ACI 117M-10

(metric)

Specification for Tolerances for Concrete Construction and Materials (ACI 117M-10) and Commentary

An ACI Standard

Reported by ACI Committee 117

American Concrete Institute®

First printing
July 2010

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Specification for Tolerances for Concrete Construction and Materials and Commentary

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Specification for Tolerances for Concrete Construction and Materials (ACI 117M-10) and Commentary

An ACI Standard

Reported by ACI Committee 117

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Specification synopsis: This specification provides standard tolerances for concrete construction and materials. 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 and materials.

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

Keywords: architectural concrete; concrete; construction; drilled piers; formwork; foundation; mass concrete; pier; precast concrete; prestressed concrete; reinforced concrete; reinforcement; specification; splice; tilt-up concrete; tolerances.

ACI 117M 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 117M-10.

ACI 117M-10 supersedes ACI 117-06 and was adopted March 1, 2010 and published July 2010.

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INTRODUCTION

SPECIFICATION

COMMENTARY

This commentary pertains to "Specifications for Tolerances for Concrete Construction and Materials (ACI 117M-10)." The purpose of the commentary is to provide an illustrative and narrative complement to the specification; it is not a part of the specification.

No structure is exactly level, plumb, straight, and true. 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 117M)" 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.

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, and the lower the degree of construction accuracy, the higher the cost of required repairs.

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, materials, and project management.

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.

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COMMENTARY

Contract document references

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

117M	Specification for Tolerances for Concrete Construction and Materials and Commentary
ITG-7M	Specification for Tolerances for Precast Concrete
301M	Specifications for Structural Concrete
303.1	Standard Specification for Cast-in-Place Architectural Concrete
336.1	Specification for the Construction of Drilled Piers
530.1/ASCE 6/ TMS 602	Specification for Masonry Structures and Commentary

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 building...... ACI 302, 303, 304, 305, 311, 315, 336, 347
Special structures.............ACI 207, 307, 313, 325, 332, 334, 358
Materials... 211, 223
Other... 228

SECTION 1—GENERAL REQUIREMENTS

SPECIFICATION

1.1—Scope

1.1.1 This specification designates standard tolerances for concrete construction.

1.1.2 The indicated tolerances govern unless otherwise specified.

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

This specification does not apply to specialized structures, such as nuclear reactors and containment vessels, bins, prestressed circular structures, and single-family residential construction. It also does not apply to precast concrete or to shotcrete.

Tolerances for specialized concrete construction that is outside the scope of this specification shall be specified in Contract Documents.

1.1.3 A series of preconstruction tolerance coordination meetings shall be scheduled and held prior to the commencement of the Work. The Contractor, subcontractors, material suppliers, and other key parties shall attend. All parties shall be given the opportunity to identify any tolerance questions and conflicts that are applicable to the work with materials, prefabricated elements, and Work assembled/installed in the field by the Contractor.

1.2—Requirements

1.2.1 Concrete construction and materials shall comply with specified tolerances.

COMMENTARY

R1.1—Scope

R1.1.2 Specification of more restrictive tolerances for specialized construction, such as architectural concrete, often results in an increase in material cost and time of construction.

R1.1.3 Preconstruction tolerance coordination meetings provide an opportunity for key participants to identify and to resolve tolerance compatibility issues prior to construction.

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.

SPECIFICATION | **COMMENTARY**

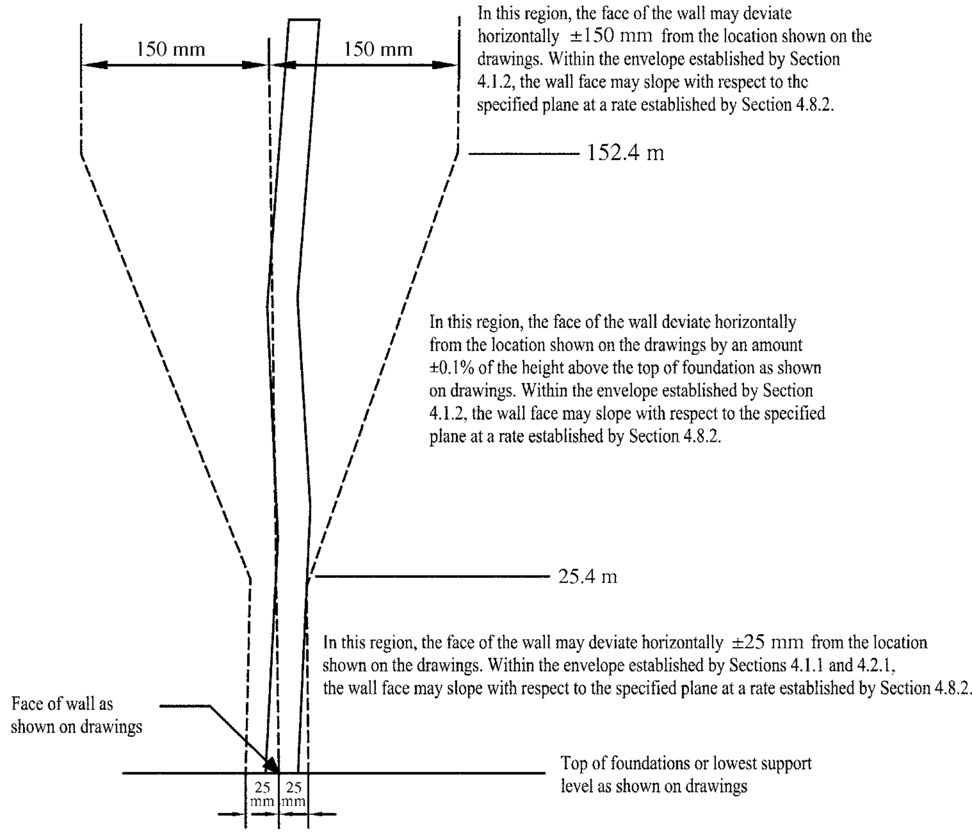

Fig. R1.2.3—Use of multiple of toleranced items to yield toleranced result.

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

R1.2.2 If the application of tolerances causes the extension of the structure beyond legal boundaries, the Architect/Engineer should be notified to initiate conflict resolution.

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

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.

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 specified tolerance in the opposing direction.

SPECIFICATION

1.2.5 If the tolerances in this document are exceeded for structural concrete, refer to Contact Documents for acceptance criteria. For other concrete, the Architect/Engineer 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; or

b) The element or total erected assembly can be modified to meet all structural and architectural requirements.

1.3—Definitions

ACI provides a comprehensive list of definitions through an online resource, "ACI Concrete Terminology," http://terminology.concrete.org. Definitions provided here complement that resource.

Architect/Engineer—the architect, engineer, architectural firm, or engineering firm issuing Contract Documents or administering the Work under Contract Documents, or both.

arris—the sharp external corner edge that is formed at the junction of two planes or surfaces.

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

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

concrete, exposed—concrete surfaces formed so as to yield an acceptable texture and finish for permanent exposure to view.

Contract Documents—a set of documents supplied by the Owner to the Contractor that serve as the basis for construction; these documents contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes.

Contractor—the person, firm, or entity under contract for construction of the Work.

COMMENTARY

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

R1.3—Definitions

arris—refer to Fig. R1.3.1.

bowing—refer to Fig. R1.3.2.

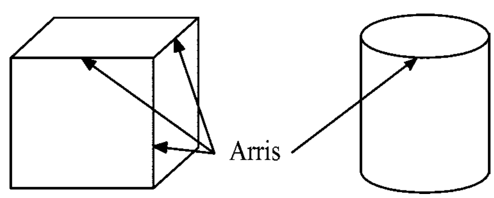

Fig. R1.3.1—Arris.

