Tolerances for Concrete Construction

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Tolerances for Concrete Construction

- What is it?
- When did we start this anyway?
- Who said we needed tolerances?
- Now that we have them, how do we use them?

Tolerance

- It's the elephant in the living room.
- Everybody knows It's there.
- If you ignore It, maybe It will go away.

Tolerances should be:

- Considered in design
- Controlled during construction
- Enforced by inspection

Tolerance - Defined

- Sympathy or indulgence for practices differing from or conflicting with one's own.
- The permissible deviation from a specified value

History of ACI 117 Tolerance

- 1962 – ACI 117 was formed.
- Committee purpose was to gather and summarize all the of tolerances that existing committees were publishing.

History of ACI 117 Tolerance

- 1980 - Proposed ACI Standard published in Concrete International
- 1981 – Concrete International published reviews praising and bashing the Proposed Standard.
- 1981 - The Standard was adopted by ACI

History of ACI 117 Tolerance

- 1990 – ACI adopts "Standard Specification for Tolerances for Concrete Construction"
- 2006 – ACI 117-06 document was published.
- 2010 – ACI 117-10 document was published.
- 2014 – ACI 117.1R-14 Tolerance Compatibility

Who Said We Need Tolerances

- If you ask an Engineer, all things are to be built exactly as specified.
- If you ask a Contractor, the tolerance limits just slow down construction.
- If you ask an Owner, they don't care as long as the building works and "things" fit!

Who Said We Need Tolerances

- No structure is exactly level, plumb, straight or true.
- Tolerances are a means to establish permissible variations from the values specified.

Tolerances are based on:

- Normal Needs
- Common Construction Practices

How do we use them?

- Tolerances should be used to provide the owner with a tangible benefit.
- Tolerances should convey to the contractor a performance expectation.
- Tolerances should be selected based on necessity rather than desirability.

Tolerances

- Overly constrictive tolerances are not impossible to achieve, just costly to produce.
- Tolerances should always be based on, normal needs and common construction practices

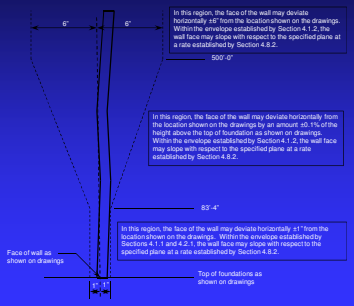
Tolerances

- Most problems with tolerances arise from unrealized expectations.
- The degree of accuracy depends on the interrelationship of the parts.

Tolerance – Chapter 1

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

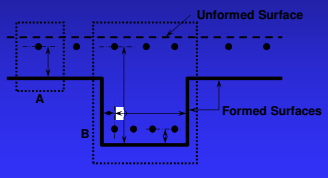
Tolerances – Chapter 1



Tolerances – Chapter 2

- **2.2.1** Placement of nonprestressed reinforcement, measured from form surface
- When member depth (or thickness) is 4 in. or less ±1/4 in.
- When member depth is over 4 in. to12 in. ± 3/8 in.
- When member depth is over 12 in. ± 1/2 in.

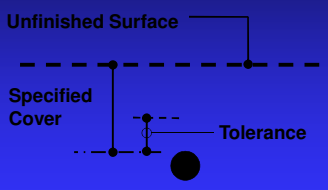
Tolerances – Chapter 2



Tolerances – Chapter 2

- **2.2.2** Concrete cover measured perpendicular to concrete surface
- When member depth (or thickness) is 12 in. or less - 3/8 in.
- When member depth is over 12 in. -1/2 in.
- Reduction in cover shall not exceed one-third the specified concrete cover.
- Reduction in cover to formed soffits shall not exceed -1/4 in.

Tolerances – Chapter 2



Tolerances – Chapter 2

- **2.2.3** Vertical deviation for slab-on-ground reinforcement ± 3/4 in.

Tolerances – Chapter 2

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

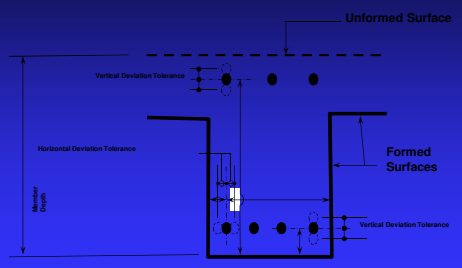
- Except as noted below ± 3 in.
- Stirrups the lesser of ± 3" or ± 1 in. per ft. of beam depth
- Ties the lesser of ± 3" or ± 1 in. per ft. of least column width
- The total number of bars shall not be less than that specified.

Tolerances – Chapter 2

- **2.2.6** Placement of prestressing reinforcement or prestressing ducts

- **2.2.6.1** Horizontal deviation
- Element depth (or thickness) 24 in. or less ± 1/2 in.
- Element depth (or thickness) over 24 in. ± 1 in.

