

# Product Tolerances for Precast and Prestressed Concrete

Prepared by

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*This supplement, prepared by PCI Committee on Tolerances, presents product tolerances for sheet piling, single riser bleacher slabs, multistemmed bridge units, prestressed concrete poles, prison cell modules, prestressed concrete railroad ties, prestressed concrete panels for storage tanks and bridge deck units.*

## 1.1 INTRODUCTION

This report includes product tolerances for those products that were not previously included in the PCI Committee on Tolerances report, "Tolerances for Precast and Prestressed Concrete," published in the January-February 1985 PCI JOURNAL.

The basic concept for the determination of product tolerances remains the same as described in the original report. That is, product tolerances are those within which precast concrete members should be made. They are a measure of dimensional accuracy of the individual members and ensure, prior to delivery, the probability that the member will fit into the structure without difficulty.

The two most important tolerance considerations are the effect of formwork and the measuring techniques used to assess the various product dimensions. Forms can be rigid, semi-rigid or flexible, and the rigidity of the form often leads to different degrees of casting accuracy. Tolerances are also established by economic and production considerations, such as how a member must fit into the overall construction and the members relationship to adjacent units.

These factors, when coupled with the individual skill of the craftsmen, will determine the final degree of accuracy. The selection of a particular casting form and the measuring techniques are often based on economic and functional reasons rather than on the manufacturer's capabilities to follow the most sophisticated methods.

At times, it is a practice that the user of a precast concrete product will specify his own range for tolerances. For example, railroad authorities may often specify the necessary tolerances for prestressed concrete rail ties. Therefore, the designer should consider PCI tolerances in conjunction with the tolerances specified by the controlling authority.

It is strongly recommended that the 1985 committee report be reviewed by users of these tolerances. A detailed understanding of the various considerations that should be taken into account when establishing tolerances is important.

A list of pertinent references on the subject of tolerances is given at the end of this report.<sup>1-31</sup>

## 1.2 DEFINITIONS

**Tolerances** — The definition can include:

- (a) The permitted variation from a basic dimension or quantity, as in the length or width of a member.
- (b) The range of variation permitted in maintaining a basic dimension, as in an alignment tolerance.
- (c) A permitted variation from location or alignment.

**Variation** — The difference between the actual and the basic dimension. Variations may be either negative (less) or positive (greater).

**Basic Dimension** — The dimensions shown on the contract drawings or called for in the specifications. The basic dimension applies to size, location and relative location. It

may also be called the nominal dimension.

**Working Dimension** — The planned dimension of the member obtained from both its basic dimension and joint (clearance) dimensions. It is to this planned dimension that the product tolerance is applied. For example, if a nominal 8 ft (2.44 m) wide double tee is designed to have a nominal  $\frac{3}{4}$  in. (19 mm) width joint on either side, the working dimension for member width would be 7 ft 11 $\frac{1}{2}$  in. (2.42 m).

**Actual Dimension** — The measured dimension of the member after casting. This dimension might differ from the working dimension due to construction and material-induced variation.

**Primary Control Surface\*** — A surface on a precast concrete element, the dimensional location of which is specifically set and controlled in the erection process. Clearance is generally allowed to vary so that the primary control surface can be set within tolerance.

**Secondary Control Surface\*** — A surface on a precast concrete element, the dimensional location of which is dependent on the location tolerance of the member primary control surfaces, plus the member feature tolerances. An example would be the elevation of a second-story corbel on a multistory column whose first story corbel is selected as the primary elevation control surface.

**Feature Tolerance\*** — The location or dimensional tolerance of a feature, such as corbel or blockout, with respect to the overall member dimensions.

## 1.3 TOLERANCE ACCEPTABILITY

It should be understood by those involved in the design and construction process that the tolerances shown in this report must be considered as guidelines for acceptability. Furthermore, it must be realized that all tolerances for a particular product or installation are not of equal significance in the structural or aesthetic performance of the products.

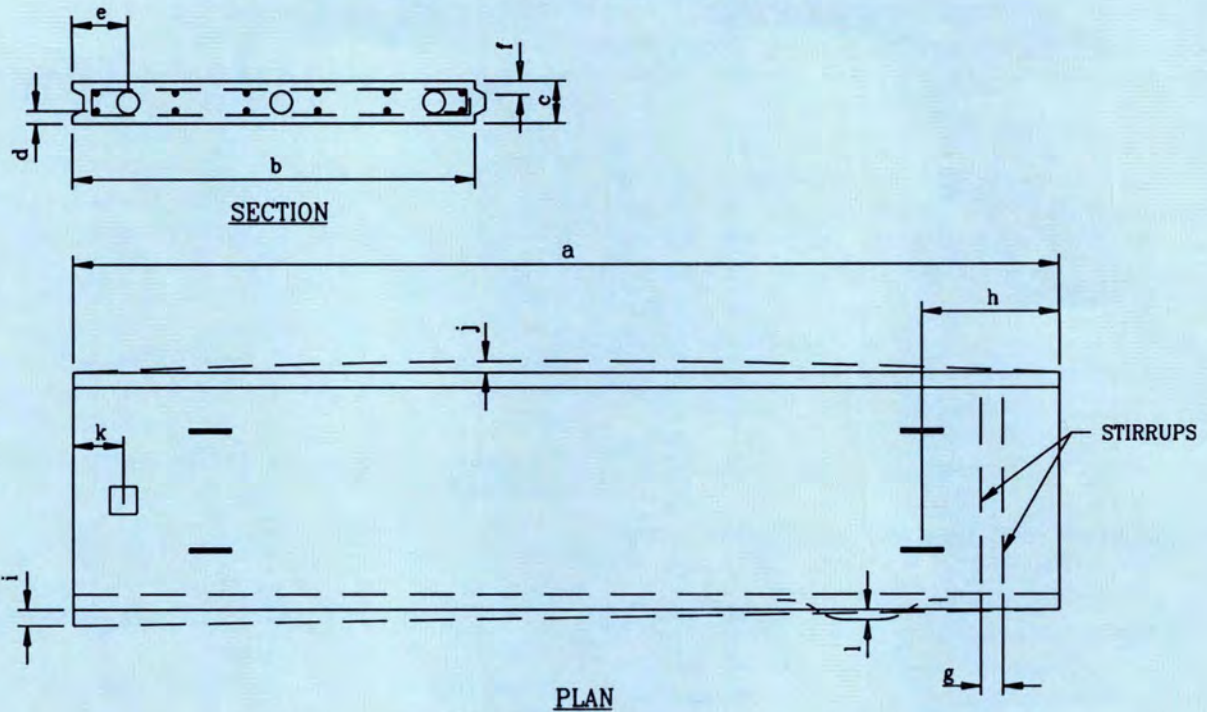
If these tolerances are met, the member should be accepted. If these are exceeded, the member may be accepted, provided it meets any of the following criteria:

