Eriksson software

TECHNICAL WRITER POSITION

Technical Writing Samples

About these samples

This packet shows the kind of documentation our technical writer works on. Eriksson Software develops structural engineering software for precast, prestressed and steel design, and our documentation has to be accurate enough for engineers and clear enough for everyone else.

Inside you will find three types of work. The product datasheet is a short, customer-facing summary of what one of our programs does. The knowledge base article explains the engineering behind a program feature for our users. The quality control pages come from a long-form verification report (about 190 pages) that checks program results against independent hand calculations.

What's inside

Product Datasheet: Eriksson Girder **2**

Knowledge Base Article: Deflections - Prestressed **4**

Quality Control Document (excerpt) **13**

- Results comparison table 13
- Design parameters 14
- Prestress losses 15
- Shear 16
- End rotation and shortening 17

Samples are provided for applicant reference only.

Eriksson Girder

Precast, Pretensioned Concrete Bridge Girder Analysis & Design

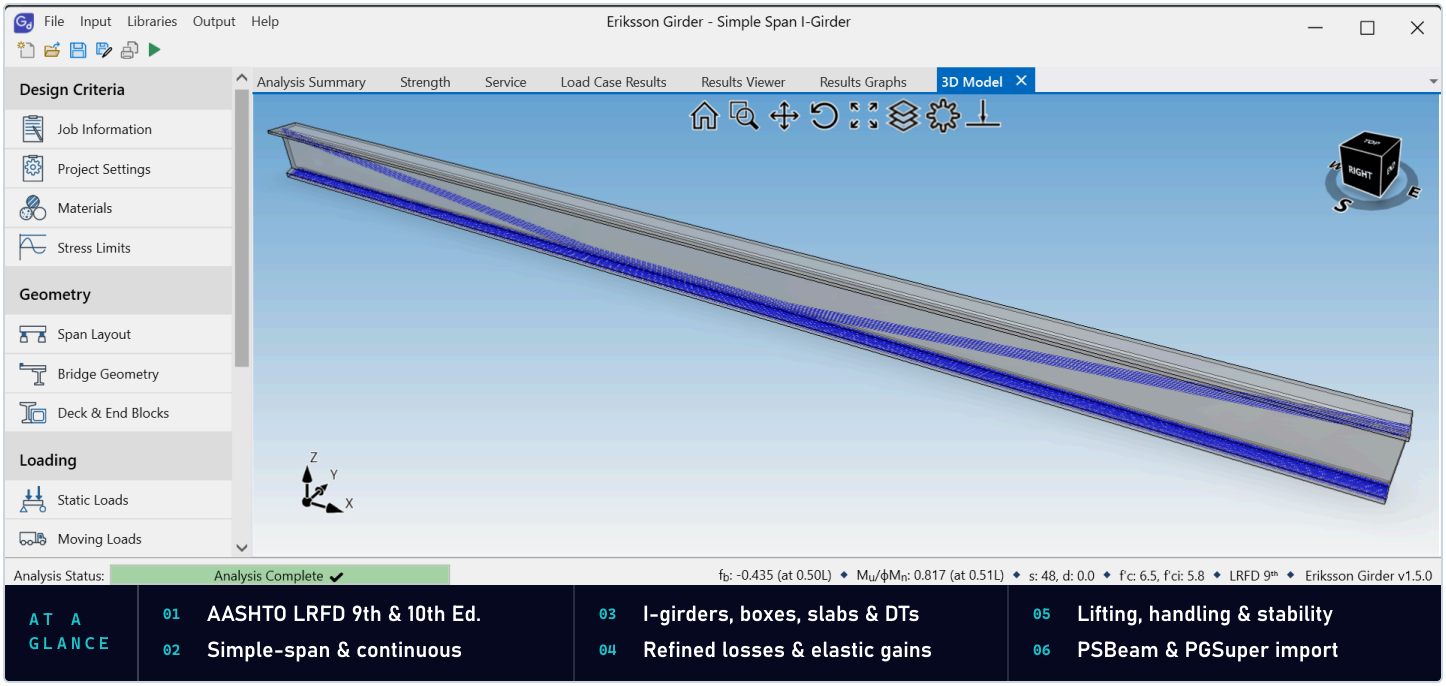
DATA SHEET

V1.5.0

Eriksson software

From the prestressing bed to the finished bridge — one design file.

Eriksson Girder gives fabricators and bridge engineers a transparent AASHTO LRFD workflow for simple-span and continuous pretensioned girders. Set the design scope to the fabrication stage, the in-place stage, or both; lay out strands, draping, and debonding visually; envelope design, legal, and permit vehicles; and document every governing check with detailed intermediate results built for hand-checking.



AT A GLANCE

01 AASHTO LRFD 9th & 10th Ed.
02 Simple-span & continuous
03 I-girders, boxes, slabs & DTs
04 Refined losses & elastic gains
05 Lifting, handling & stability
06 PSBeam & PGSuper import

01 WHY ENGINEERS SWITCH

Retire the sidecar spreadsheets.