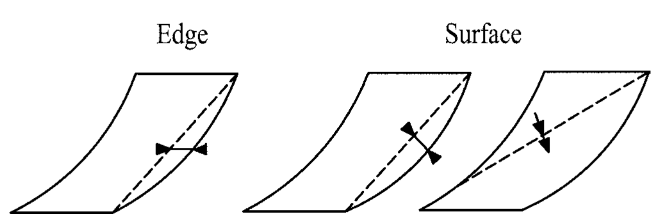

Fig. R1.3.2—Bowing.

SPECIFICATION

cover—the least distance between the surface of embedded reinforcement and the surface of the concrete.

deviation—departure from an established point, line, or surface; measured normal (perpendicular) to the reference line or surface.

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

COMMENTARY

cover—refer to Fig. R1.3.3.

deviation—refer to Fig. R1.3.4.

deviation from plane—refer to Fig. R1.3.5(a) and (b).

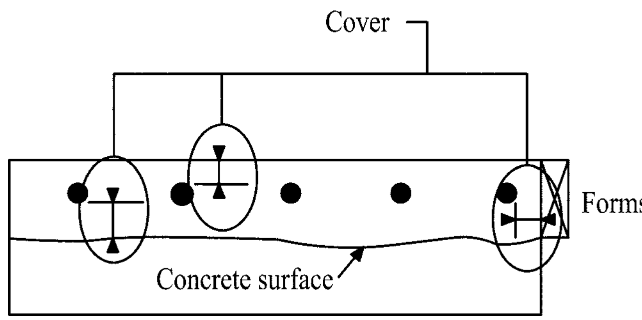

Fig. R1.3.3—Cover.

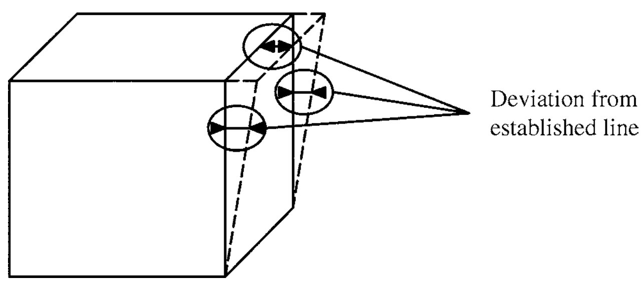

Fig. R1.3.4—Deviation.

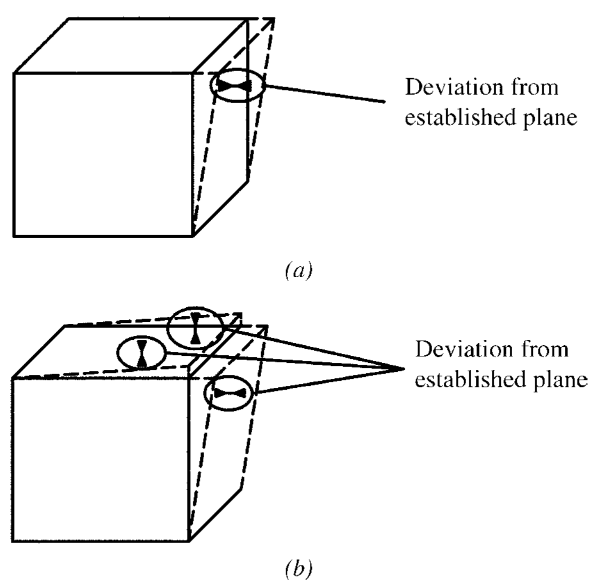

Fig. R1.3.5—Deviation from plane.

SPECIFICATION

deviation, horizontal—departure from an established point, line, or surface, measured normal (perpendicular) to a vertical line through the point of interest.

deviation, vertical—departure from an established point, line, or surface, measured normal (perpendicular) to a horizontal line through the point of interest.

COMMENTARY

deviation , horizontal—refer to Fig. R1.3.6(a), (b), and (c).

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

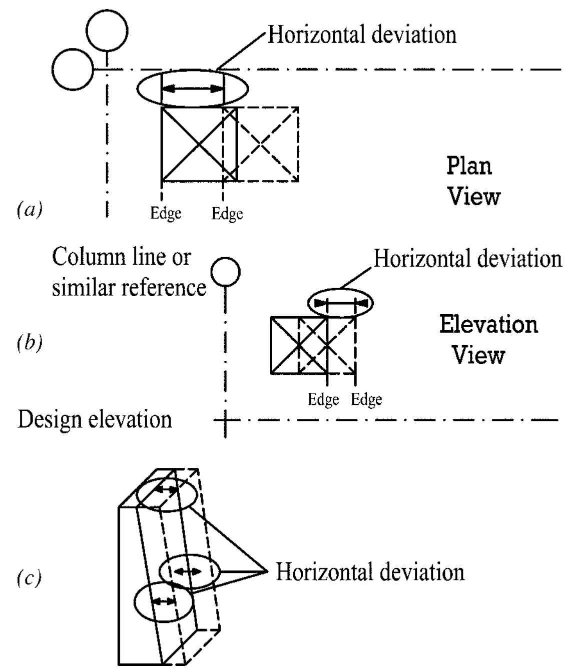

Fig. R1.3.6—Horizontal deviation.

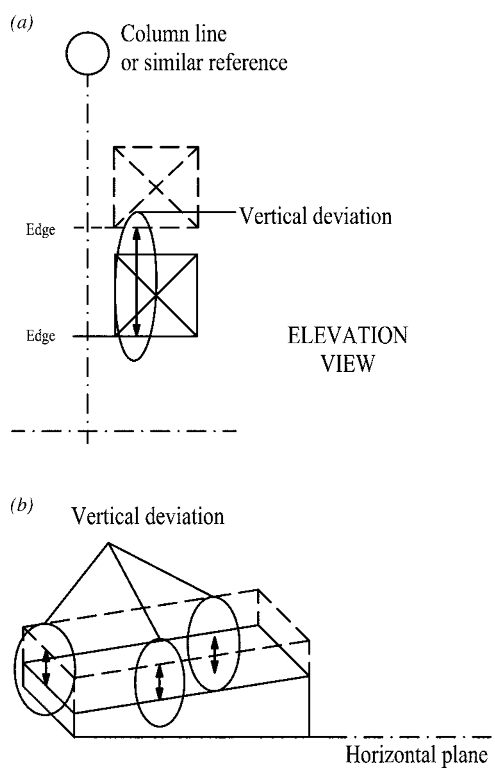

Fig. R1.3.7—Vertical deviation

SPECIFICATION

flatness—deviation of a surface from a plane.

footing—a structural element of a foundation that transmits loads directly to the soil.

foundation—a system of structural elements that transmit loads from the structure above to the earth.

levelness—deviation of a line or surface from a horizontal line or surface.

Project Drawings—graphic presentation of project requirements.

Project Specification—the written document that details requirements for the Work in accordance with service parameters and other specific criteria.

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

Work—the entire construction or separately identifiable parts thereof required to be furnished under Contract Documents.

COMMENTARY

Vertical deviation, horizontal deviation, and deviation from plumb are individually used to establish a tolerance envelope for each deviation type within which permissible variations can occur. Deviation from plane 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 for exposed concrete. 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 specific distance over which the slope is to be measured is established, and that the measurement device only contacts the surface at this specific distance.

flatness—refer to Fig. R1.3.8.

levelness—refer to Fig. R1.3.8.

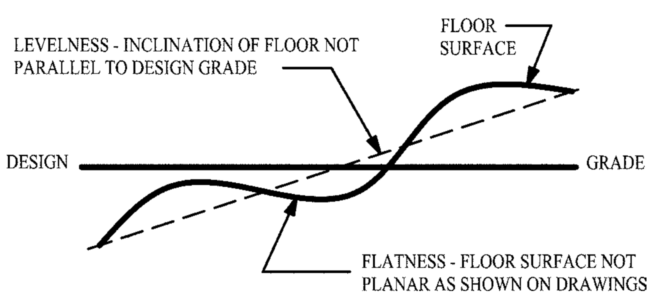

Fig. R1.3.8—Flatness and levelness.