- (a) Exceeding the tolerances does not affect the structural integrity or architectural performance of the member.
- (b) The member can be brought within tolerances by structurally and architecturally satisfactory means.
- (c) The total erected assembly can be modified to meet all structural and architectural requirements.

It should also be noted that the proposed product tolerances as recommended previously are not additive to the erection tolerances that govern the setting of member primary control surfaces. However, the product tolerances for secondary control surfaces are additive to the erection tolerances for the member.

\* For the relationship between the different tolerances, refer to the January-February 1985 PCI JOURNAL, Section 1.4.

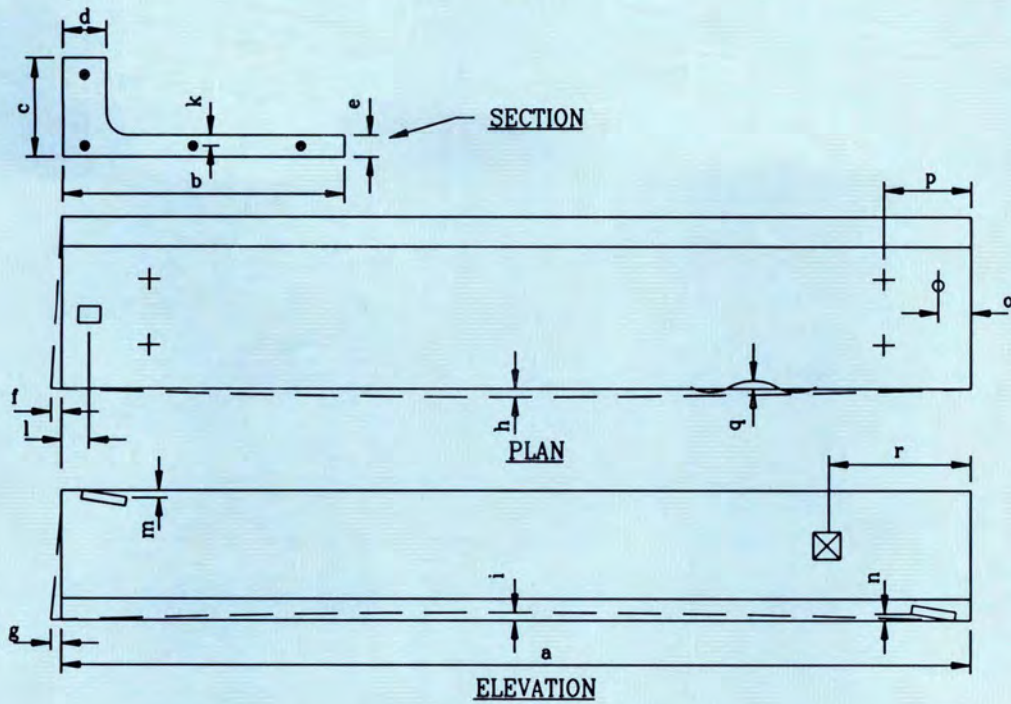
# SHEET PILING



## 2.1.1 SHEET PILING

a = Length .....	$\pm 1$ in. ( $\pm 25$ mm)	h = Position of handling devices	
b = Width .....	$\pm \frac{1}{8}$ in. ( $\pm 9$ mm)	Longitudinal .....	$\pm 6$ in. ( $\pm 152$ mm)
c = Depth .....	$\pm \frac{1}{4}$ in. ( $\pm 6$ mm)	Transverse .....	$\pm \frac{1}{2}$ in. ( $\pm 13$ mm)
d = Position of tendons .....	$\pm \frac{1}{4}$ in. ( $\pm 6$ mm)	Vertical .....	$\pm \frac{1}{2}$ in. ( $\pm 13$ mm)
e = Position of voids		i = Variation from specified end squareness or skew	
Longitudinal .....	$\pm \frac{1}{2}$ in. ( $\pm 13$ mm)	.....	$\pm \frac{1}{4}$ in. per 10 ft, $\pm \frac{1}{2}$ in. max.
Transverse .....	$\pm \frac{1}{2}$ in. ( $\pm 13$ mm)	.....	( $\pm 6$ mm per 3 m, $\pm 13$ mm max.)
Vertical .....	$\pm \frac{1}{4}$ in. ( $\pm 6$ mm)	j = Sweep .....	$\pm \frac{1}{8}$ in. per 10 ft ( $\pm 3$ mm per 3 m)
f = Wall thickness .....	$\pm \frac{1}{2}$ in. ( $\pm 13$ mm)	k = Position of blockouts .....	$\pm 1$ in. ( $\pm 25$ mm)
g = Longitudinal spacing of stirrups		l = Local smoothness	
.....	$\pm \frac{1}{4}$ in. ( $\pm 30$ mm)	.....	$\pm \frac{1}{4}$ in. per 10 ft ( $\pm 6$ mm per 3 m)

