Steel TIPS

STRUCTURAL STEEL EDUCATIONAL COUNCIL

TECHNICAL INFORMATION & PRODUCT SERVICE

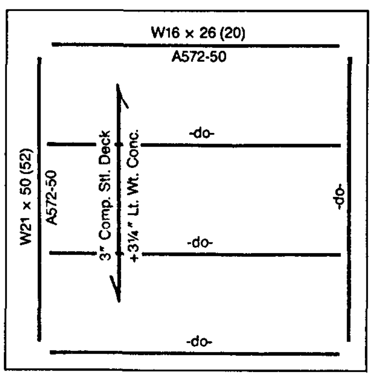
OCTOBER 1992

Economical Use of Cambered Steel Beams

Accommodating Dead Load Deflections:

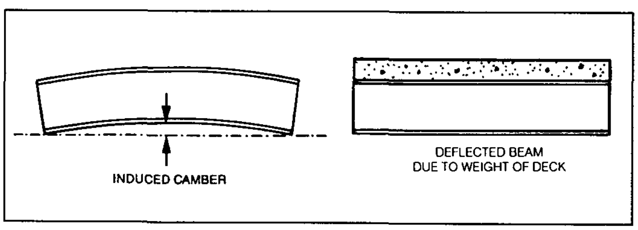
There are four methods of accommodating beam dead load deflections during concrete placement and creating an acceptably level floor slab: 1) Let beams deflect and pour a varying thickness slab; 2) Overdesign beams to minimize deflections; 3) Camber beams to compensate for anticipated deflections; 4) Shore beams prior to concrete placement.

Example: An economic analysis is helpful in selecting the best approach. As an example, consider a 30'x30' bay in a typical office building.



If beams are allowed to sag, the cost of additional concrete to produce a level slab would be $0.19/SF, assuming $60/cu yd for the concrete.

Increasing the size of the steel beams in order to reduce their deflections, and thus the excess concrete requirement, would not produce a more economical solution. The increase in cost for the heavier steel beams would exceed the cost of concrete and shear studs saved.



Cost Savings By Cambering:

For the same typical 30'x30' bay example, cambering would cost $0.13/SF. It would eliminate the need for additional concrete to obtain a level floor; and therefore, would save $0.06/SF. Plus, the cost of cambering can be accurately determined with no additional hidden costs.

> ***"When it comes to cambering beams, more is not better."***

As bay sizes increase and deflections become larger, the savings potential of cambering becomes more dramatic.

For shoring to be economical its cost would have to be less than the cambering cost of $0.13/SF, including crack control slab reinforcement over girders. In addition, there is the added expense caused by the shoring's interference with subsequent operations such as fire protection and mechanical systems installation.

Guidelines for Specifying Camber:

Specifying camber properly is crucial to obtaining an economical, level floor with the proper slab thickness. Several factors that influence camber are identified below.

Calculated Dead Load Deflections — Ideally, for most buildings, the finished floor slab should be both level and of constant thickness. Thus the beam must be level after the concrete is placed. Only the weight of the beams, metal deck, and wet concrete should be included in the dead load deflection calculations. Additional items, such as partitions, mechanicals, ceiling and any live load should be excluded.

Connection End Restraint — Connections on the beams provide some degree of end restraint. Therefore, the full calculated dead load deflection will probably not occur. The amount of camber specified can be reduced to minimize the effect of connection end restraint. Many engineers reportedly specify camber amounts in the range of 2/3 to 3/4 of the calculated simple span dead load deflection to acount for this effect.

Mill Tolerances and Camber Losses — The tolerance for mill camber of members 50 ft or less is minus 0" and plus 1/2". Over 50 ft, the plus tolerance increases 1/8" for each 10 ft in excessd of 50 ft. There will be additional camber induced at the mill to assure that it is within tolerance.

"The minimum amount of camber is dependent on both physical and economic considerations."

However, the camber induced at the mill may not necessarily be present in the same amount when received. The AISC states that "In general, 75% of the specified camber is likely to remain." But, there is no guarantee that some mill camber will be "lost" during shipment, fabrication, and erection.

The effects of mill tolerances and camber losses tend to offset each other; although, the net effect may be slightly more actual camber than specified.

"The More is Better Syndrome" — When it comes to cambering beams, "more is not better." Excess camber can result in difficulties in achieving level floors with the desired slab thickness. It is usually easier and more economical to accommodate under-cambered than over-cambered beams.

Mill Camber Limits:

Shapes to be cambered are cold-worked to produce desired curves subject to limitations shown below. Cambering other than wide flange or standard beams is subject to inquiry.