The release check, the lifting Mathcad, the top-tension worksheet, the camber tracker: Girder does the whole timeline in the design file itself. One model, one place where a change ripples through every stage.

FULL-TIMELINE SCOPE · STABILITY & HANDLING PER PCI PRACTICE

Win the checker review.

Losses follow the research behind the LRFD refined method, and every intermediate value is on the table, not buried. Reviews close faster because the checker can reproduce the calculation instead of interrogating a black box.

REFINED LOSSES & ELASTIC GAINS · SHIPPED QC REPORT & VERIFICATION MODELS

Switch without starting over.

Your PSBeam and PGSuper projects open directly, and the geometry, strands, loads, options, and vehicles defined in those files come across with the model. A new engineer is productive the first week.

PSBEAM & PGSUPER IMPORT · BUILT-IN LIBRARIES · MODERN UI

02 ONE GIRDER, FOUR STAGES

RELEASE
On the Bed
- Transfer stresses, top tension steel
- Auto strand, drape & debond design
- Release camber & elastic shortening

LIFT & HAUL
In the Yard
- Stability per PCI recommended practice
- Inclined cables, wind & impact
- Handling & shipping stresses

ERECTION
On the Pier
- Noncomposite to composite staging
- Continuity & restraining moments
- Camber & deflection with multipliers

SERVICE
Under Traffic
- HL-93 envelopes & load rating
- Service stresses & flexural strength
- Vertical & interface shear

03 SECTION FAMILIES


I-Girder / Bulb Tee


Box Beam


U-Beam


Slab


Double Tee


Decked Bulb Tee


User-Defined

04 DESIGN CHECKS BY STAGE

CHECK	RELEASE	HANDLING	FINAL	BASIS & NOTES
Concrete stresses	■	■	■	Transfer, handling, and Service I / III limits at every station
Prestress losses & gains	■	■	■	Refined time-dependent method with elastic shortening & gains
Flexural strength	–	–	■	Strength I with minimum-reinforcement (M*cr*) check
Vertical & interface shear	–	–	■	General procedure (β, θ) plus longitudinal reinforcement
Top tension steel	■	–	–	Auto-sensed requirement; required area at every analysis point
Lateral stability	–	■	–	Lifting & transport per PCI recommended practice
Camber & deflections	■	–	■	Staged history with multipliers, reactions & end rotations
Continuity effects	–	–	■	Auto time-dependent restraining moments, multi-span systems

05 LOADS, PLATFORM & INTEROPERABILITY

LIVE LOAD — Vehicle library of design, legal, and permit trucks with fully editable axle trains — HL-93 included — plus pedestrian loading, all enveloped automatically.

DISTRIBUTION — LRFD distribution factors, program-computed or manual; interior & exterior beams with spec-range validation and lever-rule fallback.

DEAD LOAD — Automatic girder self-weight, deck & haunch loads; diaphragms, barriers, FWS, and user distributed or point loads.

PRESTRESSING — All common strand types, low-relaxation & stress-relieved; straight, draped & debonded patterns (end or midspan).

CODES — AASHTO LRFD 9th & 10th Editions; load rating per MBE Part 3 (LRFR, LFR/WSR); stability per PCI recommended practice.

IMPORT — PSBeam projects across all six section families; PGSuper files for prismatic I-beam girders — geometry, strands, loads & options.

LIBRARIES — Girder sections, strands, vehicles, and rebar; US customary, metric, or custom unit configurations.

PLATFORM — Windows, x64; summary and detailed printable reports; shipped QC report with verification models.

06 TECHNICAL SPECIFICATIONS

PLATFORM — Windows, x64 desktop application.

SECTIONS — I-girder / bulb tee, box, U-beam, slab, double tee, decked bulb tee, user-defined.

IMPORT — PSBeam (all six section families); PGSuper (prismatic I-beam girders).

CODES — AASHTO LRFD 9th & 10th Ed.; MBE Part 3 (LRFR, LFR/WSR); PCI recommended practice.

ANALYSIS — Simple-span & continuous; refined time-dependent losses; parallelized moving-load solver.

REPORTS — Summary & detailed printable reports; shipped QC report with verification models.

Eriksson software **See the full design timeline — schedule an Eriksson Girder product briefing**

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SCAN FOR MORE

© 2026 Eriksson Software, Inc. AASHTO LRFD and PCI references identify the engineering standards used by the software. Eriksson Girder is an engineering aid; the licensed design professional remains responsible for all inputs, assumptions, interpretation, and final design.

Deflections - Prestressed

By jcallahan 9 min Add a reaction

Code References

ACI 318-14

Background

In general, four items needed for accurate camber/deflection prediction:

1. Accurate knowledge of material properties, namely the elasticity of the concrete, preferably on an hourly basis, daily basis is acceptable.
2. Accurate knowledge of the prestress losses, again preferably on an hourly basis, again daily is acceptable. Note that the use of a time-dependent method for prestress losses is required (not ‘lump sum’).
3. Changes in loading and support conditions, again at least daily.
4. System of equations that ties all of this together.