# SINGLE RISER BLEACHER SLABS



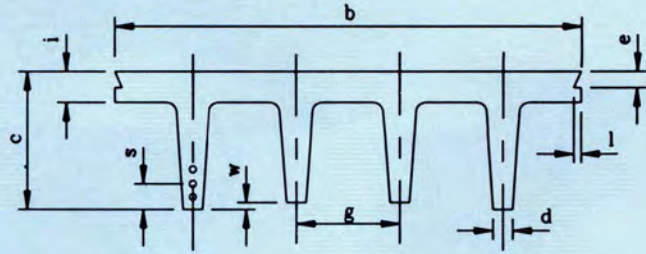
## 2.1.2. SINGLE RISER BLEACHER SLABS\*

- |  |   |   |  |
|--|---|---|--|
| a = Length.....                                      | $\pm \frac{1}{2}$ in. ( $\pm 13$ mm)  | j = Differential camber between members of the same design (not shown on drawing) | $\pm \frac{1}{4}$ in. per 10 ft, $\frac{1}{2}$ in. max. (6 mm per 3 m, 13 mm max.) |
| b = Width .....                                      | $\pm \frac{1}{4}$ in. ( $\pm 6$ mm)   | k = Position of tendons .....   | $\pm \frac{1}{4}$ in. ( $\pm 6$ mm)  |
| c = Depth .....                                      | $\pm \frac{1}{4}$ in. ( $\pm 6$ mm)   | l = Position of plates .....  | $\pm 1$ in. ( $\pm 25$ mm)   |
| d = Stem width .....                                 | $\pm \frac{1}{4}$ in. ( $\pm 3$ mm)   | m = Tipping and flushness of plates.....  | $\pm \frac{1}{4}$ in. ( $\pm 6$ mm)  |
| e = Flange thickness ...                             | $+\frac{1}{4}$ in., $-\frac{1}{4}$ in. (+ 6 mm, - 3 mm)   | n = Tipping and flushness of bearing plates (not shown on drawing).....           | $\pm \frac{1}{2}$ in. ( $\pm 3$ mm)  |
| f = Variation from specified flange squareness ..... | $\pm \frac{1}{8}$ in. per 12 in., $\pm \frac{1}{4}$ in. max. ( $\pm 3$ mm per 305 mm, 6 mm max.)    | o = Position of inserts .....   | $\pm \frac{1}{2}$ in. ( $\pm 13$ mm)   |
| g = Variation from specified end squareness .....    | $\pm \frac{1}{8}$ in. per 12 in., $\pm \frac{1}{4}$ in. max. ( $\pm 3$ mm per 305 mm, $\pm 13$ mm)  | p = Position of handling devices (not shown on drawing) Parallel to span .....    | $\pm 6$ in. ( $\pm 152$ mm)  |
| h = Sweep .....                                      | $\pm \frac{1}{4}$ in. to 40 ft ( $\pm 6$ mm to 12 m)  | Transverse.....   | $\pm 1$ in. ( $\pm 25$ mm)   |
| i = Camber variation from design camber .....        | $\pm \frac{1}{8}$ in. to 40 ft ( $\pm 6$ mm to 12 m)  | q = Local smoothness ....   | $\pm \frac{1}{4}$ in. per 10 ft (6 mm per 3 m)                                     |
|  | $\pm \frac{1}{8}$ in. max. ( $\pm 9$ mm)  | r = Position and size of blockout.....  | $\pm 1$ in. ( $\pm 25$ mm)   |
|  | $\pm \frac{1}{4}$ in. per 10 ft, $\pm \frac{1}{2}$ in. max. ( $\pm 6$ mm per 3 m, $\pm 13$ mm max.) |   |  |

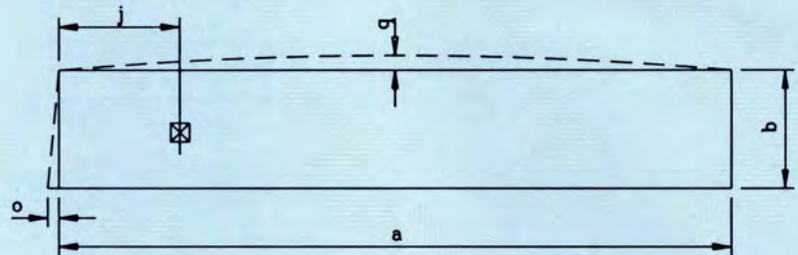
\*Tolerances more stringent than these may require special prestressing.