Tolerances – Chapter 2



Tolerances – Chapter 2

- **2.2.6.2** Vertical deviation
- Element depth 8 in. or less ± 1/4 in.
- Element depth over 8 in. to 24 in. ± 3/8 in.
- Element depth more than 24 in. ± 1/2 in.

Tolerances – Chapter 2

- 2.2.7 Longitudinal location of bends in bars and ends of bars.
- At discontinuous ends of corbels and brackets ± 1/2 in.
- At discontinuous ends of others ± 1 in.
- At other locations ± 2 in.

Tolerances – Chapter 2

- 2.2.8 Embedded length of bars and length of bar laps
- # 3 - # 11 bar sizes -1 in.
- # 14 - #18 bar sizes -2 in.

Tolerances – Chapter 2

- 2.2.9 Bearing plate for prestressing tendons, deviation from specified plane.
  ± 1/4 in. per ft., but not less than ± 1/8 in.

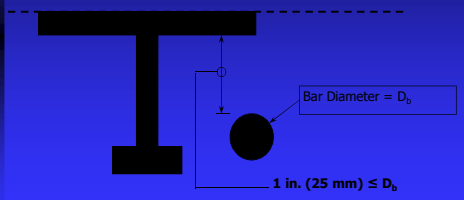
Tolerances – Chapter 2

- 2.2.10 Placement of smooth rod or plate dowels in slab on ground.
- 2.2.10.1 Centerline of dowel, vertical deviation slab depth 8 in. or less ± 1/2 in.
- When slab depth greater than 8 in. ± 1 in.
- 2.2.10.2 Spacing of dowels ± 3 in.
- 2.2.10.3 Centerline dowel location ± 1/2 in.

Tolerances – Chapter 2

- **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.

Tolerances – Chapter 2



Tolerances – Chapter 2

- **2.3.4** Anchor bolts in concrete
- **2.3.4.1** Top of anchor bolt from specified elevation
- Vertical deviation ±1/2 in.

- **2.3.4.2** Centerline of individual anchor bolts from specified location
- Horizontal deviation
- 3/4 in. and 7/8 in. bolts ±1/4 in.
- 1 in., 1-1/4 in., and 1 1/2 in. bolts ±3/8 in.
- for 1 3/4 in., 2 in., and 2 1/2 in. bolts ±1/2 in.

Chapter 3 - Foundations

- **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) ±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) ±1.5% of shaft length
- **3.1.3** Category C — For reinforced concrete piers ±2.0% of shaft length

Tolerances – Chapter 3

- **3.2 Deviation from location**
- **3.2.1** Foundations, unless noted otherwise in this section
- Horizontal deviation of the as-cast edge with a width of less than 8 ft. ± 2% of the foundation's width or ± 1/2 in.
- Horizontal deviation of the as-cast edge 8 ft. or greater ± 2 in.
- **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.
- **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.

Tolerances – Chapter 3

- **3.3 Deviation from elevation**
- **3.3.1** Top surface of foundations
- Vertical deviation +1/2 in.
  -2 in.
- **3.3.2** Top surface of drilled piers
- Vertical deviation +1 in.
  -3 in.

Tolerances – Chapter 3

- **3.5 Deviation from cross-sectional dimensions of foundations**
- **3.5.1** Formed footings
- Horizontal deviation +2 in.
  -1/2 in.
- **3.5.2** Unformed footings cast against soil
- Horizontal deviation from plan dimension
- Where dimension is 2 ft. or less +3 in.
  -1/2 in.
- Where dimension is more than 2 ft. +6 in.
  -1/2 in.
- **3.5.3** Deviation from footing thickness -5%

Chapter 4 – Cast In Place For Buildings

- **4.1 Deviation from plumb**
- **4.1.1** For heights less than or equal to 83 ft 4 in.
- 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.
- For the outside corner of an exposed corner column and control 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 ±1/2 in.

Tolerances – Chapter 4

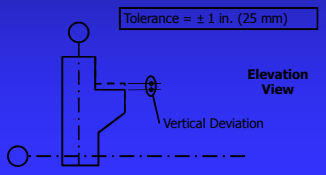
- **4.1.2** For heights greater than 83 ft 4 in.
- For lines, surfaces corners, arises and elements: the lesser of 0.1% times the height above the top of foundations as shown on structural drawings or ± 6 in.
- For the outside corner of an exposed corner columns and control joint grooves in concrete exposed to view: the lesser of 0.05% times the height above the top of foundations as shown on structural drawings or ± 3 in.

Tolerances – Chapter 4

- **4.2 Deviation from location**
- **4.2.1** Horizontal deviation
- Vertical Elements, measured at the top of element foundation ±1 in.
- Other Elements ±1 in.
- Edge location of all openings ±1/2 in.
- Sawcuts, joints, and weakened plane embedments in slabs ±3/4 in.