From PCA Notes on ACI 318: “Because of the variability of concrete structural deformations, designers must not place undue reliance on computed estimates of deflections. In most cases, the use of relatively simple procedures for estimating deflections is justified."

Bi-Linear Deflections

Eriksson Beam calculates deflections using the bi-linear method in addition to the deflection multipliers present in the PCI Design Handbook. When using the bi-linear deflection methods, the member allows the user of the gross section properties up until the point the member cracks. At that point the rest of the

1. Compute I_g for each analysis section.
2. Compute total moment and total stresses for each loading stage for each analysis section.
3. Compute deflections for each loading stage at each analysis section, using either I_g, I_{cr}, or a combination of the two. E_{ci} is used for the 1st loading stage, E_c is used for all others.
    a. If an analysis section cracks during a loading stage, (the applied moment exceeds M_{cr}) compute the point within the loading stage where the section cracks. Then compute I_{cr} for this loading stage and for every loading stage after this one.
    b. For the loading stage where an analysis section cracks, two deflections are calculated. One using the portion of the applied load below cracking in conjunction with I_g, and a second deflection using the portion of the load above cracking in conjunction with I_{cr}, and then sum them.
4. Multiply the initial and erection stage camber/deflections by the creep and shrinkage multipliers in Table 5.9.2 in the PCI Design Handbook. Note that these multipliers can (and probably should) be reduced based on the ratio of the areas of the mild and prestressed reinforcement present at that analysis section (see the section on the Creep and Shrinkage Multipliers for a detailed discussion of these modifiers).
5. Sum the deflections obtained at each loading stage to calculate the total deflection.

Loading Stages

Eriksson Beam uses 5 loading stages

Stage	Loads	Material Properties	Section Properties
1	Self Weight + Prestress	Initial	Gross

The section properties will change to the cracked section properties if the applied moment exceeds the cracking moment. However, only sections under a positive moment will crack. In example, if Stage 1 cracks along the top of the member from the prestressing, the stage will still use gross section properties at that location.

Cracked Section Analysis

When a given stage cracks, the stage is split into two sub stages, a before cracking stage and a after cracking stage. For these two stages the loads are divided by first computing how much moment can be applied before cracking as follows:

$$M_{cr} = M_{PS} + M_s + \gamma_{cr} M_a$$

$$y_{cr} = \frac{M_{cr} - M_{PS}}{M_a}$$

where M_{cr} is the cracking moment,

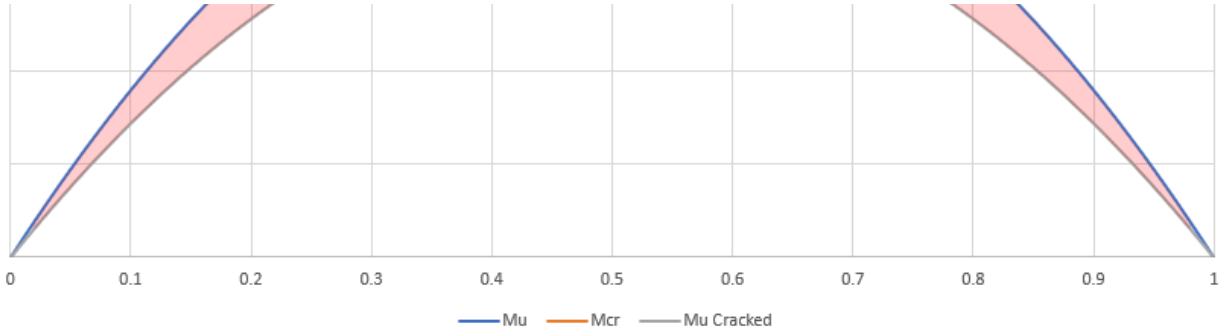
M_{PS} is the moment due to prestress,

M_s is the moment due to the previous stage,

M_a is the applied moment,

and γ_{cr} is the percentage of moment that can be added before cracking

The above procedure is done on a point by point basis. The moment is split by the maximum percentage that is cracked along the member. IE if midspan moment is 20% above Mcr, 20% of all stage loading will be applied to the cracked section.



Here, only the red part of the moment curve will be applied to the cracked section

Beam uses a bi-linear deflection approach (I_g/I_{cr}) to calculate deflections at sections where the applied M is greater than M_{cr} during a loading stage. Only that portion (or %) of M which is greater than M_{cr} is applied to I_{cr}, while the remainder of M is applied to I_g. In the spirit of ACI E24.2.3.7 when the midspan cracks, the program computes I_{cr} at every section where the member is NOT Class U, using the procedure outlined in Robert Masts' *"Analysis of Cracked Prestressed Concrete Sections: A Practical Approach,"*. The program then calculates the % of load that is applied to I_{cr} at the first section that cracks (typically at or near midspan) and applies this % of load to every section where I_{cr} was just calculated.