# MULTISTEMMED BRIDGE UNITS

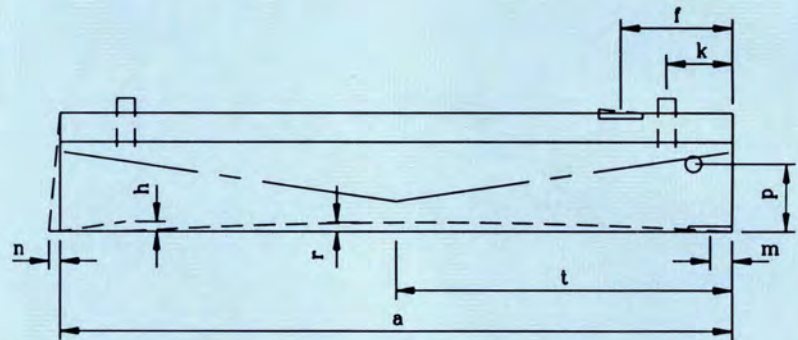
BRIDGE MEMBER CROSS SECTION



BRIDGE MEMBER PLAN



BRIDGE MEMBER ELEVATION



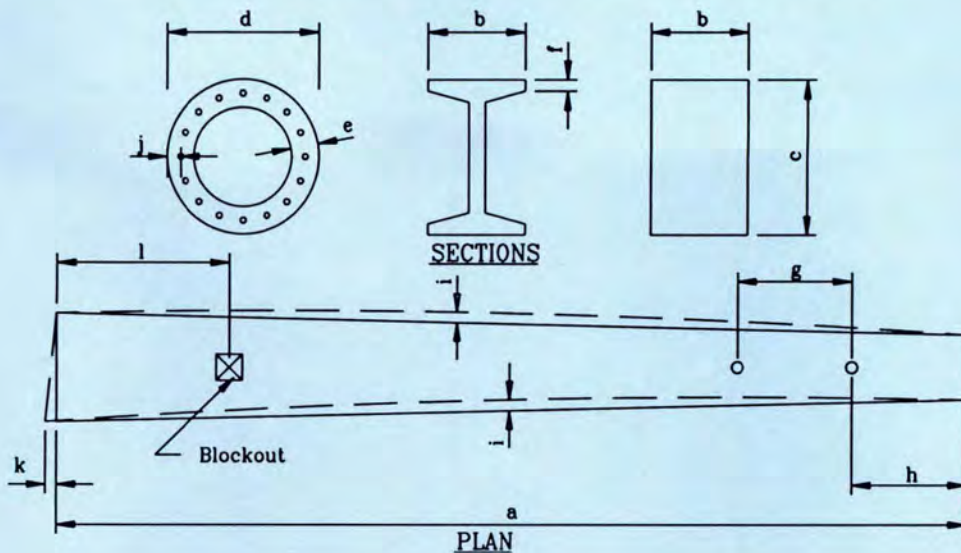
## 2.1.3 MULTISTEMMED BRIDGE UNITS\*

a = Length.....	$\pm \frac{3}{8}$ in. ( $\pm 19$ mm)	Greater than 60 ft (18 m) .....	$\pm \frac{1}{2}$ in. ( $\pm 13$ mm)
b = Width .....	$\pm \frac{3}{8}$ in. ( $\pm 6$ mm)	r = Camber deviation from design	
c = Depth .....	$\pm \frac{3}{8}$ in. ( $\pm 6$ mm)	.....	$\pm \frac{3}{8}$ in. per 10 ft ( $\pm 6$ mm per 3 m)
d = Stem thickness .....	$\pm \frac{3}{8}$ in. ( $\pm 6$ mm)	.....	$\pm \frac{3}{8}$ in. ( $\pm 19$ mm) max.
e = Depth at shear key .....	$\pm \frac{3}{8}$ in. ( $\pm 6$ mm)	s = Position of tendons	
f = Position of weld plates .....	$\pm 1$ in. ( $\pm 25$ mm)	Individual.....	$\pm \frac{3}{8}$ in. ( $\pm 6$ mm)
g = Distance between stems.....	$\pm \frac{3}{8}$ in. ( $\pm 3$ mm)	Bundled .....	$\pm \frac{1}{2}$ in. ( $\pm 13$ mm)
h = Bearing area deviation from level ....	$\pm \frac{3}{8}$ in. ( $\pm 3$ mm)	t = Position of hold-downs <sup>†</sup> .....	$\pm 6$ in. ( $\pm 152$ mm)
i = Flange thickness		u = Longitudinal spacing of stirrups	
.....	$+\frac{1}{4}$ in. (+ 6 mm) - $\frac{1}{8}$ in. (- 3 mm)	.....	$\pm 1$ in. ( $\pm 25$ mm)
j = Blockout size and location.....	$\pm 1$ in. ( $\pm 25$ mm)	v = Differential camber between members of the same design (not shown on drawing)	
k = Position of handling devices		.....	$\pm \frac{3}{8}$ in. per 10 ft ( $\pm 6$ mm per 3 m)
Longitudinal.....	$\pm 6$ in. ( $\pm 152$ mm)	.....	$\frac{3}{8}$ in. (19 mm) max.
Transverse.....	$\pm 1$ in. ( $\pm 25$ mm)	w = Differential bearing elevation.....	$\pm \frac{1}{16}$ in. ( $\pm 2$ mm)
l = Width of shear key.....	$\pm \frac{3}{8}$ in. ( $\pm 6$ mm)		
m = Bearing plate location.....	$\pm \frac{1}{2}$ in. ( $\pm 13$ mm)		
n = End squareness (vertical) .....	$\pm \frac{3}{8}$ in. ( $\pm 19$ mm)		
o = End squareness (horizontal) .....	$\pm \frac{3}{8}$ in. ( $\pm 19$ mm)		
p = Position of pipe sleeves .....	$\pm \frac{1}{2}$ in. ( $\pm 13$ mm)		
q = Sweep			
Up to 40 ft (12 m) length.....	$\pm \frac{3}{8}$ in. ( $\pm 6$ mm)		
40 to 60 ft (12 to 18 m).....	$\pm \frac{3}{8}$ in. ( $\pm 9$ mm)		

\* Bridge authorities often specify a full set of tolerances for bridge deck units. One must check these tolerances against those specified by the bridge authority controlling the project.

