelope value where the standard tolerance values in this specification are inadequate or inappropriate.
Section 2—Materials	
2.2 Reinforcement	Tolerances for fabrication, placement, and lap splices for welded wire reinforcement must be specified by the specifier.
Section 3—Foundations	
3.1 Drilled piers	Specify category of drilled pier. The specifier should be aware that the recommended vertical alignment tolerance of 1.5% of the shaft length indicated in Category B drilled piers is based on experience in a wide variety of soil situations combined with a limited amount of theoretical analysis using the beam on elastic foundation theory and minimum assumed horizontal soil restraint.
Section 4—Cast-in-place concrete for buildings	
4.8.3 Form offsets	Designate class of surface (A, B, C, D): Class A: For surfaces prominently exposed to public view where appearance is of special importance; Class B: Coarse-textured, concrete-formed surfaces intended to receive plaster, stucco, or wainscoting; Class C: General standard for permanently exposed surfaces where other finishes are not specified; and Class D: Minimum quality surface where roughness is not objectionable, usually applied where surfaces will be concealed.
4.8.4 Floor finish	Choose Section 4.8.5 and 4.8.6 .
4.8.5.1 F-numbers	Choose specified overall F_F . Choose specified overall F_L , if applicable.
4.8.6.1 Manual straightedge	Choose maximum gap. Specify minimum number of samples, test procedure (must be reproducible), and acceptance criteria.
Section 5—Precast concrete	
	Specifier shall address tolerance requirements for precast concrete elements in the project documents.
Section 6—Masonry	
	Specifier shall address tolerance requirements for masonry elements in the project documents.

COMMENTARY

OPTIONAL REQUIREMENTS CHECKLIST

Section/Part/Article	Notes to the specifier
Section 2—Materials	
2.2.2 Concrete cover	The tolerance for reduction in cover in reinforcing steel may require a reduction in magnitude where the reinforced concrete is exposed to chlorides or the environment. Where possible, excess cover to other protection of the reinforcing steel should be specified instead of reduced tolerance because of the accuracy of locating reinforcing steel using standard fabrication accessories and installation procedures.
2.3.2 Embedded items	Tolerance given is for general application. Specific design use of embedded items may require the specifier to designate tolerances of reduced magnitude for various embedded items.
Section 3—Foundations	
3.5.3	Plus tolerance for the vertical dimension is not specified because no limit is imposed. Specifier should designate plus tolerance if desired.
Section 4—Cast-in-place concrete for buildings	
4.8	Choose Waviness Index as alternative to methods specified in 4.8.5 or 4.8.6. Testing shall be in accordance with ASTM E 1486. Specified Overall Surface Waviness Index and Minimum Local Surface Waviness Index must be specified.
4.8.6.3	Choose computerized simulation of manual straightedge. Specify minimum number of samples, test procedure (must be reproducible), and acceptance criteria.