Cambers less than minimums outlined can be furnished, but no guarantee can be given with respect to their permanency.

Order must specify a single minimum value within the ranges shown below for the length ordered.

Camber will approximate a simple regular curve nearly the full length of the beam, or between any two points as specified. Reverse or other compound curves are available but subject to negotiation and customer approval before shipment. Camber shall be specified by the ordinate at mid length of the portion of the beam to be curved. Ordinates at other points can be specified but require negotiation.

* Inquire All Sections 300 lb per ft

* For grades other than A36 or lengths 60 ft 0 in., and longer maximuns are available on inquiry for the following sections:

W24 x 62	W21 x 57	W18 x 46	W16 x 31	W14 x 26
55	50	40	26	22
	44	35		
W12 x 22	W10 x 19	W8 x 15	W6 x 16	
19	17	13	12	
16	15	10	9	
14	12			

Minimum and Maximum Camber Inches

Nominal Depth (Inches)	Over 20 to 30 incl	Over 30 to 40 incl	Over 40 to 52 incl	Over 52 to 65 incl	Over 65 to 85 incl	Over 85 to100 incl
24 and over*	Inquire	1/2 to 1-1/2 incl	1/2 to 2-1/2 incl	1 to 4 incl	1 to 5 incl	1 to 6 incl
14 to 21 incl*	Inquire	1/2 to 2 incl	1/2 to 3 incl	1 to 4 incl	1 to 5 incl	Inquire
4 to 13 incl*	Inquire	1/2 to 2 incl	1/2 to 3 incl	Inquire	Inquire	Inquire

The preceding table provides reasonable guidelines for minimum and maximum induced cambers. Obtaining larger cambers on lighter weight beams with shorter lengths, particularly for grades other than A36, is more difficult. Therefore, it is prudent to consult the producer prior to specifying cambers near these extremes.

> ***"The maximum amount of camber that can be put into a member is limited, and is dependent on its cross section, length and material grade."***

The minimum amount of camber is dependent on both physical and economic considerations. Cambers of 1/2" or less should probably be avoided. At 1/2" the cost of cambering usually exceeds the potential savings in concrete, especially since natural mill camber will probably be present. Also, below 1/2" the permanency may not be assured.

The maximum amount of camber that can be put into member is limited, and is dependent on its cross section, length and material grade.

Availability:

Cambering is available from the producing mills and generally adds only two weeks to the delivery of material. Many fabricators also have the capability and expertise to offer cambering.

Cost:

Most mills published price book offers cambering for $0.03/lb on beams up to 50 lbs/ft, and $0.02/lb for beams over 50 lbs/ft.

Effect of Construction Methods:

Both methods used in the finishing of concrete slabs, constant thickness and constant elevation, are greatly affected by the actual elevation of the erected steel and are more seriously affected by high points in the steel than by low ones.

In the constant thickness method, the finished floor follows the steel below. High points in the steel cause high points in the finished slab, which may hinder the installation of interior finishes.

In the constant elevation method, the finished floor is set using a level. High points in the steel can result in inadequate slab thickness.

Therefore, prior to placing concrete slabs, beam elevations should be verified. Then, if the expected floor profile is not satisfactory, the finishing approach can be modified.

Summary:

Cambering is often the most economical method of handling dead load deflections in beams. It saves money by reducing the excess concrete that may be required. The cost of cambering can be accurately determined with no additional hidden costs to consider.

The amount of camber should be specified only after considering the following items:

1. Calculated dead load deflection.
2. Connection end restraint.
3. Mill tolerances and camber losses.
4. The "More is Better" Syndrome.
5. Camber limits.

> ***"Cambering is often the most economical method of handling dead load deflections in beams."***

Reference:

"Economical Use of Cambered Steel Beams," by J.W. Larson and R.K. Huzzard, Bethlehem Steel Corporation, presented at the AISC National Steel Construction Conference, March 1990.

Credit:

This TIPS is reprinted from a Bethlehem Steel Corp. Technical Bulletin titled "Economical Use of Cambered Steel Beams."

STRUCTURAL STEEL EDUCATIONAL COUNCIL

470 Fernwood Drive
Moraga, CA 94556
(510) 631-9570

SPONSORS

The local structural steel industry (above sponsors) stands ready to assist you in determining the most economical solution for your products. Our assistance can range from budget prices and estimated tonnage to cost comparisons, fabrication details and delivery schedules.

Funding for this publication provided by the California Field Iron Workers Administrative Trust.