<sup>†</sup> The economical location of strand deflection points depends in large measure on the individual bed characteristics. Use of a large location tolerance for this item is often possible with little design consequence. Location tolerances on the order of  $\pm 20$  in. ( $\pm 510$  mm) will provide benefits of economy.

# PRESTRESSED CONCRETE POLES

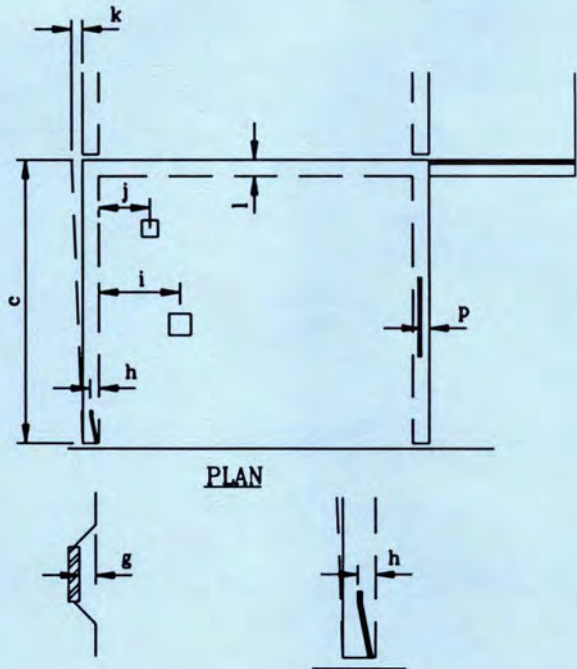
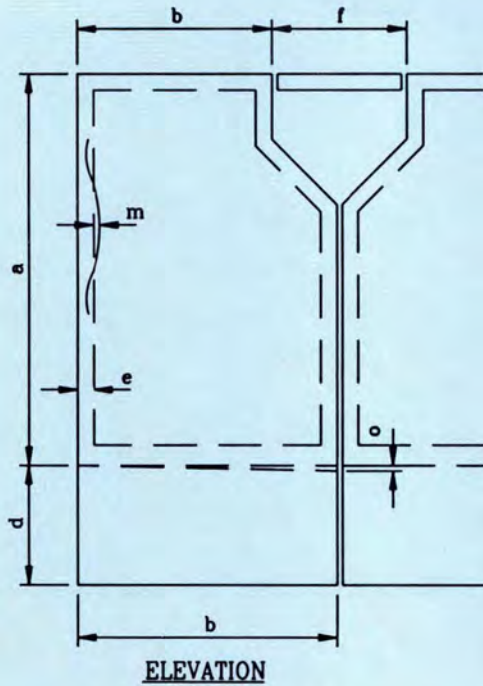


## 2.1.4 PRESTRESSED CONCRETE POLES

- |   |   |
|---|---|
| <p>a = Length<br/>         ..... <math>\pm \frac{1}{8}</math> in. (<math>\pm 3</math> mm) per 10 ft (3.05 m)<br/>         ..... or <math>\pm 2</math> in. (<math>\pm 50</math> mm), whichever is greater</p> <p>b or c = Width or depth — static cast poles<br/>         ..... <math>\pm \frac{3}{8}</math> in. (<math>\pm 9</math> mm) for less than 24 in. (609 mm)<br/>         ..... <math>\pm \frac{1}{2}</math> in. (<math>\pm 13</math> mm) for 24 to 36 in. (609 to 914 mm)<br/>         ..... <math>\pm \frac{3}{4}</math> in. (<math>\pm 16</math> mm) for over 36 in. (914 mm)</p> <p>d = Diameter — spun poles ..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 6</math> mm)</p> <p>e = Wall thickness* ..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 6</math> mm)<br/>         or + 20 percent, - 10 percent, whichever is greater</p> <p>f = Flange thickness ..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 6</math> mm)</p> <p>g = Position of holes or inserts for matching hardware within a pattern ..... <math>\pm \frac{1}{8}</math> in. (<math>\pm 3</math> mm)</p> <p>h = Position of holes in groups or individuals<br/>         ..... <math>\pm 1</math> in. (25 mm)</p> | <p>i = Sweep ..... <math>\pm \frac{1}{2}</math> in. (<math>\pm 13</math> mm)<br/>         or <math>\frac{1}{4}</math> in. (<math>\pm 6</math> mm) per 10 ft (3.05 m) length,<br/>         whichever is greater</p> <p>j = Position of tendons ..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 6</math> mm)</p> <p>k = End squareness<br/>         Top ..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 6</math> mm)<br/>         Bottom ..... <math>\pm 1</math> in. (<math>\pm 25</math> mm)</p> <p>l = Blockouts (shown on drawing weight)<br/>         ..... <math>\pm 1</math> in. (25 mm) of centerline location<br/>         ..... <math>\pm 8</math> percent of design weight</p> |
|---|---|

\* This requirement may be waived provided that structural adequacy and durability are not impaired.