Creep and Shrinkage Multipliers

For all sections at erection, there are two creep and shrinkage multipliers:

1. Deflection (downward), applied to the elastic deflection due to the self-weight at release of prestress
2. Camber (upward), applied to the elastic camber due to the prestress at the time of release of prestress

For non-composite sections at final, there are three additional creep and shrinkage multipliers:

superimposed dead load only

For composite sections at final, there are four additional creep and shrinkage multipliers:

1. Deflection (downward), applied to the elastic deflection due to the self-weight at release of prestress
2. Camber (upward), applied to the elastic camber due to prestress at the time of release of prestress
3. Deflection (downward), applied to the elastic deflection due to superimposed dead load only
4. Deflection (downward), applied to the elastic deflection caused by the composite topping

Condition	Factor	Equation #
Erection: SW Deflection	1.85	1
Erection: P/S Camber	1.80	2
Final: SW Deflection (non-comp)	2.70	3
Final: SD Deflection (non-comp)	2.45	4
Final: SW Deflection (non-comp)	3.00	5
Final: SW Deflection (comp)	2.40	6
Final: P/S Camber (comp)	2.20	7

In ACI 318-71 9.5.2.3, the base factor used to modify initial deflections to account for long-term effects was calculated using the following equation:

$$\mu_b = [2 - 1.2(A_s'/A_s)]$$

For prestressed construction, this equation reduces to a base factor, μ_b, equal to 2.0.

In ACI 317-83 9.5.2.5, this equation was changed to:

$$\lambda = \frac{\xi}{1 + 50\rho'}$$

For sustained loads, ξ may be taken equal to 2.0 when the age of the member is greater than 60 months, which matches the base value from the earlier equation (assuming ρ' = 0). This equation (along with the suggested time-dependent factors) can be seen in Section 24.2.4.1.

The long-term factor applied to the initial deflection caused by the member self-weight for a non-composite member can be calculated as follows:

$$\mu_{df} = \frac{E_{ci}}{E_c}\mu_b \qquad Eq.3$$

Assuming that the release strength is about 70% percent of the final strength, the initial elasticity would be about 85% of the final. Adding 1 to this (to account for the initial deflection), and you get a factor of 2.70 for this stage. Note that the initial deflection used in these calculations should be based on the final support locations.

The long-term factor applied to the initial camber caused by the prestressing force for a non-composite member can be calculated as follows:

$$\mu_{pf} = \mu_{df}\frac{P}{P_i} \qquad Eq.4$$

For both non-composite and composite members, the erection modifier for deflection due to self-weight is the same. This equation assumes that about ½ of the long-term effects will have occurred by the time of erection.

$$\mu_{de} = 0.5\mu_{df} \qquad Eq.1$$

Adding 1 to this equation gives us a value of 1.85 for this term. This factor is applied to the initial deflection caused by the member weight.

Similarly, the erection modifier for camber is the same for both non-composite and composite members.

$$\mu_{pe} = \mu_{de}\frac{P_i + P}{2P_i} \qquad Eq.2$$

Substituting for the various terms works out to a factor of about 1.80 (rounded up). This factor is applied to the initial camber caused by the prestress at release.

For composite members, the equations for the deflection factors assumes that the section becomes composite at roughly the same time as erection. Therefore, both the self-weight modifier and the camber modifier are adjusted by the ratio of the non-composite to composite moments of inertia. For the self-weight modifier, the new equation looks like this:

$$\mu_{dfc} = \mu_{de} + (\mu_{df} - \mu_{de})(I_{nc}/I_c) \qquad Eq.6$$

For 2" of composite topping, we can assume that the ratio of the moment of inertias is about 0.65. This gives us a value of 2.40 for this factor. This factor is applied to the initial deflection caused by the self-weight of the member.

The equation for the camber modifier is also modified by the ratio of the moments of inertia:

$$\mu_{pfc} = \mu_{pe} + (\mu_{pf} - \mu_{pe})(I_{nc}/I_c) \qquad Eq.7$$

$$\mu_t = \mu_{sd}(I_{nc}/I_c) \qquad Eq.9$$

This works out to a value of 2.30. This factor is applied to the immediate deflection caused by the placement of the topping.

Superimposed dead loads cause immediate deflections and additional long-term deflections. Since the long-term deflection is a result of the creep caused by this sustained load, the long-term deflection factor is assumed equal to the base factor from ACI 318. Note that this factor is the same for both non-composite and composite members.

$$\mu_{sd} = \mu_b \qquad Eq\ 5\ \&\ 8$$

Adding 1 to this value (to account for the immediate deflection), gives us 3.00 for this factor. This factor is applied to the immediate deflection caused by the superimposed dead load.