SPECIFICATION

1.4—Reference standards

ASTM International

C94/C94M-09	Standard Specification for Ready-Mixed Concrete
C174/C174M-06	Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
C1383-04	Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method
D4748-06	Standard Test Method for Determining Thickness of Bound Pavement Layers Using Short-Pulse Radar
E1155M-96(2008)	Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers
E1486M-98(2004)	Standard Test Method for Determining Floor Tolerances Using Waviness, Wheel Path and Levelness Criteria

COMMENTARY

R1.4—Informative references

The documents 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

301M	Specifications for Structural Concrete
304.6R	Guide for the Use of Volumetric-Measuring and Continuous Mixing Concrete Equipment
318M	Building Code Requirements for Structural Concrete and Commentary

American Institute of Steel Construction

Design Guide 1: Base Plates and Anchor Rod Design

American Society of Concrete Contractors

Position Statement #14—Anchor Bolt Tolerances

ASTM International

C685/C685M	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing

Concrete Reinforcing Steel Institute

10MSP	Manual of Standard Practice

Precast/Prestressed Concrete Institute

MNL-116	Manual for Quality Control for Plants and Production of Structural Precast Concrete Products
MNL-135	Tolerance Manual for Precast and Prestressed Concrete Construction

National Ready Mixed Concrete Association

Quality Control Manual—Section 3; Certification of Ready Mixed Concrete Production Facilities (Checklist)

Volumetric Mixer Manufacturers Bureau

VMMB 100	Volumetric Mixer Standards of the Volumetric Mixer Manufacturers Bureau

These publications may be obtained from:

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

American Institute of Steel Construction
One East Wacker Dr., Suite 700
Chicago, IL 60601
www.aisc.org

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American Society of Concrete Contractors
2025 Brentwood Blvd.
St. Louis, MO 63144
www.ascconline.org

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

Concrete Reinforcing Steel Institute
933 North Plum Grove Rd.
Schaumburg, IL 60173
www.crsi.org

Precast/Prestressed Concrete Institute
200 W. Adams St., #2100
Chicago, IL 60606
www.pci.org

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

Volumetric Mixer Manufacturers Bureau
900 Spring Street
Silver Spring, MD 20910
www.vmmb.org