# PRISON CELL MODULES



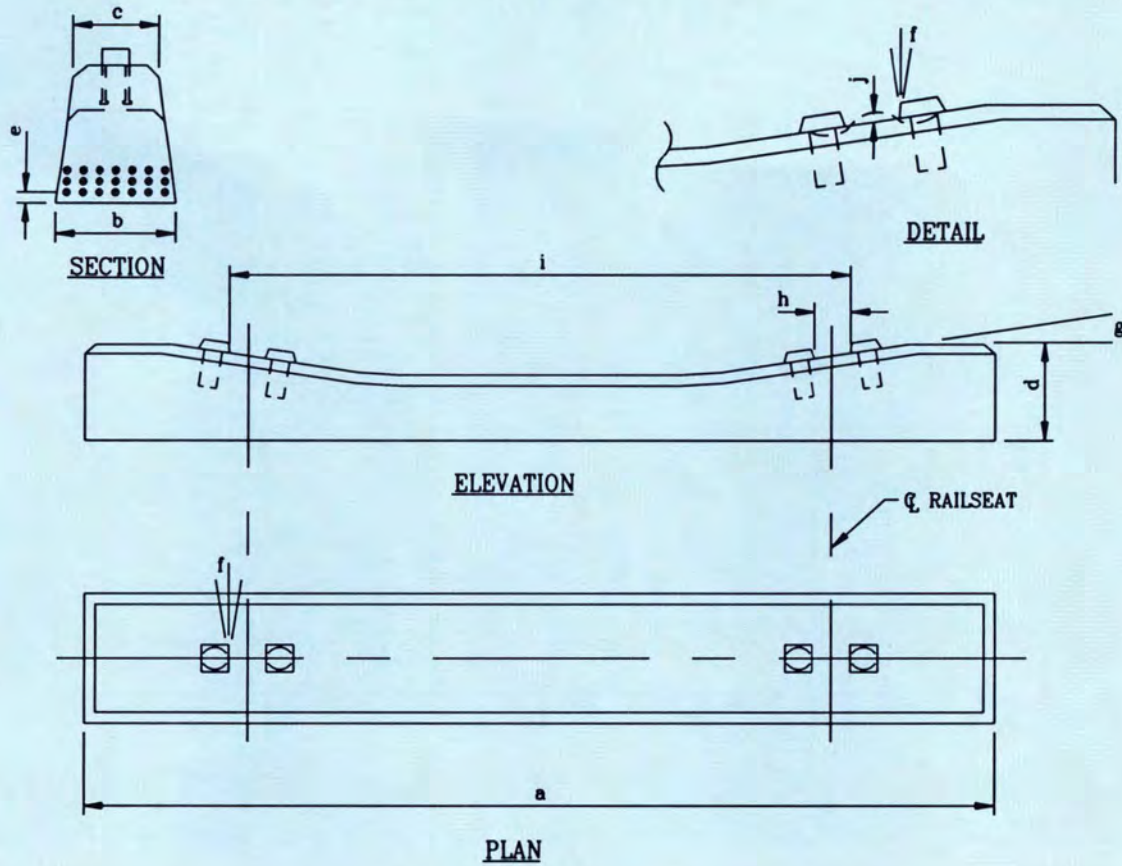
## 2.1.5 PRISON CELL MODULES\*

- a = Length
  - Single or double cell .....  $\pm \frac{1}{4}$  in. ( $\pm 6$  mm)
- b = Width
  - Single cell .....  $\pm \frac{1}{8}$  in. ( $\pm 3$  mm)
  - Double cell .....  $\pm \frac{1}{4}$  in. ( $\pm 6$  mm)
- c = Height .....  $\pm \frac{1}{4}$  in. ( $\pm 6$  mm)
- d = Balcony width
  - Single or double cell.....  $\pm \frac{1}{4}$  in. ( $\pm 6$  mm)
- e = Wall thickness .....  $+\frac{1}{4}$  in., 0 in.  
(+ 6 mm, 0 mm)
- f = Width — chase closure panel  
..... 0 in.,  $-\frac{1}{2}$  in. (0 mm, - 13 mm)
- g = Plate recess .....  $+\frac{1}{4}$  in.,  $-\frac{1}{8}$  in. (+ 6 mm, - 3 mm)
- h = Tipping of plates.....  $\pm \frac{1}{8}$  in. ( $\pm 3$  mm)

- i = Position of plates .....  $\pm \frac{1}{2}$  in. ( $\pm 12$  mm)
- j = Position of electrical boxes .....  $\pm 1$  in. ( $\pm 25$  mm)
- k = Vertical cell plumbness .....  $\pm \frac{1}{8}$  in. ( $\pm 3$  mm)
- l = Floor thickness.....  $\pm \frac{1}{4}$  in. ( $\pm 6$  mm)
- m = Local smoothness.....  $\frac{1}{8}$  in. per 10 ft, any surface  
(3 mm per 3 m)
- o = Squareness top and bottom (not shown on drawing)  
.....  $\pm \frac{1}{8}$  in. ( $\pm 3$  mm)
- p = Concrete cover on reinforcing .....  $\pm \frac{1}{4}$  in. ( $\pm 6$  mm)

\* The tolerances for items unique to cell construction such as security hardware, mechanical/electrical/plumbing and doors and windows should be established by the architect/engineer on a project basis and included in the contract documents.