Modification to Creep and Shrinkage Multipliers

From Shaikh, A. F., and Branson D. E., 1970, "Non-Tensioned Steel in Prestressed Concrete Beams", the creep and shrinkage deflection multipliers can be reduced by the addition of mild reinforcement. Using this method, a given multiplier is reduced using the following equation:

$$C_2 = \frac{C_1 + \frac{A_s}{A_{ps}}}{1 + \frac{A_s}{A_{ps}}}$$

where: C_1 = multiplier from Table 5.8.2 (PCI Handbook 7th)

C_2 = revised multiplier

A_s = area of non-prestressed reinforcement

A_{ps} = area of prestressed reinforcement

$$\lambda = \frac{\xi}{1 + 50\rho'}$$

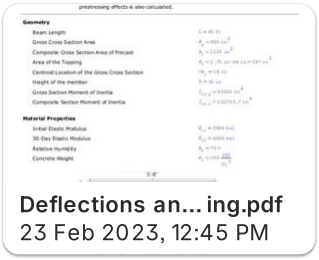
where λ is the deflection multiplier

ξ is the time-dependent factor for sustained loads factor (from Table 24.2.4.1.3), and

ρ’ is the ratio of compression reinforcement to the area of concrete.

This deflection multiplier is applied to all sustained loads on the members.

Hand Calculation



Deflections an... ing.pdf
23 Feb 2023, 12:45 PM

References

Martin, L.D., *“A Rational Method for Estimation Camber and Deflection of Precast Prestressed Members*,” *PCI Journal*, V. 22, No. 1, January-February 1977, pp. 100-108.

Mast, Robert F., *“Analysis of Cracked Prestressed Concrete Sections: A Practical Approach*,” *PCI Journal*, V. 43, No. 4, July-August 1998, pp. 80-91.

PCI Industry Handbook Committee, PCI Design Handbook, 8th Ed., PCI, Chicago, 2017.

Shaikh, A.F., and Branson, D.E., *“Non-Tensioned Steel in Prestressed Concrete Beams*,” *PCI Journal*, V. 15, No. 1, February 1970, pp. 14-36.

PROJECT:	Eriksson Beam QC Document		
CLIENT:	Eriksson Software		
BY:	Eriksson Technologies	DATE:	10/12/2023

DT Calculation Comparison Table

Description	Program Output	Hand Calc	Δ%
Properties:			
Moment of Inertia (in^4)	63650	63650.44	0%
Composite Moment of Inertia (in^4)	91181	91180.5	0%
Demand:			
Moment (kip*ft)	985.5	985.5	0%
Shear (kip)	65.7	65.7	0%
Losses:			
Construction Loss	4.10%	4.14%	1%
Final Loss w/ LL regain	7.28%	7.28%	0%
Flexure Capacity:			
Non composite (kip*ft)	915.25	915.24	0%
Composite (kip*ft)	1019.96	1019.96	0%
Shear Capacity:			
Concrete Vertical (kip)	112.5	112.4	0%
Horizontal (kip)	3110.4	3110.4	0%
Service:			
Release Tension Center (psi)	0	0	0%
Release Compression Center (psi)	1075.7	1074.96	0%
Release Tension End (psi)	153.1	153.1	0%
Release Compression End (psi)	2122.9	2122.8	0%
Final Tension Center (psi)	726	726	0%
Final Compression Center Precast (psi)	832.4	832.4	0%
Final Compression Center Topping (psi)	223.9	223.9	0%
Construction Camber (in)	0.98	0.984	0%
Final Deflection (in)	-1.01	-1.02	1%
End Shortening (in)	0.231	0.232	0%
Lifting:			
Moment Capacity (kip*ft)	915.25	908.43	1%
Tension Stress (psi)	0	0	0%
Compression Stress (psi)	788.4	799.18	1%
Lifter Load (kip)	14.18	14.18	0%

*Differences here occur due to rounding errors. Hand calculations take losses at specific locations while the program is more exact and takes losses down the length of the member.

QC Problem #1 - Double Tee

Project: Eriksson Beam QC Document

Client: Eriksson Software **Date:** 2023-08-21

By: Eriksson Technologies **Eng:** J. Castello P.E.
C. Montoya, PE
T. Monroe, E.I.

References: *PCI Handbook 8th Ed, ACI 318-19, ASCE 7-16*

1. Design Parameters

The design parameters that are input below match that of the inputs used within our design software. No additional inputs are used within this Mathcad without explanation from where they came from and how to get that value.

1.1 Concrete Extents:

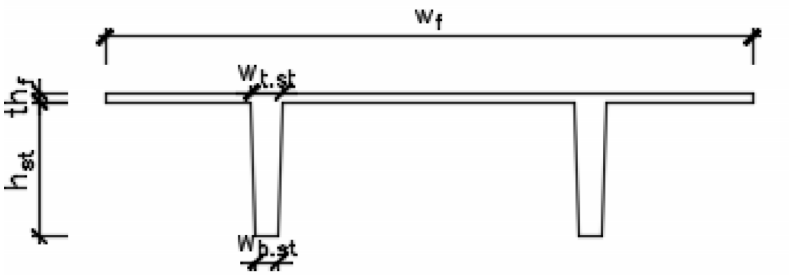
Span Length $L := 60 \cdot ft$ (span length)