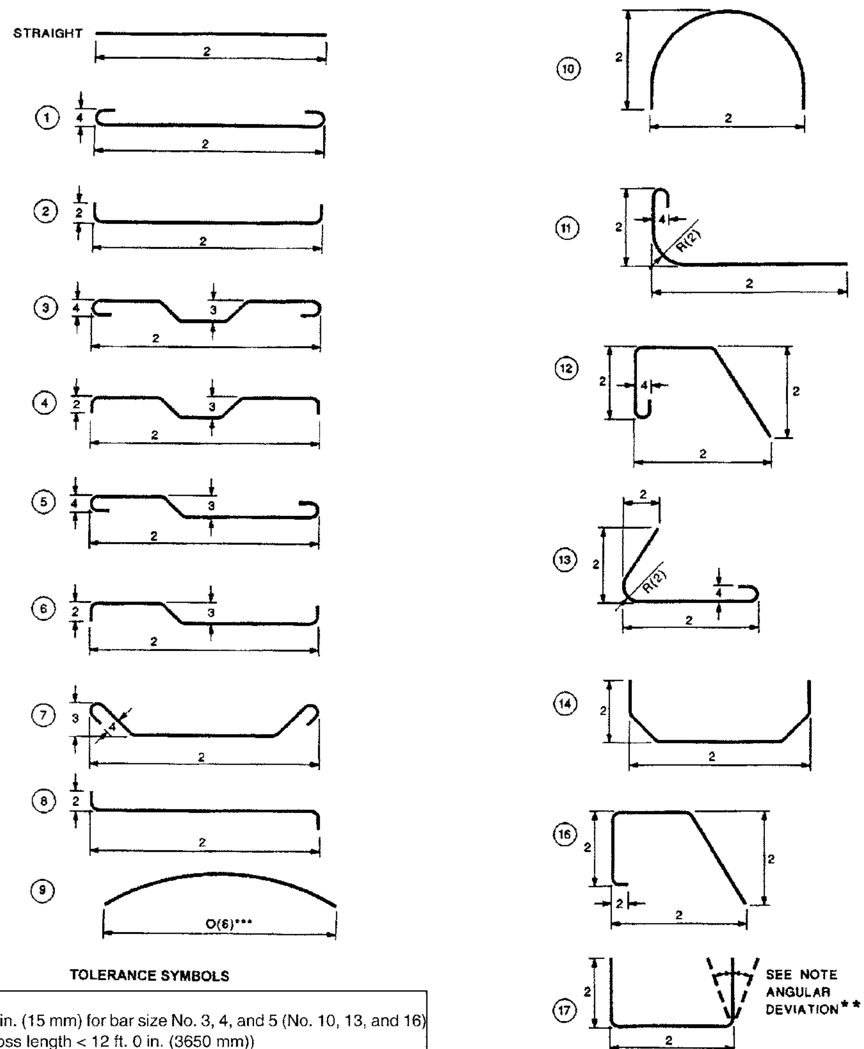
SECTION 2—MATERIALS

SPECIFICATION

2.1—Reinforcing steel fabrication and assembly

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

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



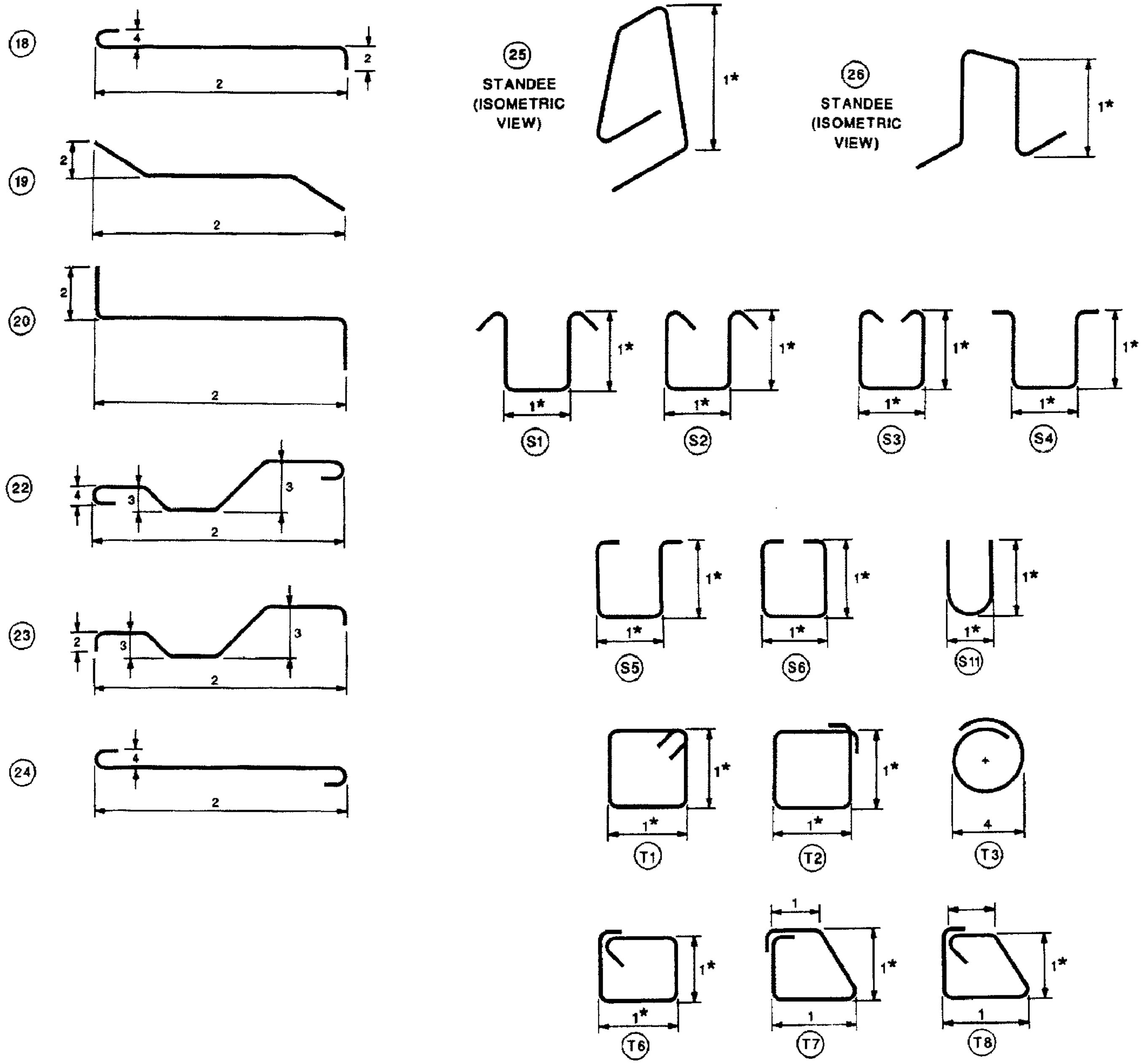
TOLERANCE SYMBOLS

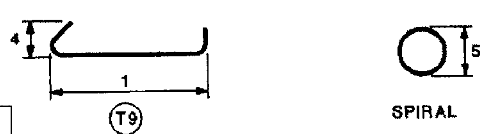
1 =	±1/2 in. (15 mm) for bar size No. 3, 4, and 5 (No. 10, 13, and 16) (gross length < 12 ft. 0 in. (3650 mm))
1 =	±1 in. (25 mm) for bar size No. 3, 4, and 5 (No. 10, 13, and 16) (gross length ≥ 12 ft. 0 in. (3650 mm))
1 =	±1 in. (25 mm) for bar size No. 6, 7, and 8 (No. 19, 22, and 25)
2 =	± 1 in. (25 mm)
3 =	+ 0, -1/2 in. (15 mm)
4 =	±1/2 in. (15 mm)
5 =	±1/2 in. (15 mm) for diameter ≤ 30 in. (760 mm)
5 =	±1 in. (25 mm) for diameter > 30 in. (760 mm)
6 =	± 1.5% × "O" dimension, ≥ ± 2 in. (50 mm) minimum

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 ± 2-1/2 degrees or ± 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 > 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)—Standard fabricating tolerances for bar sizes No. 10 through 36. (Figure courtesy of Concrete Reinforcing Steel Institute.)

SPECIFICATION





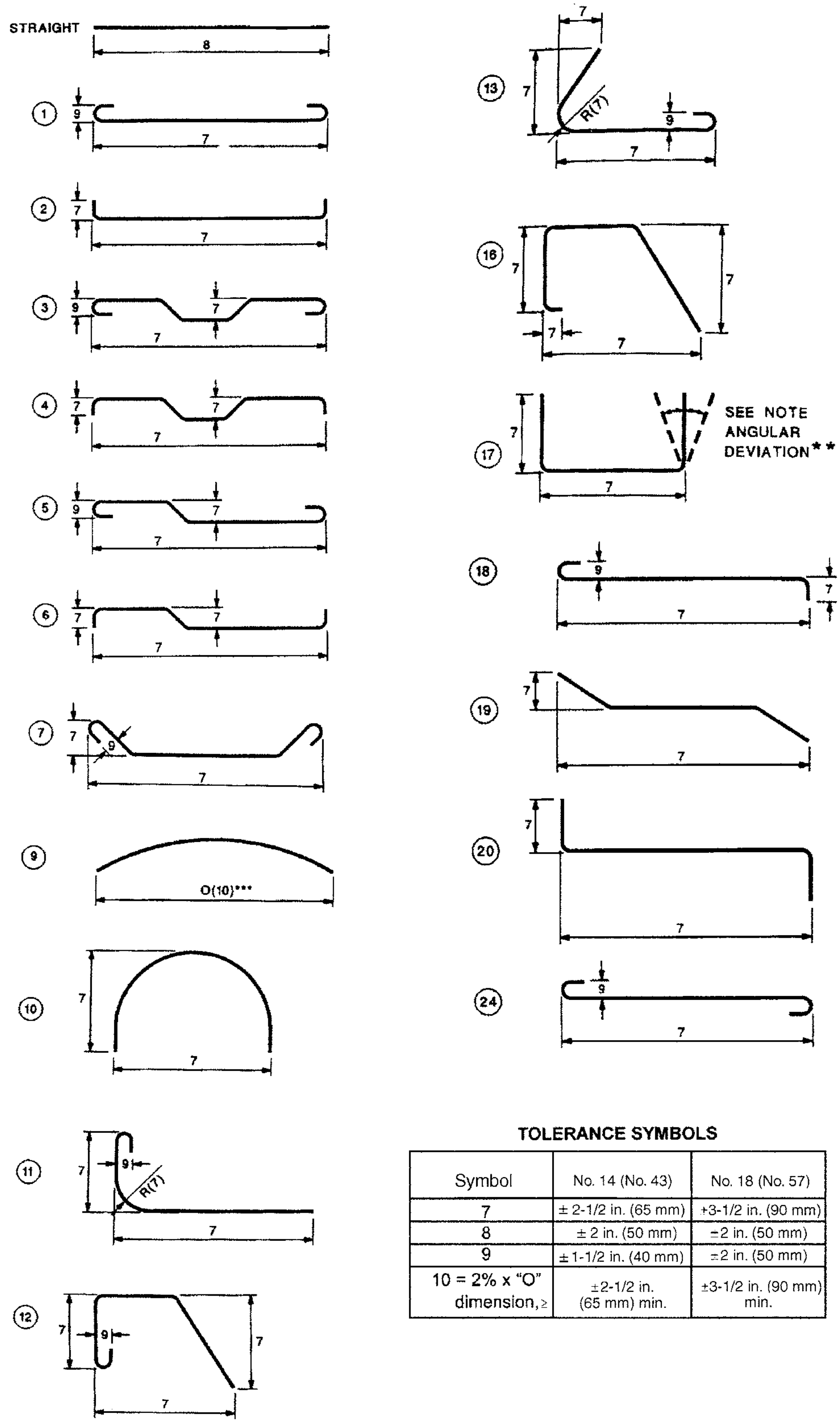
TOLERANCE SYMBOLS

1	=	±1/2 in. (15 mm) for bar size No. 3, 4, and 5 (No. 10, 13, and 16) (gross length < 12 ft. 0 in. (3650 mm))
1	=	±1 in. (25 mm) for bar size No. 3, 4, and 5 (No. 10, 13, and 16) (gross length ≥ 12 ft. 0 in. (3650 mm))
1	=	±1 in. (25 mm) for bar size No. 6, 7, and 8 (No. 19, 22, and 25)
2	=	± 1 in. (25 mm)
3	=	+ 0, -1/2 in. (15 mm)
4	=	±1/2 in. (15 mm)
5	=	±1/2 in. (15 mm) for diameter ≤ 30 in. (760 mm)
5	=	±1 in. (25 mm) for diameter > 30 in. (760 mm)
6	=	± 1.5% × "O" dimension, ≥ ± 2 in. (50 mm) minimum

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 ± 2-1/2 degrees or ± 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 ≥ 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. 10 through 36. (Figure courtesy of Concrete Reinforcing Steel Institute.)