# PRESTRESSED CONCRETE RAILROAD TIES



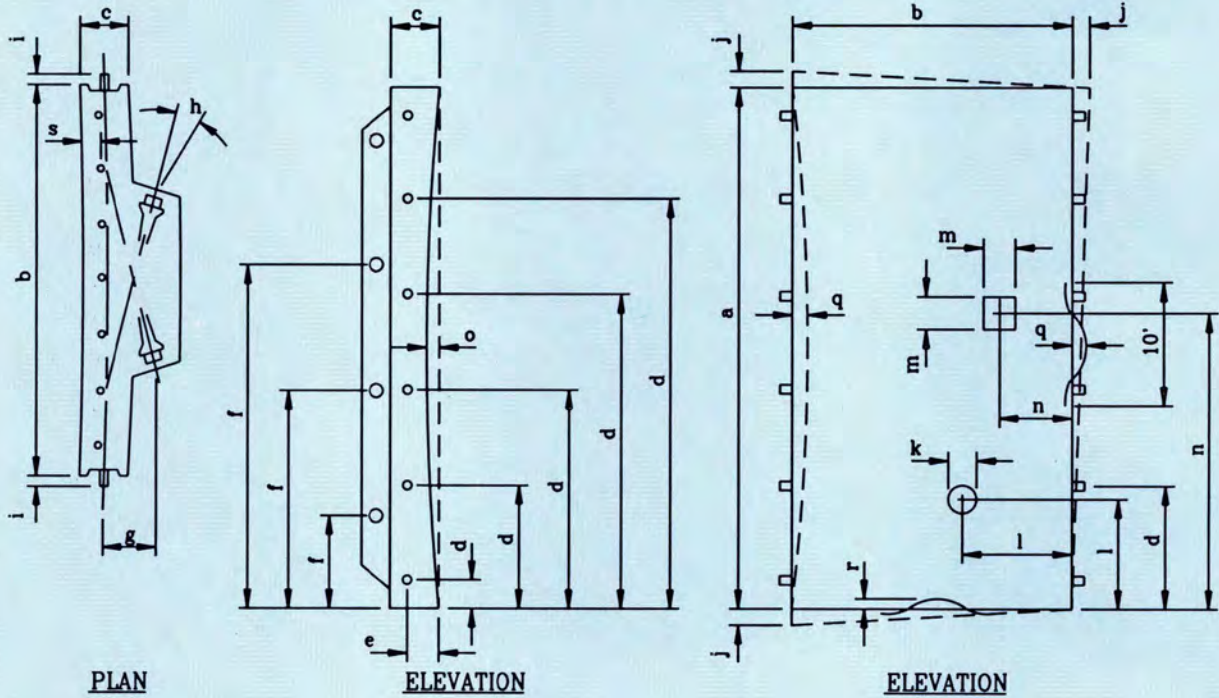
## 2.1.6 PRESTRESSED CONCRETE RAILROAD TIES\*

- a = Length .....  $\pm \frac{1}{8}$  in. ( $\pm 3$  mm)  
up to 9 ft (2.74 m) length
- b = Bottom width.....  $\pm \frac{1}{8}$  in. ( $\pm 3$  mm)
- c = Top width.....  $\pm \frac{1}{8}$  in. ( $\pm 3$  mm)
- d = Height.....  $\pm \frac{3}{16}$  in. ( $\pm 5$  mm)  
up to 10 in. (254 mm) height
- e = Position of tendons or wires .....  $\pm \frac{1}{8}$  in. ( $\pm 3$  mm)
- f = Vertical or horizontal tilt of shoulders  
.....  $\pm 2$  degrees\*
- g = Rail seat slope .....  $\pm 5$  degrees (i.e., 1:30  $\pm 5$  degrees)
- h = Tolerance between adjacent cast-in inserts used for  
holding each rail in correct position

- ..... + 0.08 in., 0 in. (+ 2 mm, 0 mm)  
up to 7 in. (180 mm) spacing
- i = Tolerance between field cast-in inserts used for  
setting track gauge .....  $\pm \frac{1}{16}$  in. ( $\pm 2$  mm)  
up to 70 in. (1800 mm) spacing
- j = Local smoothness —  
railseat over 6 sq in. (3870 mm<sup>2</sup>) area  
.....  $\pm \frac{1}{32}$  in. ( $\pm 1$  mm)

\* Not shown on drawing. Railroad authorities and fastening system manufacturers usually do not specify a full set of tolerances for railroad ties. One must check these tolerances against those specified by railroad authority controlling the project.