$L_r := L = 60\ ft$ (total length)

Topping Thickness $th_{top} := 3 \cdot in$

Flange Width $w_f := 12 \cdot ft$

Flange Thickness $th_f := 2 \cdot in$



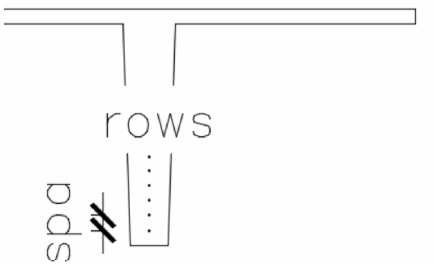
Stem Geometry

Height $h_{st} := 2 \cdot ft + 6 \cdot in$

Thickness at Base $w_{b.st} := 5 \cdot in$

Thickness at Top $w_{t.st} := 7 \cdot in$

Number of Stems $stems := 2$



1.2 Material Properties:

The properties below are used throughout the QC problem. This includes section properties and material properties. Section properties are found using standard geometry the parallel axis theorem. Material properties are calculated using ACI equations (cited at right).

1.2.1 Concrete

Member Strength

final: $f_c := 6 \cdot ksi$

initial: $f_{ci} := 4 \cdot ksi$

Member Conc. Density $\gamma_c := 150 \cdot pcf$

Topping Conc. Density $\gamma_{c.top} := 150 \cdot pcf$

Strain Limit $\varepsilon_c := 0.003$

Topping Strength

final: $f_{c.top} := 4 \cdot ksi$

Elastic Modulus

initial: $E_{ci} := 33 \cdot \left(\frac{\gamma_c}{pcf}\right)^{1.5} \cdot \sqrt{f_{ci} \cdot psi} = 3834.25\ ksi$ (ACI 318-18 eq 19.2.2.1.a)

final: $E_c := 33 \cdot \left(\frac{\gamma_c}{pcf}\right)^{1.5} \cdot \sqrt{f_c \cdot psi} = 4695.98\ ksi$ (ACI 318-18 eq 19.2.2.1.a)

topping: $E_{c.top} := 33 \cdot \left(\frac{\gamma_c}{pcf}\right)^{1.5} \cdot \sqrt{f_{c.top} \cdot psi} = 3834.25\ ksi$ (ACI 318-14 eq 19.2.2.1.a)

4. Losses

Losses below follow the PCI handbook method (long term losses - simplified) provided in the 8th ed. Section 5.8.3. This includes elastic shortening at release, creep at loading, shrinkage of concrete, and relaxation of tendons. Calculations are based on the report provided by ACI-ASCE Committee 423. Live Load regain is also included in analysis.

4.1 Strand Properties:

Total Area of Strand: $A_{ps} := A_{st} \cdot rows \cdot stems = 1.84\ in^2$

Strand Locations: $i := 1 .. rows$ $loc_{strand_i} := spa \cdot i$ $loc_{strand}{}^{T} = [2 \ \ \ldots]\ in$

Centroid of Strand: $y_{cg.st} := \text{mean}(loc_{strand}) = 7.00\ in$

Depth to Steel: $d_s := h_{st} + th_f - \text{mean}(loc_{strand}) = 25\ in$

Non-Composite Strand Ecc.: $e_0 := y_g - y_{cg.st} = 15.57\ in$

Composite Strand Eccentricity: $e_{0.c} := y_{g.c} - y_{cg.st} = 19.43\ in$

Initial Prestress Force: $P_i := pull \cdot A_{ps} \cdot f_{pu} = 347.00\ kip$

Initial Prestress Stress: $f_{pi} := \frac{P_i}{A_{ps}} = 189.00\ ksi$

4.2 Elastic Shortening:

P/S Loss Coeff.: $K_{es} := 1.0$ (pretensioned components, applied to elastic shortening) (PCI 8th ed., Section 5.8.3)

P/S Loss Coeff.: $K_{cir} := 0.9$ (pretensioned components, applied to net compressive stress) (PCI 8th ed., Section 5.8.3)

Per PCI 8th ed. Section 5.2.3, effective prestress is assumed to be 170 ksi which is typical for low-relaxation strand tensioned to the maximum allowable.

