DIVISION 7 — PRODUCT TOLERANCES

Standard

7.1 Requirements for Finished Product

7.1.1 Product Tolerances – General

The tolerances listed in this Division shall govern unless other tolerances are noted in the contract documents for a specific project.

Commentary

C7.1 Requirements for Finished Product

C7.1.1 Product Tolerances — General

Tolerances are divided into three categories: product tolerances, erection tolerances and interfacing tolerances. See Appendix I for erection tolerances.*

Tolerance is a specified permissible variation from exact requirements of the contract documents. A tolerance may be expressed as an additive or subtractive (±) variation from a specified dimension or relation or as an absolute deviation from a specified relation. Tolerances should be established for the following reasons:

1. **Structural.** To ensure that the structural design properly accounts for factors sensitive to variations in dimensional control. Examples include eccentric loading conditions, bearing areas, reinforcement locations, and hardware and hardware anchorage locations.
2. **Feasibility.** To ensure acceptable performance of joints and interfacing materials in the finished structure and to ensure that designs and details are dimensionally feasible from manufacturing and construction points of view.
3. **Visual effects.** To ensure that the variations will be controllable and result in an acceptable looking structure.
4. **Economics.** To ensure ease and speed of production and erection by having a known degree of accuracy in the dimensions of the precast concrete units.
5. **Legal.** To avoid encroaching on property lines and to establish a tolerance standard against which the work can be compared in the event of a dispute.
6. **Contractual.** To establish a known acceptability range and also to establish responsibility for developing, achieving and maintaining mutually agreed tolerances.

It is very important that the entity (architect, engineer of record, or precaster) taking responsibility for establishing the project tolerances be clearly defined at the onset of the project.

The architect/engineer should be responsible for coordinating the tolerances for precast concrete work with the requirements of other trades whose work adjoins the precast concrete construction. In all cases the tolerances must be reasonable, realistic and within generally accepted limits. It should be understood by those involved in the design and construction process that tolerances shown in Article 7.1.2 must be considered as guidelines for an acceptable range and not limits for rejection. If these tolerances are met, the unit should be accepted. If

* See the full report of the PCI Committee on Tolerances, "Tolerances for Precast and Prestressed Concrete," PCI JOURNAL, V. 30, No. 1, January-February, 1985, for a complete discussion on erection and interfacing tolerances.

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Commentary

these tolerances are exceeded, the unit may still be acceptable if it meets any of the following criteria:

1. Exceeding the tolerance does not affect the structural integrity or architectural performance of the unit.
2. The unit can be brought within tolerance by structurally and architecturally satisfactory means.
3. The total erected assembly can be modified to meet all structural and architectural requirements.

Where a project involves particular features sensitive to the cumulative effect of generally accepted tolerances on individual portions, the architect/engineer should anticipate and provide for this effect by setting a cumulative tolerance or by providing escape areas (clearances) where accumulated tolerances can be absorbed. The consequences of all tolerances permitted on a particular project should be investigated to determine whether a change is necessary in the design or in the tolerances applicable to the project or individual components.

Careful inspection of the listed tolerances will reveal that many times one tolerance will override another. The allowable variation for one unit of the structure should not be applicable when it will permit another unit of the structure to exceed its allowable variations. Restrictive tolerances should be reviewed to ascertain that they are compatible and that the restrictions can be met. For example, a requirement which states that "no bowing, warpage or movement is permitted" is not practical or possible to achieve.

Applicable product tolerances shall be clearly conveyed to production and quality control personnel.

Accurate measuring devices and methods with precision capability appropriate to the tolerance being controlled shall be used for both setting and checking product tolerances. To maximize accuracy, products shall not be measured in increments in a manner which creates the possibility of cumulative error.

Any special measuring or record keeping methods specified in the contract documents shall be observed by the plant quality control personnel.

7.1.2 Product Tolerances

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Product tolerances are those needed in any manufacturing process. They are normally determined by economical and practical production considerations, and functional and appearance requirements.

The architect/engineer should specify product tolerances or require performance within generally accepted limits. Tolerances for manufacturing are standardized throughout the industry and should not be made more exacting, and therefore more costly, unless absolutely necessary.

