Technical Q & A

Camber

by Ryan J. Dexter, P.E.

How you can determine the amount of camber to account for.

Truss chords under gravity load have a tendency of bending and deflecting downward under their constant dead load weight. Camber is a slight upward curvature built into a truss to compensate for this deflection such that when it is loaded the truss sits from bearing to bearing in a more level plane. (See Figure 1.)

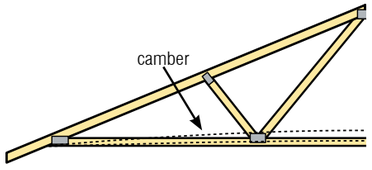

Figure 1: Illustration of Camber

Question

I was unable to find any guidance on camber while reviewing the code referenced National Design Standard for Metal Plate Connected Wood Truss Construction ANSI/TPI 1-2007. Is there an industry standard on bottom chord camber in trusses?

Answer

There is no standard that specifies how much camber (if any) should be built into a truss. The industry has removed any specific camber requirements that were previously listed in TPI 1 because it was so often specific to each job and the applied Dead Load. It was also difficult for the machinery to do efficiently and consistently. The majority of component manufacturers were assessing it based on the Building Designer's specifications and Dead Load, the desired flatness of the resulting ceiling, and in many cases the Dead to Live Load percentage were not high enough to warrant camber.

However, there is a different way to account for deflection; the intended effect of camber can be built into a truss using deflection criteria. The amount of expected deflection for the truss is part of the structural design parameters and is listed on the individual Truss Design Drawings (see Figure 2).

H. DEFLECTION

The maximum deflection of a truss under design load is specified on the Truss Design Drawing. It is often shown using two formats.

- **Magnitude & Direction**

This is the actual, numerical value of the truss deflection (usually in inches). It assumes positive values for upward deflection and negative values for downward deflection.

- **Deflection Ratio**

The deflection ratio is the ratio of the truss span (in inches) to the maximum expected deflection. For example, if a 60' truss deflects 2", the deflection ratio would be 360 (720"/2"). Note: Building codes often establish maximum deflection criteria depicted as span (L) over Deflection Ratio (e.g. L/360).

Truss deflections are calculated assuming that all truss supports do not contribute to truss deflection. In situations where this is not the case, such as when support is provided by a beam or girder truss, additional deflection should be expected.

DEFLECTION	(in)	L/Defl
Vert (LL)	-0.47	715
Vert (DL)	-0.29	1159
Vert (TL)	-0.76	442

Figure 2: From the How to Read a Truss Design Drawing TTB document available from SBCA

The building code specifies the following Live and Total Load deflection criteria for structural applications. (See Figure 3.)

TABLE 1604.3
DEFLECTION LIMITS[a, b, c, d, e]

CONSTRUCTION	L	S or W[f]	D + L[d, e]
Roof members:[g]			
Supporting plaster ceiling	l/360	l/360	l/240
Supporting nonplaster ceiling	l/240	l/240	l/180
Not supporting ceiling	l/180	l/180	l/120
Floor members	l/360	—	l/240
Exterior walls and interior partitions:			
With brittle finishes	—	l/240	—
With flexible finishes	—	l/120	—
Farm buildings	—	—	l/180
Greenhouses	—	—	l/120

For SI: 1 foot = 304.8 mm.

a. For structural roofing and siding made of formed metal sheets, the total load deflection shall not exceed l/60. For secondary roof structural members supporting formed metal roofing, the live load deflection shall not exceed l/150. For secondary wall members supporting formed metal siding, the design wind load deflection shall not exceed l/90. For roofs, this exception only applies when the metal sheets have no roof covering.

b. Interior partitions not exceeding 6 feet in height and flexible, folding and portable partitions are not governed by the provisions of this section. The deflection criterion for interior partitions is based on the horizontal load defined in Section 1607.13.

c. See Section 2403 for glass supports.