Effective Prestress Estimate: $f_{se.i} := 170\ ksi$ (PCI 8th ed., Section 5.2.3, Design Aid 15.2.4)

Transfer Length: $L_t := \frac{f_{se.i}}{3}\ dia_{st} \cdot \left(\frac{in^2}{kip}\right) = 28.33\ in$ $L_t = 2.36\ ft$ (ACI 319-19, Eq. 21.2.3)

Dead Load Moment at Midspan: $M_g := M_{SW} = 303.75\ kip \cdot ft$

Net Compressive Stress from Prestress and SW: $f_{cir} := K_{cir} \cdot \left(\frac{P_i}{A_g} + \frac{P_i \cdot e_0{}^2}{I_{xx}}\right) - \frac{M_g \cdot e_0}{I_{xx}} = 780.18\ psi$ (PCI 8th ed., Eq. 5-100)

Dead Load Moment at Transfer: $M_{g.tran} := \frac{w_{SW} \cdot L_t}{2} \cdot (L_r - L_t) = 45.93\ kip \cdot ft$

Net Compressive Stress from Prestress and SW at Transfer Length: $f_{cir.end} := K_{cir} \cdot \left(\frac{P_i}{A_g} + \frac{P_i \cdot e_0{}^2}{I_{xx}}\right) - \frac{M_{g.tran} \cdot e_0}{I_{xx}} = 1537.18\ psi$ (PCI 8th ed., Eq. 5-100)

Elastic Shortening at Midspan: $ES := \frac{K_{es} \cdot E_{ps} \cdot f_{cir}}{E_{ci}} = 5.90\ ksi$ (PCI 8th ed., Eq 5-99)

Elastic P/S Loss at Midspan: $\%_{loss.ES} := \frac{ES \cdot A_{ps}}{P_i} = 3.12\%$

Elastic Shortening at Transfer: $ES_{end} := \frac{K_{es} \cdot E_{ps} \cdot f_{cir.end}}{E_{ci}} = 11.63\ ksi$ (PCI 8th ed., Eq 5-99)

Elastic P/S Loss at Transfer: $\%_{loss.ES.end} := \frac{ES_{end} \cdot A_{ps}}{P_i} = 6.15\%$

6. Shear

The shear capacities calculated below are split into a vertical and horizontal analysis. Vertical shear capacity is based on the prestress shear section and uses Vci or Vcw as the capacity. Shear is taken at 3 ft from end to account for partial strand development but after strand transfer has occurred. Horizontal shear is caused by flexure. Compression from flexure is resisted along the horizontal shear plane. This analysis shows PCI's method where no steel is required if the plane is roughened.

6.1 Vertical Shear (prestress):

End Info $M_{end} := 85.927 \cdot kip \cdot ft$ $P_{e.end} := 321.2 \cdot kip$ $\%_{loss.end} := 7.28\%$ $A_{PS.end} := 0.97\ in^2$

Stress info $f_{pc} := \frac{P_i \cdot (1 - \%_{loss.end})}{A_g} \cdot \frac{A_{PS.end}}{A_{ps}} = 262.32\ psi$

$f_{pe} := \frac{P_{e.end}}{A_g} \cdot \frac{A_{PS.end}}{A_{ps}} = 0.26\ ksi$

Cracking Moment $M_{cre} := S_{t.c.top} \cdot \left(6 \cdot \sqrt{f_c \cdot psi} + f_{pe}\right) = 643.89\ kip \cdot ft$ (PCI 8th Ed. Eq 5-26)

Shear Section

Slope of Stem Sides $slope := \frac{(w_{t.st} - w_{b.st}) \cdot 0.5}{h_{st}} = 0.03\ \frac{in}{in}$

Effective Shear Depth $d_v := \max\left(d_s, 0.8 \cdot (h_{st} + th_f)\right) = 25.60\ in$

Shear Depth Loc. from Top $d_{loc} := (h_{st} + th_f) - d_v = 6.40\ in$



Average Shear Sect. Width $w_{v.st} := \text{mean}\left(w_{t.st}, slope \cdot d_{loc} \cdot 2 + w_{b.st}\right) = 6.21\ in$

Shear Area $bd := \left(w_{v.st} \cdot (d_v - th_f) + th_f \cdot w_{t.st}\right) \cdot stems = 321.27\ in^2$

Concrete Capacity Equations

Comb. Shear and Moment Case 1 $V_{ci.1} := 0.6 \cdot \sqrt{f_c \cdot psi} \cdot bd + V_d + \frac{V_i \cdot M_{cre}}{M_{end}} = 250.26\ kip$ (PCI 8th Ed. Eq 5-25)

Comb. Shear and Moment Case 2 $V_{ci.2} := 1.7 \cdot \sqrt{f_c \cdot psi} \cdot bd = 42.31\ kip$ (PCI 8th Ed. Eq 5-27)

Greater of Case 1 and 2 $V_{ci} := \max\left(V_{ci.1}, V_{ci.2}\right) = 250.26\ kip$

Tensile Stress in Web $V_{cw} := \left(3.5 \cdot \sqrt{f_c \cdot psi} + 0.3 \cdot f_{pc}\right) \cdot bd = 112.38\ kip$ (PCI 8th Ed. Eq. 5-28)

Nominal Capacity $V_c := min\left(V_{ci}, V_{cw}\right) = 112.38\ kip$

Resistance Factor $\phi_V := 0.75$

Shear Capacity $\phi V_c := \phi_V \cdot V_c = 84.29\ kip$

Shear Demand $\max\left(V_{u.2}\right) = 59.13\ kip$

Check $\text{if}\left(\max\left(V_{u.2}\right) > \frac{\phi V_c}{2}, \text{if}\left(\max\left(V_u\right) > \phi V_c, \text{“Design for Vs”}, \text{“Min Steel Req”}\right), \text{“No Steel Req”}\right) = \text{“Min Steel Req”}$