SPECIFICATION



TOLERANCE SYMBOLS

Symbol	No. 14 (No. 43)	No. 18 (No. 57)
7	± 2-1/2 in. (65 mm)	+3-1/2 in. (90 mm)
8	± 2 in. (50 mm)	±2 in. (50 mm)
9	± 1-1/2 in. (40 mm)	±2 in. (50 mm)
10 = 2% x "O" dimension,≥	±2-1/2 in. (65 mm) min.	±3-1/2 in. (90 mm) min.

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. 43 and 57. *(Figure courtesy of Concrete Reinforcing Steel Institute.)*

SPECIFICATION

For bars No. 25 through 57 in size used in end-bearing splices, refer to Fig. 2.1(c).

For all end-bearing splice assemblies, refer to Fig. 2.1(d).

For all bar sizes, specified minimum inside radius of bend .... –0 mm

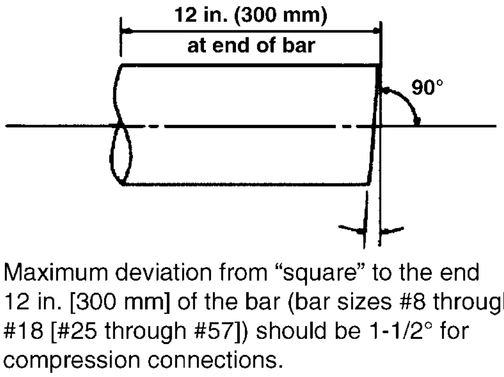


Fig. 2.1(c)—Maximum end deviation for bars No. 25 through 57 in size used in end-bearing splices. (Figure courtesy of Concrete Reinforcing Steel Institute.)

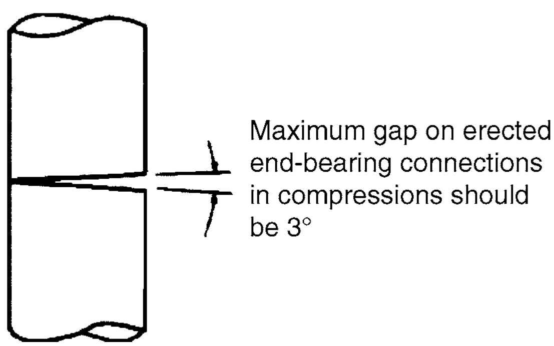


Fig. 2.1(d)—Maximum assembled gap for all bars used in end-bearing splices. (Figure courtesy of Concrete Reinforcing Steel Institute.)

COMMENTARY

SPECIFICATION

2.2—Reinforcement location

2.2.1 *Placement of nonprestressed reinforcement*
When member depth (or thickness) is 100 mm or less ....±6 mm

When member depth (or thickness) is over 100 mm and not over 300 mm..........±10 mm

When member depth (or thickness) is over 300 mm ....±13 mm

2.2.2 *Concrete cover measured perpendicular to concrete surface*
When member depth (or thickness) is 300 mm or less ....–10 mm

When member depth (or thickness) is over 300 mm ....–13 mm

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

Reduction in cover to formed soffits shall not exceed 6 mm.

2.2.3 Vertical deviation for slab-on-ground reinforcement ....±20 mm

COMMENTARY

R2.2—Reinforcement location

The tolerance for ***d***, as stated in ACI 318M, is for use in a strength calculation 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 117M and, if required, should be specified by the Specifier. Before placement of concrete, inspection of reinforcing bars for conformance to specified placement tolerances may involve measurements to formwork or soil. 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.

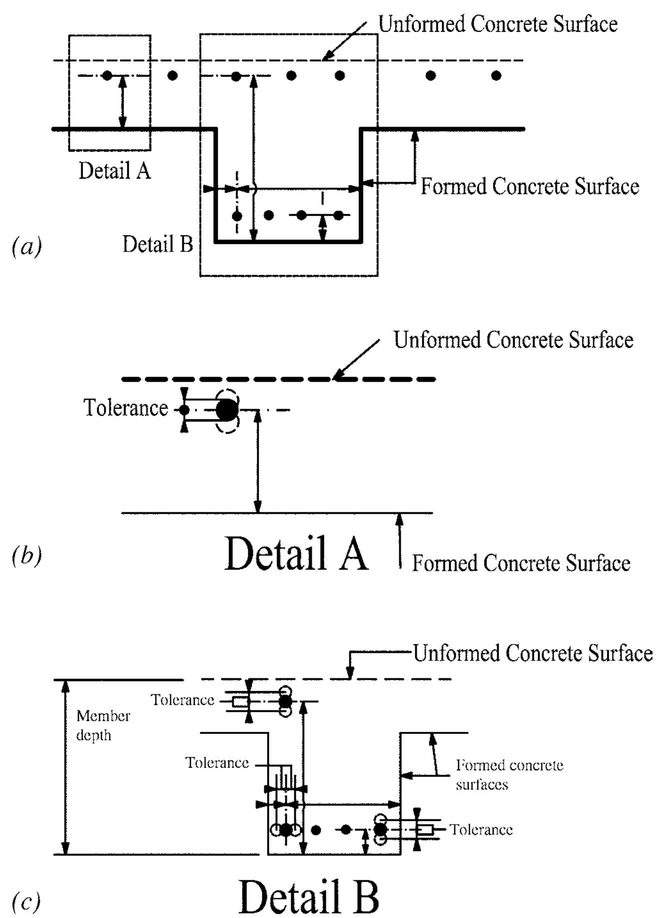


Fig. R2.2.1—Placement.

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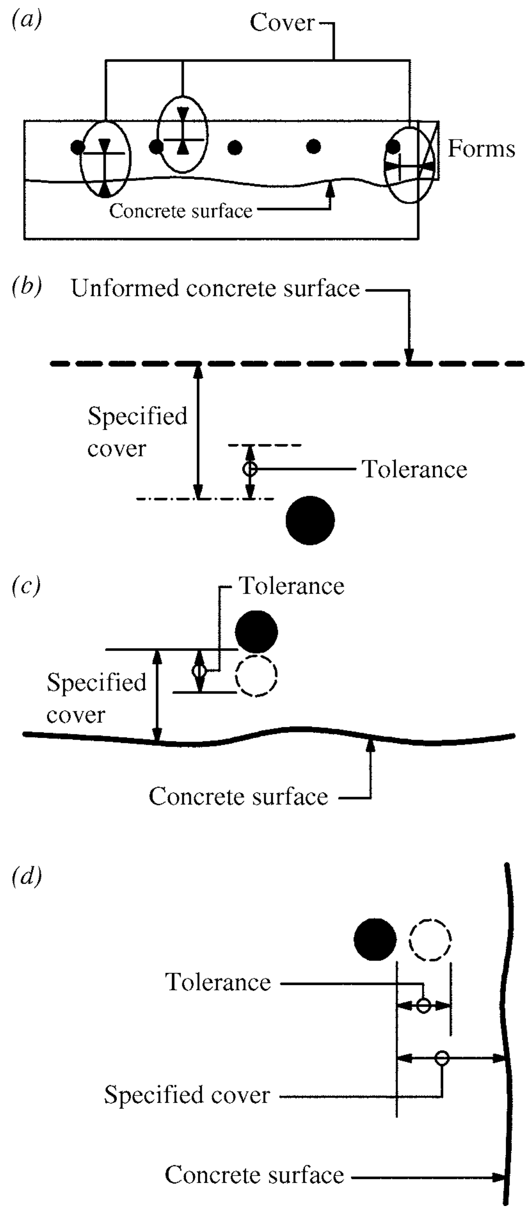

Fig. R2.2.2—Cover.

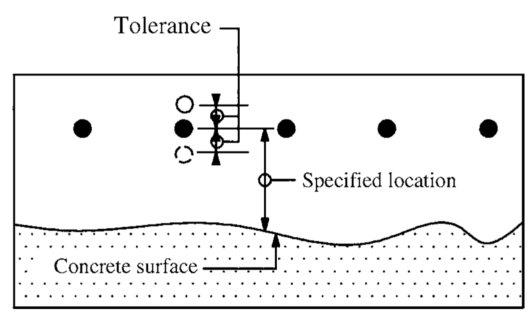

Fig. R2.2.3—Vertical placement.