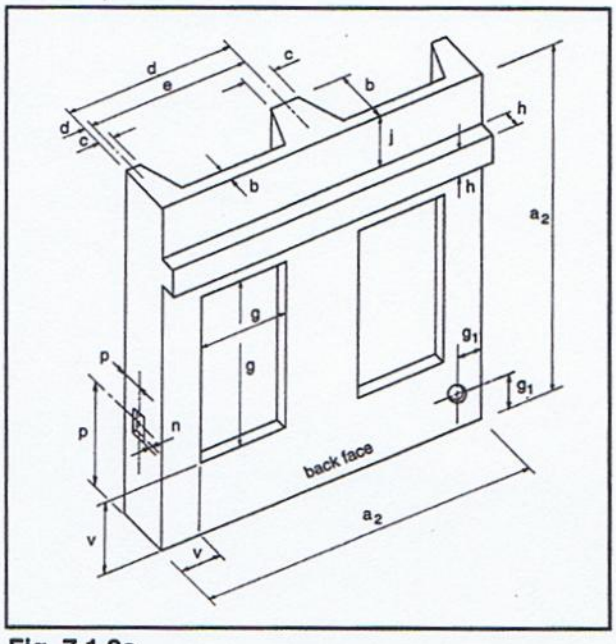

Fig. 7.1.2a

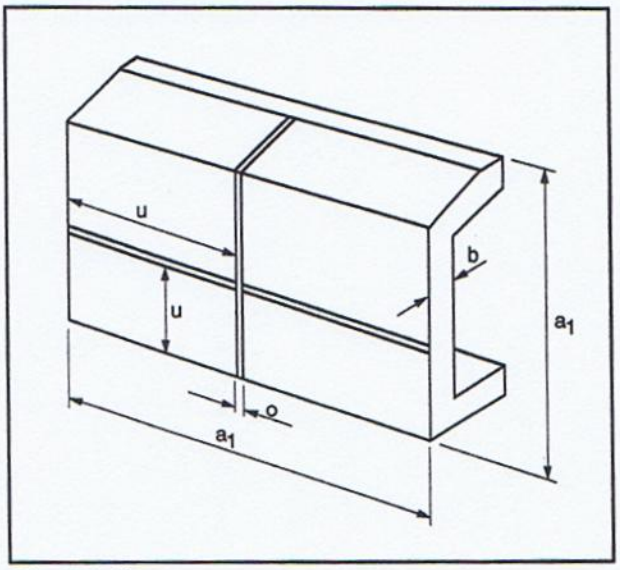

Fig. 7.1.2b

During the pre- and post-pour check of dimensions, the inspector shall have the approved shop drawings for reference. Discrepancies shall be noted on the post-pour record and transmitted to management or engineering for their evaluation.

Figs. 7.1.2a and b shows the location of the tolerances listed below.

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Units* shall be manufactured so that the face of each unit which is exposed to view after erection complies with the following dimensional requirements:

a_1 Overall height and width of units measured at the face exposed to view.

10 ft or under ..... ± 1/8 in. (±3 mm)

10 to 20 ft ...+ 1/8 in., –3/16 in. (+3 mm, –5 mm)

20 to 40 ft ..... ± 1/4 in. (±6 mm)

Each additional 10 ft .. ± 1/16 in. (±1.5 mm) per 10 ft (3 m)

a_2** Overall height and width of unit measured at the face not exposed to view.

10 ft or under ..... ± 1/4 in.

10 to 20 ft ..... + 1/4 in., –3/8 in.

20 to 40 ft ..... ± 3/8 in.

Each additional 10 ft..... ± 1/8 in.

b Total thickness or flange thickness ..... + 1/4 in., –1/8 in. (+6 mm, –3 mm)

c Rib thickness ..... ± 1/8 in. (±3 mm)

d Rib to edge of flange ..... ± 1/8 in. (±3 mm)

e Distance between ribs ..... ± 1/8 in. (±3 mm)

f Variation from square or designated skew (difference in length of the two diagonal measurements) ..... ± 1/8 in. (±3 mm per 2 m) per 6 ft of diagonal or ± 1/2 in. (±13 mm), whichever is greater.***

g Length and width of blockouts and openings within one unit ..... ± 1/4 in. (±6 mm)

g_1 Location and dimensions of blockouts hidden from view and used for HVAC and utility penetrations ..... ± 3/4 in. (±19 mm)

h Dimensions of haunches .... ± 1/4 in. (±6 mm)

i Haunch bearing surface deviation from specified plane ..... ± 1/8 in. (±3 mm)

Commentary

a_1. Length or width dimensions and straightness of a unit will affect the joint dimensions, opening dimensions between panels, and perhaps the overall length of the structure.

b. Thickness variation of the precast concrete unit becomes critical when interior surfaces are exposed to view. A non-uniform thickness of adjacent panels will cause offsets of the front or the rear faces of the panels.

f. Panels out-of-square can cause tapered joints and make adjustment of adjacent panels difficult.