Tolerances – Chapter 4

- **4.2.2** Vertical deviation
- Elements ±1 in.
- Edge location of all openings ±1/2 in.



Tolerances – Chapter 4

- **4.4 Deviation from elevation**
- **4.4.1** Top surface of slabs
- Slabs-on-ground ±3/4 in.
- Formed suspended slabs, before removal of supporting shores ±3/4 in.
- Slabs on structural steel or precast concrete. no requirement
- **4.4.2** Formed surfaces before removal of shores ±3/4 in.

Tolerances – Chapter 4

- 4.4.3Lintels, sills, parapets, horizontal grooves, and other lines exposed to view ±1/2 in.
- **4.4.4** Top of walls ±3/4 in.
- **4.4.5** Fine grade for slabs-on-ground ±3/4 in.

Tolerances – Chapter 4

- **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. -1/4 in.
- More than 12 in. not more than 36 in. +1/2 in. -3/8 in.
- Over 36 in. +1 in. -3/4 in.

- **4.5.2** Unformed beams and walls cast against soil
- Horizontal deviation from plan dimension:
- Where dimension is 2 ft. or less +3 in. –1/2 in.
- Where dimension is more than 2 ft. +6 in. –1/2 in.
- **4.5.3** Thickness of suspended slabs -1/4 in.

Tolerances – Chapter 4

- **4.5.4** Thickness of slabs-on-ground
- Average of all samples -3/8 in.
- Individual sample -3/4 in.
- **4.5.4.1**Minimum number of samples shall be four per 5,000 sq. ft. or part thereof.
- **4.5.4.2** Samples shall be taken within 7 days of placement.

Tolerances – Chapter 4

- **4.6 Deviation from formed opening width or height** –1/2 in.
  + 1 in.

Tolerances – Chapter 4

- **4.7 Deviation from relative elevations or widths**
- **4.7.1**Stairs, measured along a line parallel to the stair axis
- Difference between largest and smallest tread or riser in any flight shall not exceed 3/8 in.
- Difference in height of adjacent risers measured at the nose shall not exceed 3/16 in.
- Difference in depth of adjacent treads shall not exceed 3/16 in.

Tolerances – Chapter 4

- **4.8 Deviation from slope or plane**
- **4.8.1** Stair tread from back to nosing ±1/4 in.
- **4.8.2**Formed surfaces over distances of 10 ft.
- 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%

Tolerances – Chapter 4

- **4.8.3** Formed surface irregularities (gradual or abrupt)
- Abrupt irregularities shall be measured within 1 in. of the irregularity. Gradual surface irregularities shall be measured by determining the gap between concrete and near surface of a 5 ft straightedge, measured between contact points.
- Class A Surface..... +1/8 in.
- Class B Surface..... +1/4 in.
- Class C Surface..... +1/2 in.
- Class D Surface..... +1 in.

Tolerances – Chapter 4

- **4.8.4** Random traffic floor surface finish tolerances shall meet the requirements of Section 4.8.5 or 4.8.6.
- **4.8.4.4** Floor test surfaces shall be measured and reported within 72 hr. after completion of slab concrete finishing operations and before removal of any supporting shores.
- **4.8.4.6** Floor surface test measurements shall not cross planned changes in floor surface slope.
- **4.8.4.7** Test results shall be reported in a manner that will allow the data to be verified or the tests to be replicated.

Tolerances – Chapter 4

Table R4.8.4—Methods to evaluate flatness

Floor classification	F_F flatness (SOF_F)	10 ft manual straightedge maximum gap, in.
Conventional	20	0.628 to 0.284
Moderately flat	25	0.569 to 0.254
Flat	35	0.359 to 0.163
Very flat	45	0.282 to 0.144
Super flat	60	0.253 to 0.135

Floor classification	10 ft manual straightedge maximum gap, in.	SOF_F range
Conventional	1/2	17.4 to 27.7
Moderately flat	3/8	20.3 to 34.9
Flat	1/4	24.0 to 45.9
Very flat	3/16	31.7 to 64.3
Super flat	1/8	37.7 to 109.3

Tolerances – Chapter 4

- **4.8.5.1** Specified overall values for flatness (SOFF) and levelness (SOFL) shall conform to one of the following floor surface classifications, unless noted otherwise.
- Floor SurfaceClassification:

	Specified OverallFlatness	Specified OverallLevelness
Conventional	20	15
Moderately flat	25	20
Flat	35	25
Very flat	45	35
Super flat	60	40

Tolerances – Chapter 4

- **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:

Tolerances – Chapter 4

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

	Maximum Gap90%	Maximum Gap100%
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

Tolerances – Chapter 4

- **4.9 Sawcut depth in slab-on-ground**
- **4.9.1** Depth of sawcut joint ±1/4 in.

Tolerances

Questions?