SPECIFICATION

2.2.4 *Clearance between reinforcement or between reinforcement and embedment*
One-quarter specified distance not to exceed
....±25 mm

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

For bundled bars, the distance between bundles shall not be less than the greater of 25 mm or a bar diameter derived from the equivalent total area of all bars in the bundle.

2.2.5 *Spacing of nonprestressed reinforcement, measured along a line parallel to the specified spacing*
Except as noted below....................................±75 mm

Stirrups, the lesser of ±75 mm or ±25 mm per 300 mm of beam depth

Ties, the lesser of ±75 mm or ±25 mm per 300 mm of least column width

The total number of bars shall not be fewer 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 their design requirements may not allow for reinforcement 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.

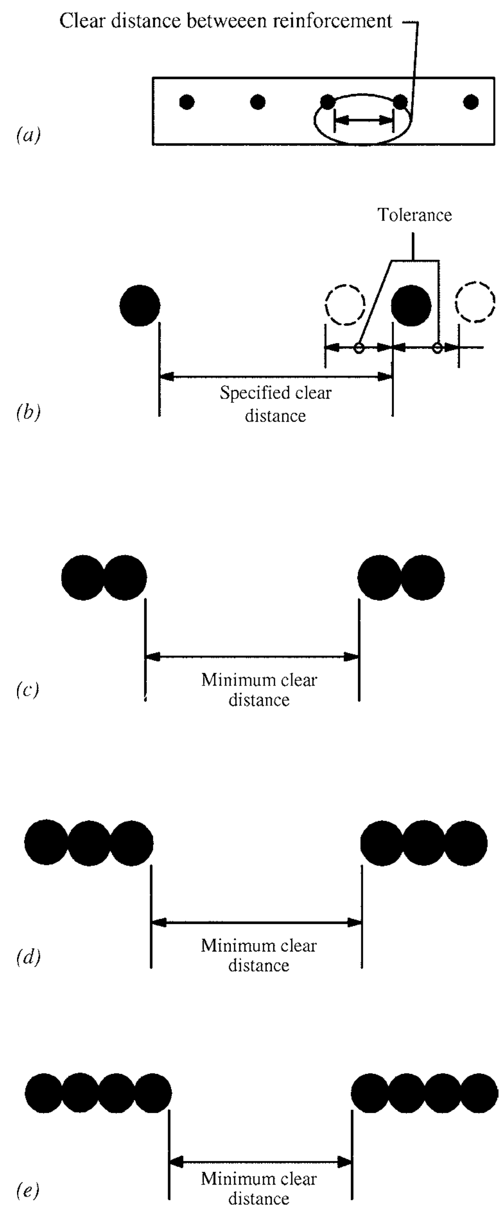

Fig. R2.2.4—Clear distance.

SPECIFICATION

COMMENTARY

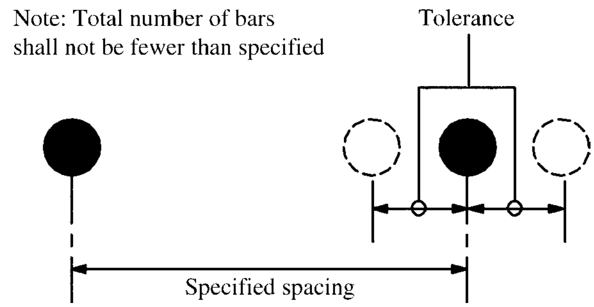

Fig. R2.2.5—Reinforcement spacing.

2.2.6 *Placement of prestressing reinforcement or prestressing ducts, measured from form surface*

2.2.6.1 *Horizontal deviation*
Element depth (or thickness) 600 mm or less..... ±13 mm

Element depth (or thickness) over 600 mm .. ±25 mm

2.2.6.2 *Vertical deviation*
Element depth (or thickness) 200 mm or less ... ±6 mm

Element depth (or thickness) over 200 mm and not over 600 mm .... ±10 mm

Element depth (or thickness) more than 600 mm
.... ±13 mm

R.2.2.6 The vertical deviation tolerance should be considered in establishing minimum prestressing tendon covers, particularly in applications exposed to deicer chemicals or saltwater 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).

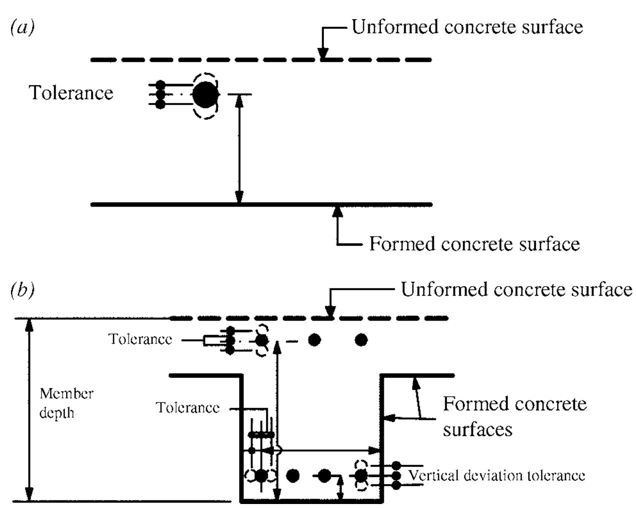

Fig. R2.2.6—Prestressing reinforcement placement.

2.2.7 *Longitudinal location of bends in bars and ends of bars*
At discontinuous ends of corbels and brackets .. ±13 mm

At discontinuous ends of other elements .... ±25 mm

At other locations... ±50 mm

2.2.8 *Embedded length of bars and length of bar laps*
No. 10 through 36 bar sizes .... –25 mm

No. 43 and 57 bar sizes.................................. –50 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.

SPECIFICATION

2.2.9 Bearing plate for prestressing tendons, deviation from specified plane
.... ±20 mm per m, but not less than ±3 mm

2.2.10 *Placement of smooth rod or plate dowels in slabs-on-ground*

2.2.10.1 Centerline of dowel, vertical deviation measured from bottom of concrete slab at the joint for element depth 200 mm or less ....±13 mm

When element depth is over 200 mm ....±25 mm

2.2.10.2 Spacing of dowels, measured along a line parallel to the specified spacing.......................±75 mm

The total number of dowels shall not be fewer 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 ....±13 mm

Vertical deviation...±13 mm

COMMENTARY

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.

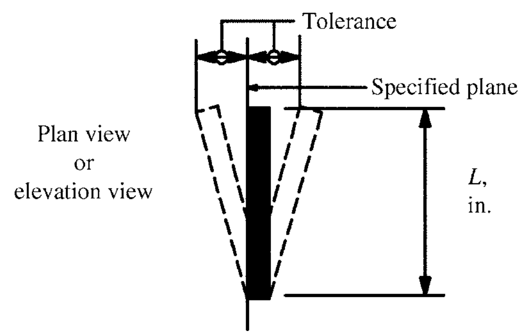

Fig. R2.2.9—Bearing plate for prestressing tendons.

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.

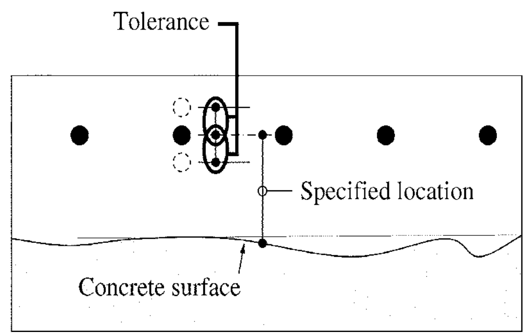

Fig. R2.2.10.1—Dowel placement.