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* For non-architectural precast concrete units, such as columns, beams, etc., tolerance requirements are given in PCI MNL-116, *Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products.*

** Unless joint width and fit up requirements require more stringent tolerances.

*** Applies both to panel and to major openings in the panel.

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j Difference in relative position of adjacent haunch bearing surfaces from specified relative position ..... ± 1/4 in. (±6 mm)

k Bowing ..... ± L/360 max. 1 in. (25 mm)

l Local smoothness .... 1/4 in. in 10 ft (6 mm in 3 m) Does not apply to visually concealed surfaces. (Refer to Fig. C7.1.2c for definition.) For clay

Commentary

k. Bowing is an overall out-of-planeness condition which differs from warping in that while the corners of the panel may fall in the same plane, the portion of the panel between two parallel edges is out of plane. Bowing conditions are shown in Fig. C7.1.2a.

Bowing and warping tolerances have an important effect on the edge match up during erection and on the visual appearance of the erected panels, both individually and when viewed together. The requirements for bowing and warping of panels may be overridden by tolerances for panels as installed with reference to joint widths, jog in alignment and step in face.

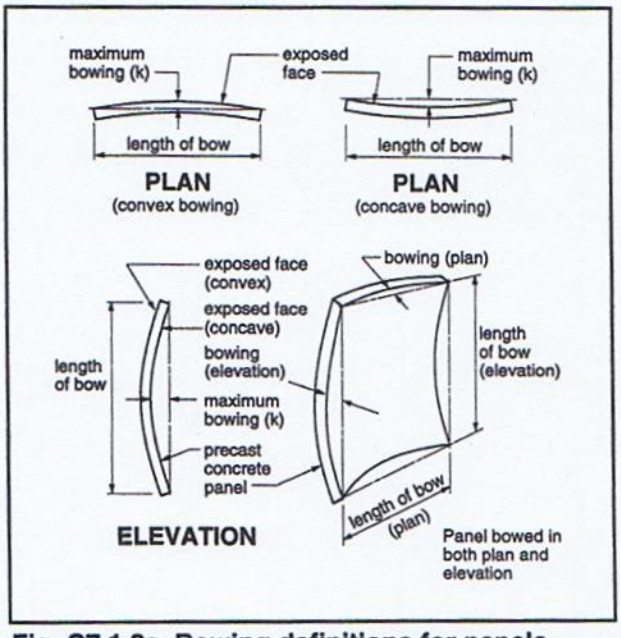

Fig. C7.1.2a. Bowing definitions for panels

A special appearance requirement may be necessary for honed or polished flat concrete walls where bowing or warping tolerances might have to be decreased to 75 or 50% of tolerances in Article 7.1.2 in order to avoid joint shadows. Another special case might be tolerances for dimensions controlling the matching of open shaped panels. These tolerances may have to be smaller than the standard dimensional tolerance (75% or 50%), unless the architect has recognized and solved the alignment problem as part of the design.

l. Surface out-of-planeness, which is not a characteristic of the entire panel shape, is defined as a local smoothness variation rather than a bowing variation. Examples of local smoothness

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product faced units 1/16 in. (2 mm) variation between adjacent clay products.

Commentary

variations are shown in Fig. C7.1.2b. The tolerance for this type of variation is usually expressed in fractions of an inch per 10 ft (mm per 3 m).

Fig. C7.1.2b also shows how to determine if a surface meets a tolerance of 1/4 in. in 10 ft (6 mm per 3 m). A 1/4 in. (6 mm) diameter by 2 in. (50 mm) long roller should fit anywhere between the 10 ft (3 m) long straightedge and the element surface being measured when the straightedge is supported at its ends on 3/8 in. (10 mm) shims as shown. A 1/2 in. (12 mm) diameter by 2 in. (50 mm) long roller should not fit between the surface and the straightedge.

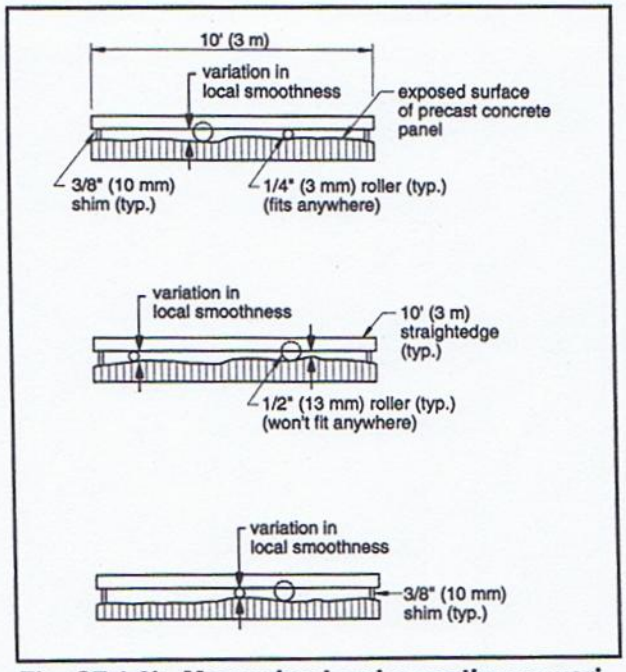

Fig. C7.1.2b. Measuring local smoothness variations.