Figure 3: 2009 IBC Table 1604.3 Deflection Limits

at a glance

- Gravity loads causes trusses to deflect.
- Dead loads are permanent loads.
- Camber is an upward curvature built into a truss to compensate for dead load deflection.

A very common Live Load deflection specified for roof truss applications is ℓ/240. To calculate what this means in terms of actual deflection amounts (if one was to design to this criterion), let's look at an example:

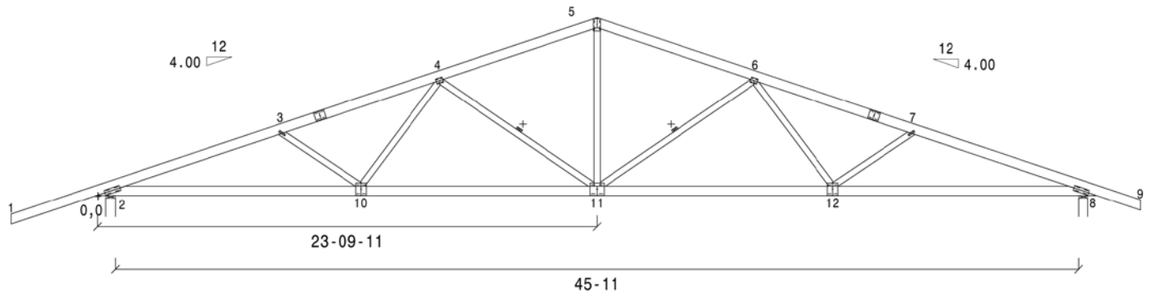

Figure 4: Truss Design Example

LOADING
LL(20.0)+DL(10.0) ON TOP CHORD = 30.0 PSF
DL ON BOTTOM CHORD = 10.0 PSF
TOTAL LOAD = 40.0 PSF

The truss in Figure 4 has a clear span of 45'-11". To determine the magnitude of a ℓ/240 deflection for this particular truss, convert the 45-11-0 clear span to inches [ℓ = (12"/1' x 45') + 11" = 551"] and divide by 240 (ℓ/240= 551/240= 2.296"). This is the maximum amount of deflection permitted by the code for this truss under Live Load only. Truss Design Drawings typically provide calculated deflections for Live, Dead and Total Load. Subtract the Live Load deflection from the Total Load deflection to get the expected Dead Load deflection.

The Truss Design Drawing for the truss shown in Figure 4 lists a calculated Live Load deflection of 0.301" or ℓ/1830, which is considerably less than the code allowed maximum of 2.296". In a uniformly loaded, simply supported truss, the maximum deflection will always occur at mid-span (e.g., 23-9-11 or 23'-9.7").

MAX LL DEFL = 0.301" (L/1830) @ 23'- 9.7" L/240 = 2.296"

Figure 5: Actual Live Load Deflection from Truss Design Drawing Example

If camber is required, it should be specified by the Building Designer as indicated in Sections 2.3.2.4(h)(3) and 2.4.2.4(h)(3) of ANSI/TPI 1-2007.

2.4.2.4 Required Information in the Construction Documents.

The Building Designer, through the Construction Documents, shall provide information sufficiently accurate and reliable to be used for facilitating the supply of the Structural Elements and other information for developing the design of the Trusses for the Building, and shall provide the following: ...

(h) Criteria related to serviceability issues including: ...
(3) Any Truss camber requirements. ...

Typical camber requirements are for Dead Load deflection only, but make sure you always check the construction documents since this is up to the discretion of the Building Designer. It should be noted that ANSI/TPI 1-2007 also now lists a Creep Factor (K_{cr}) that will be multiplied by the Dead Load deflection in the calculation of the Total Load deflection when it is used in the design of the truss. (You can read more about Creep Factor in the upcoming Jan/Feb 2011 *Technical Q&A* column.)

In order to align manufacturing with the actual performance, rather than adding camber to account for Dead Load deflection, many component manufacturers will work with the Building Designer to adjust the Live Load deflection limits to meet floor or roof system stiffness and deformation needs. SBC

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