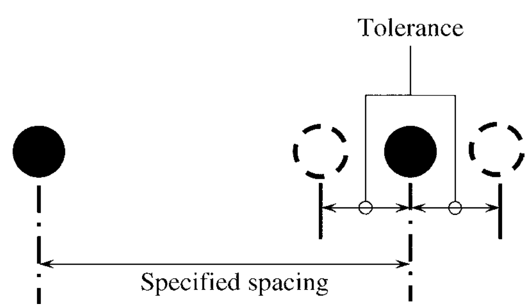

Fig. R2.2.10.2—Dowel spacing.

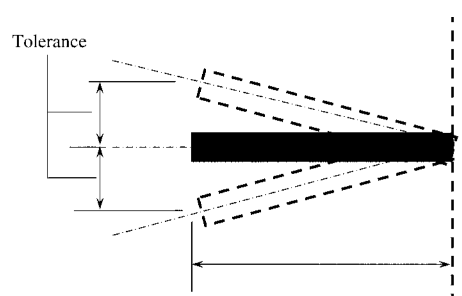

Fig. R2.2.10.3—Dowel deviation from line.

SPECIFICATION

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

2.3.1 Clearance to nearest reinforcement shall be the greater of the bar diameter, largest aggregate size, or .... 25 mm

2.3.2 *Centerline of assembly from specified location*

Horizontal deviation .... ±25 mm

Vertical deviation .... ±25 mm

2.3.3 *Surface of assembly from surface of element*

Assembly dimension 300 mm or smaller .... ±40 mm per m
but not less than .... ±6 mm

Assembly dimension greater than 300 mm ..... ±13 mm

2.3.4 *Anchor bolts in concrete*

2.3.4.1 *Top of anchor bolt from specified elevation*
Vertical deviation .... ±13 mm

2.3.4.2 *Centerline of individual anchor bolts from specified location*

Horizontal deviation
for M20 and M22 bolts.................................. ±6 mm
for M24, M27, M30, M33, and M36 bolts ...... ±10 mm
for larger than M36 bolts................................ ±13 mm

COMMENTARY

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

R2.3.1 The minimum clearance between reinforcement and embedded items is determined by this section. Refer to Fig. R2.3.1(a) and (b).

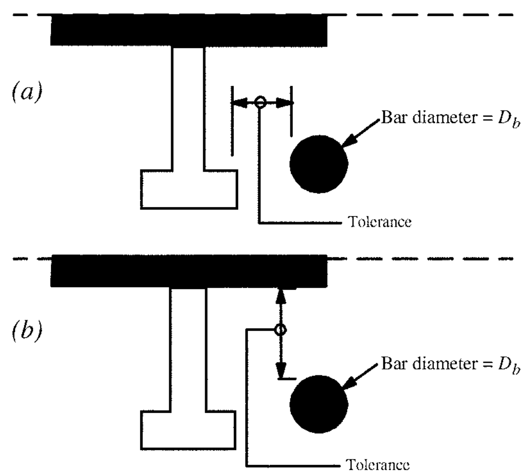

Fig. R2.3.1—Clear distance.

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 (10MSP). The tolerance for the location of anchor bolts is based on using oversized holes per the *AISC Design Guide 1: Base Plates and Anchor Rod Design*, 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 #14*.

SPECIFICATION

2.4—Concrete batching

Refer to Table 2.4.

Table 2.4—Concrete batching tolerances (ASTM C94/C94M)

Material	Tolerance
Cementitious materials 30% of scale capacity or greater	±1% of required mass
Less than 30% of scale capacity	–0 to +4% of the required mass
Water 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
Aggregates 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
Admixtures	±3% of the required amount or plus or minus the amount of dosage required for 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"
For all values..+0 mm

Specified slump 75 mm or less........................–40 mm

Specified slump more than 75 mm ....–65 mm

Where slump is specified as a single value
Specified slump 50 mm and less................... ±13 mm

Specified slump more than 50 mm but not greater than 100 mm ....±25 mm

Specified slump more than 100 mm...................±40 mm

Where slump is specified as a range........no tolerance

COMMENTARY

R2.4—Concrete batching

Refer to ASTM C94/C94M and ACI 304.6R for additional information regarding concrete batching. ASTM C685/C685M provides information for concrete made with materials continuously batched by volume. The Volumetric Mixer Manufacturers Bureau (VMMB 100) provides standardized information concerning volumetric mixers.

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 C94/C94M, 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 (HRWRAs) (also called superplasticizers) are regularly used at specified slumps of 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 HRWRA is used to achieve flowing concrete. When HRWRAs are used, concrete slump should be specified for the concrete mixture prior to the addition of the HRWRA.

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

SPECIFICATION

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

COMMENTARY

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

SPECIFICATION

3.1—Deviation from plumb

Note: *Excavation shall be measured before concrete placement.*

3.1.1 *Category A*—For unreinforced concrete 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)—±12.5% of shaft diameter.

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

3.1.3 *Category C*—For reinforced concrete piers—±2.0% of shaft length.

COMMENTARY

R3.1—Deviation from plumb

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

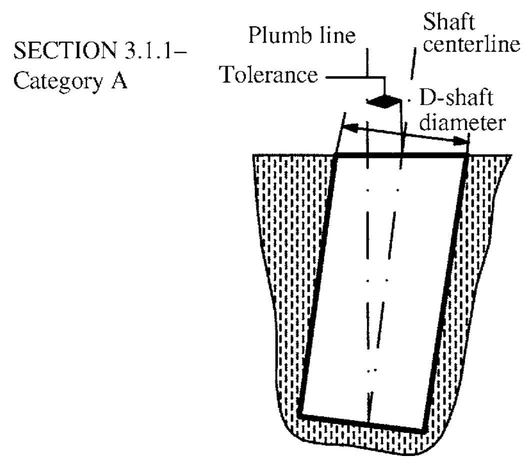

Fig. R3.1.1—Category A.

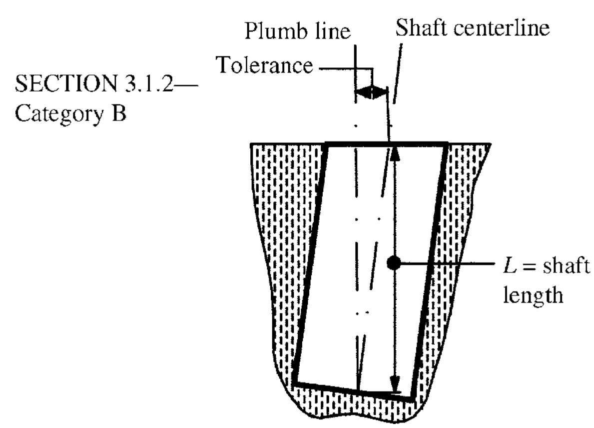

Fig. R3.1.2—Category B.

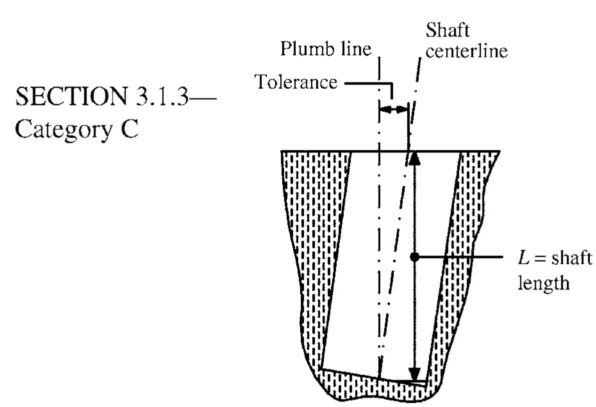

Fig. R3.1.3—Category C.

SPECIFICATION

3.2—Deviation from location

3.2.1 *Foundations, unless noted otherwise in this section*

Horizontal deviation of the as-cast edge:
Where dimension is 2.4 m or more ....±50 mm

Where dimension is less than 2.4 m
...the greater of ±2% of specified dimension or 13 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).