m Warping ..... 1/16in. per ft (1.5 mm per 300 mm) of distance from nearest adjacent corner

m. Warping is generally an overall variation from planeness in which the corners of the panel do not all fall within the same plane. Warping tolerances are stated in terms of the magnitude of the corner variation, as shown in Fig. C7.1.2c.

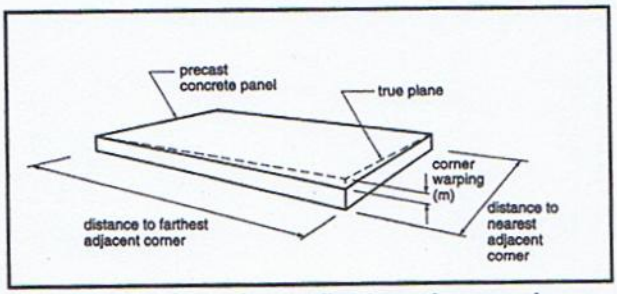

Fig. C7.1.2c. Warping definitions for panels

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n Tipping and flushness of plates ..... ± 1/4 in. (±6 mm)

o Dimensions of architectural features and rustications ..... ± 1/8 in. (±3 mm)

Positions tolerances. For cast-in items measured from datum line location as shown on approved erection drawings:

p Weld plates ..... ± 1 in. (±25 mm)

q Inserts ..... ± 1/2 in. (±13 mm)

r Handling devices ..... ± 3 in. (±75 mm)

s_1 Reinforcing steel and welded wire fabric ..... ± 1/4 in. (±6 mm) where position has structural implications or affects concrete cover, otherwise ± 1/2 in. (±13 mm)

s_2 Reinforcing steel extending out of member ..... ± 1/2 in. (±13 mm) of plan dimensions

t Tendons .....vertical: ± 1/4 in. (±3 mm)

.....horizontal: ± 1 in. (±25 mm)

u Location of rustication joints ± 1/8 in. (±3 mm)

v Location of opening within panel ..... ± 1/4 in. (±6 mm)

w Flashing reglets ..... ± 1/4 in. (±6 mm)

x Flashing reglets at edge of panel ..... ± 1/8 in. (±3 mm)

y Reglets for glazing gaskets ..... ± 1/8 in. (±1.5 mm)

z Electrical outlets, hose bibs, etc. ..... ± 1/2 in. (±13 mm)

aa Haunches ..... ± 1/4 in. (±6 mm)

bb Allowable rotation of plate, channel insert, electrical box, etc., Fig. 7.1.2c..... 2 deg. rotation or 1/4 in. (6 mm) max. over the full dimension of the element

Commentary

Note that bowing and warping tolerances are of primary interest at the time the panel is erected. Careful attention to pre-erection storage of panels is necessary, since storage conditions can be an important factor in achieving and maintaining panel bowing and warping tolerances.

The likelihood that a panel will bow or warp depends on the design of the panel and its relative stiffness or ability to resist deflection as a plate member. Slender panels are more likely to bow, and the tolerances should be more liberal.

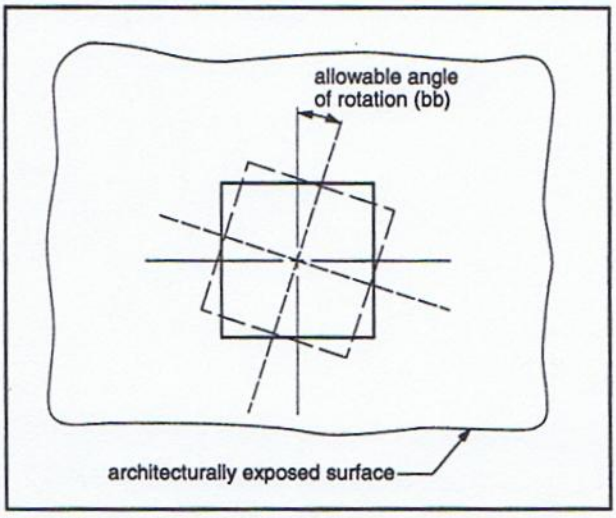

Fig. 7.1.2c. Allowable rotation.