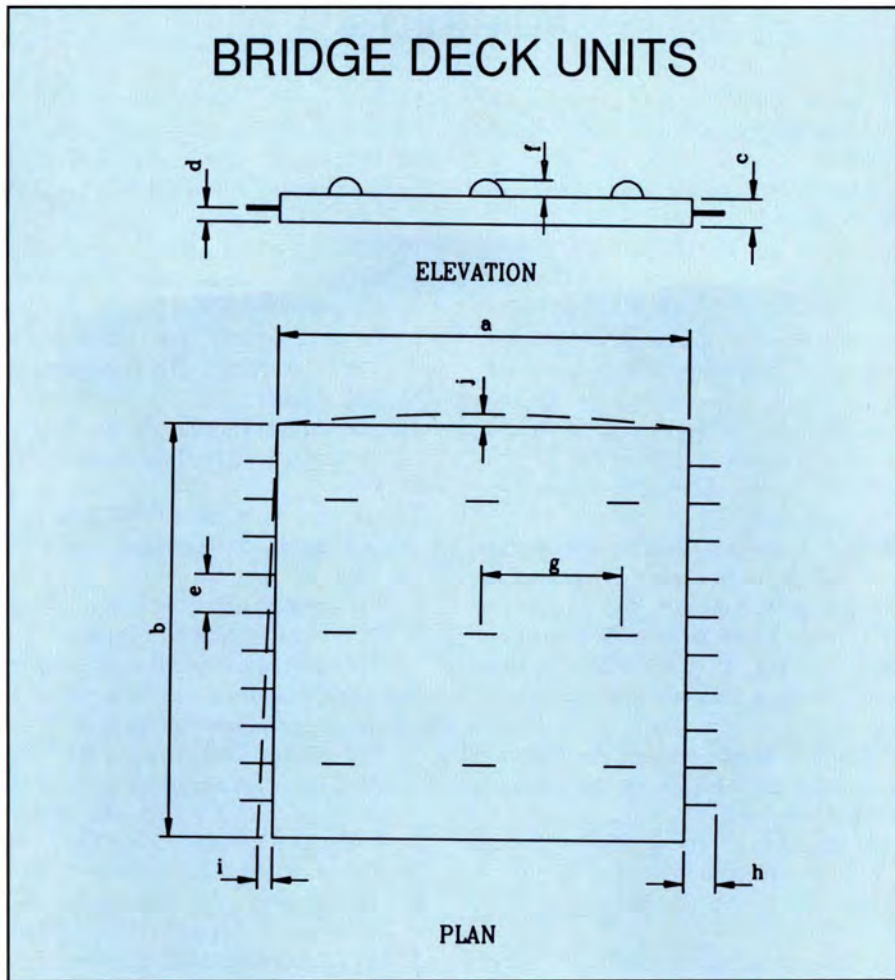
# PRESTRESSED CONCRETE PANELS FOR STORAGE TANKS



## 2.1.7 PRESTRESSED CONCRETE PANELS FOR STORAGE TANKS

- |   |   |
|---|---|
| <p><i>a</i> = Length ..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 6</math> mm)</p> <p><i>b</i> = Width ..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 6</math> mm)</p> <p><i>c</i> = Depth ..... <math>+\frac{1}{4}</math> in., <math>-\frac{3}{8}</math> in. (<math>+6</math> mm, <math>-3</math> mm)</p> <p><i>d</i> = Tendon duct location (elevation)<br/>..... <math>\pm \frac{1}{8}</math> in. (<math>\pm 3</math> mm)</p> <p><i>e</i> = Tendon duct location (in depth)<br/>..... <math>\pm \frac{1}{8}</math> in. (<math>\pm 3</math> mm)</p> <p><i>f</i> = Tendon anchor location (elevation)<br/>..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 6</math> mm)</p> <p><i>g</i> = Tendon anchor location (in depth)<br/>..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 6</math> mm)</p> <p><i>h</i> = Tendon anchor alignment ..... <math>\pm 5</math> degrees</p> <p><i>i</i> = Exposed length of tendon duct ..... <math>\pm \frac{1}{2}</math> in. (<math>\pm 13</math> mm)</p> <p><i>j</i> = Variation in square<br/>(difference in length of the two diagonals)<br/>..... <math>\pm \frac{1}{8}</math> in. per 6 ft (<math>\pm 3</math> mm per 2 m)<br/>..... <math>\pm \frac{1}{4}</math> in. max. (<math>\pm 6</math> mm)</p> | <p><i>k</i> = Length, width, diameter of blockout or penetration<br/>within same panel unit ..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 6</math> mm)</p> <p><i>l</i> = Location of blockouts and penetrations<br/>..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 19</math> mm)</p> <p><i>m</i> = Size of embedded plate and hardware<br/>..... <math>\pm \frac{1}{8}</math> in. (<math>\pm 3</math> mm)</p> <p><i>n</i> = Location of embedded plate and hardware<br/>..... <math>\pm \frac{1}{4}</math> in. (<math>\pm 19</math> mm)</p> <p><i>o</i> = Bowing <math>L/360</math> ..... or <math>\frac{1}{4}</math> in. (19 mm) max.</p> <p><i>p</i> = Differential bowing between panels of same design<br/>(not shown on drawing) ..... <math>\pm \frac{1}{8}</math> in. (<math>\pm 9</math> mm)</p> <p><i>q</i> = Local smoothness — vertical surface<br/>..... <math>\frac{1}{4}</math> in. per 10 ft (6 mm per 3 m)</p> <p><i>r</i> = Local smoothness — horizontal surface<br/>..... <math>\frac{1}{8}</math> in. per 10 ft (3 mm per 3 m)</p> <p><i>s</i> = Location of pretensioned strand<br/>..... <math>\pm \frac{1}{4}</math> in. (6 mm)</p> |
|---|---|

# BRIDGE DECK UNITS



## 2.1.8 BRIDGE DECK UNITS\*

- a = Length .....  $\pm \frac{1}{4}$  in. ( $\pm 6$  mm)
- b = Width .....  $\pm \frac{1}{4}$  in. ( $\pm 6$  mm)
- c = Depth .....  $+\frac{1}{4}$  in.,  $-\frac{1}{4}$  in. ( $+6$  mm,  $-3$  mm)
- d = Position of tendons .....  $\pm \frac{1}{8}$  in. ( $\pm 3$  mm)
- e = Spacing of tendons .....  $\pm \frac{1}{4}$  in. ( $\pm 6$  mm)
- f = Stirrup projection.....  $\pm \frac{1}{2}$  in. ( $\pm 13$  mm)
- g = Spacing of stirrups.....  $\pm 1$  in. ( $\pm 25$  mm)
- h = Tendon projection at ends .....  $\pm \frac{1}{2}$  in. ( $\pm 13$  mm)

- i = Variation from specified end squareness  
.....  $\pm \frac{1}{4}$  in. ( $\pm 6$  mm)
- j = Sweep (variation from straight line parallel to center-  
line of member) .....  $\pm \frac{1}{8}$  in. ( $\pm 3$  mm)

\* Bridge authorities often specify a full set of tolerances for bridge deck units. One must check these tolerances against those specified by the bridge authority controlling the project.

## REFERENCES

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