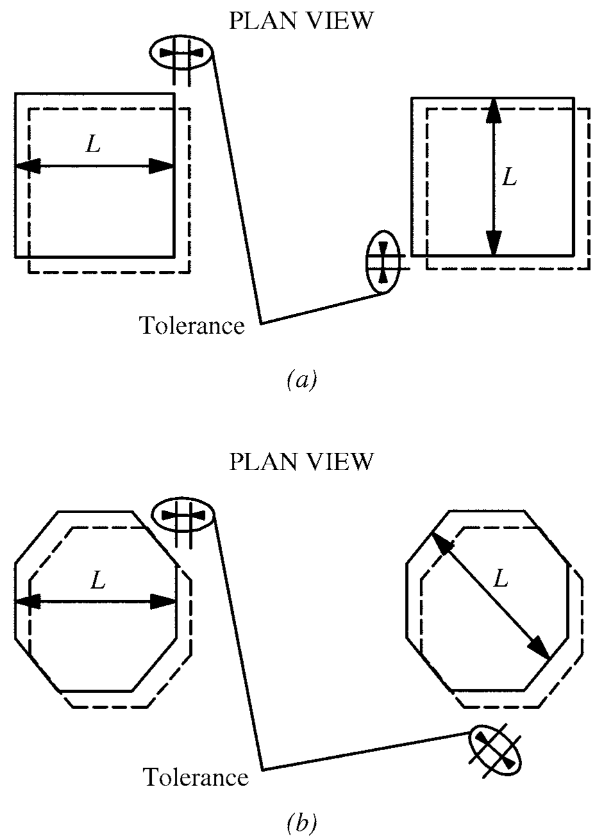

Fig. R3.2.1—Foundations, unless otherwise noted.

SPECIFICATION

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 ±13 mm.

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 ±75 mm.

COMMENTARY

R3.2.2 *Foundations supporting masonry*

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

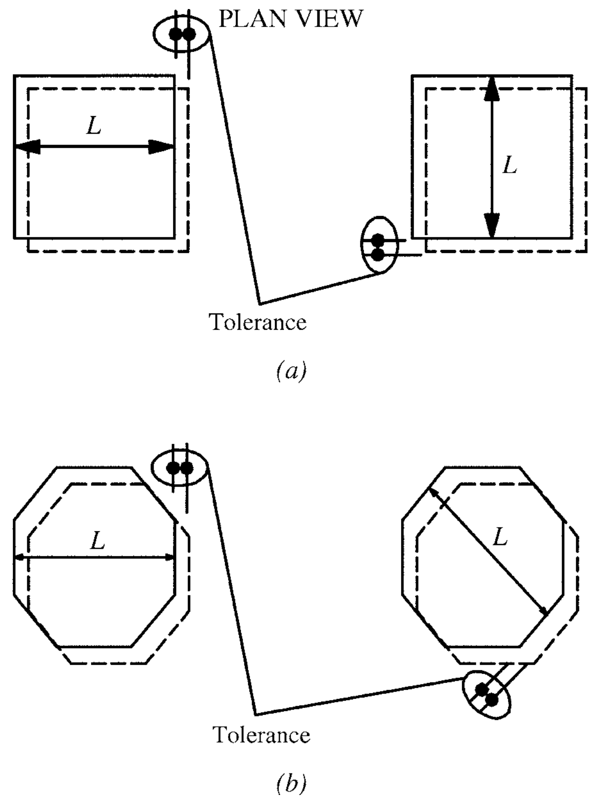

Fig. R3.2.2—Foundations supporting masonry.

R3.2.3 *Top of drilled piers*

Refer to Fig. R3.2.3.

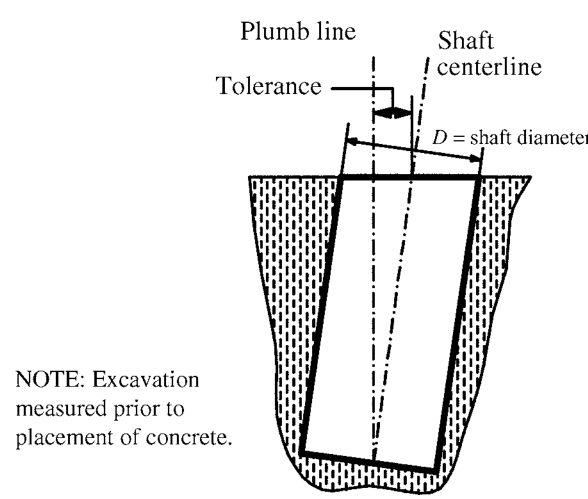

Fig. R3.2.3—Top of drilled piers: horizontal deviation.

SPECIFICATION

3.3—Deviation from elevation

3.3.1 *Top surface of foundations*
Vertical deviation .... +13 mm
.... –50 mm

3.3.2 *Top surface of drilled piers*
Vertical deviation .... +25 mm
.... –75 mm

3.4—Deviation from plane

3.4.1 *Base of bell pier*

The lesser of 10% of the bell diameter or ±75 mm.

3.4.2 *Top surface of footings at interface with supported element*

Maximum gap between the concrete and the near surface of a 3 m straightedge, measured between the support points, shall not exceed +13 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.

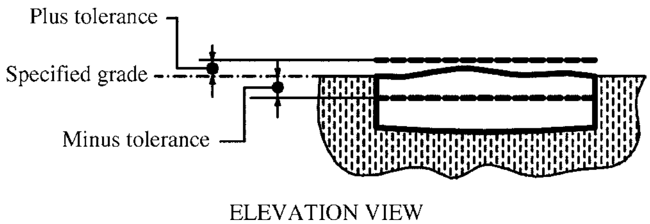

Fig. R3.3.1—Top surface of foundations: vertical deviation.

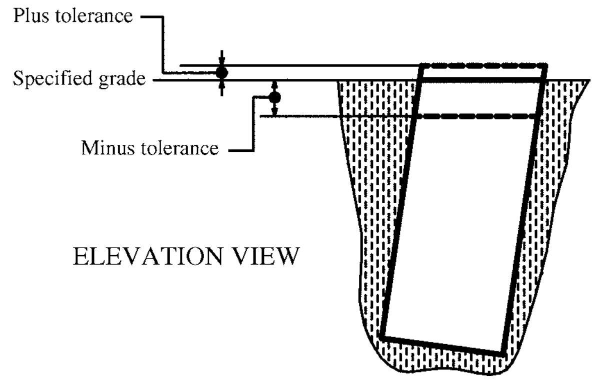

Fig. R3.3.2—Top surface of drilled piers: vertical deviation.

R3.4—Deviation from plane

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

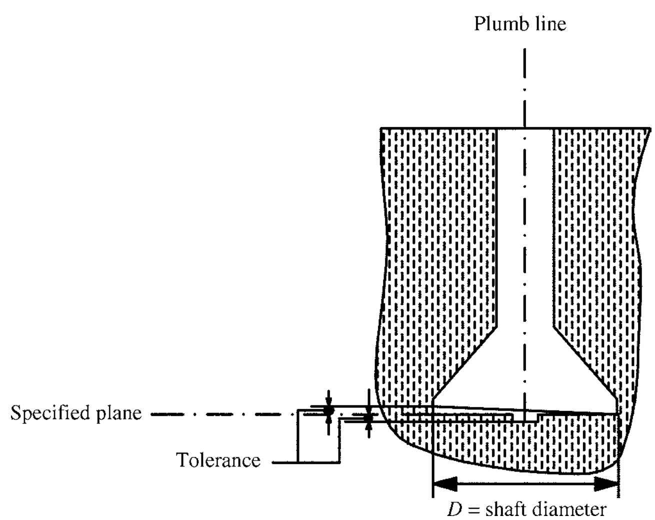

Fig. R3.4.1—Base of bell pier.