6.2 Horizontal Shear:

Shear Interface Surface Width $b_v := w_f = 144.00\ in$

Horizontal Shear Length $l_{vh} := \frac{L_r}{2} = 360.00\ in$ (PCI 8th Ed. Fig. 5.3.3)

Horizontal Shear Force $F_h := C = 494.60\ kip$

Factor of Safety $\phi_{vh} := 0.75$

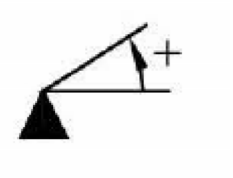
Roughened Surface Capacity $\phi_{vh} V_{n.h} := \phi_{vh} \cdot 80 \cdot psi \cdot b_v \cdot l_{vh} = 3110.40\ kip$ (PCI 8th Ed. Section 5.3.5)

$\text{if}\left(F_h > \phi_{vh} V_{n.h}, \text{“Add Horiz Steel”}, \text{“Okay”}\right) = \text{“Okay”}$

7.5 End Rotation/Shortening:

Shortening uses small angle theory and multiplies the radian of the rotation times the distance from the CG to determine the lengths required. Creep and shrinkage effects are accounted for through ACI 209

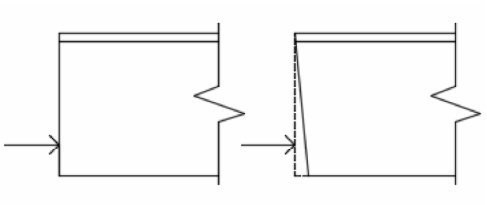
End Rotation



Camber (Prestress) $\theta_{PS} := \frac{P_{i.s.mid} \cdot e_0 \cdot L}{2 \cdot E_{ci} \cdot I_{xx}} = 0.0076\ \textbf{rad}$ (PCI 8th Ed. Design Aid 15.1.4 (3))

Self Weight $\theta_{SW} := \frac{-w_{SW} \cdot L^3}{24 \cdot E_{ci} \cdot I_{xx}} = -0.0036\ \textbf{rad}$ (PCI 8th Ed. Design Aid 15.1.4 (6))

Total Rot. at Construction $\theta_{end} := \theta_{PS} + \theta_{SW} = 0.0041\ \textbf{rad}$



Base Shortening $\delta_x := \frac{P_{i.s.mid} \cdot L}{A_g \cdot E_{ci}} = 0.10\ \textbf{in}$

7.5.1 Creep Effects:

Coefficient $C_u := 2.35$ (ACI 209 eq A-19)

Reduction Factor $\phi_{cu.vs} := \frac{2}{3} \cdot \left(1 + 1.13 \cdot \mathbf{e}^{-0.54 \cdot \frac{A_g}{S \cdot \textbf{in}}}\right) = 0.99$ (Volume to surface effects - ACI 209 eq A-25)

$\phi_{cu.RH} := 1.27 - 0.67 \cdot \frac{RH}{100} = 0.80$ (Humidity effects - ACI 209 eq A-24)

Time Factor $f_{tc} := \frac{\left(\frac{Erection}{\textbf{day}}\right)^{0.6}}{10 + \left(\frac{Erection}{\textbf{day}}\right)^{0.6}} = 0.43$ (ACI 209 eq A-18)

Total Creep Multiplier $\gamma_{cr} := 1 + f_{tc} \cdot \phi_{cu.RH} \cdot \phi_{cu.vs} \cdot C_u = 1.81$ (ACI 209 eq A-21)

7.5.2 Shrinkage Effects:

Base Shrinkage Strain $\varepsilon_{SH} := 780 \cdot 10^{-6}$ (ACI 209 eq A-4)

Reduction Factor $\phi_{sh.vs} := 1.23 - 0.152 \cdot \frac{A_g}{S \cdot \textbf{in}} = 0.99$ (Volume to surface effects - ACI 209 eq A-9)

$\phi_{sh.RH} := 1.4 - 1.02 \cdot \frac{RH}{100} = 0.69$ (Humidity effects - ACI 209 eq A-7)

Time Factor $f_{tsh} := \frac{\left(\frac{Erection}{\textbf{day}}\right)}{55 + \left(\frac{Erection}{\textbf{day}}\right)} = 0.35$ (ACI 209 eq A-1)

Total Shrinkage $\delta_{sh} := f_{tsh} \cdot \phi_{sh.vs} \cdot \phi_{sh.RH} \cdot \varepsilon_{SH} \cdot L = 0.13\ \textbf{in}$

7.5.3 Total Shortening:

Shortening at CG $\delta_{CG} := \delta_x \cdot \gamma_{cr} + \delta_{sh} = 0.31\ \textbf{in}$

Tot. Shortening at Bottom $\delta_{f.bot} := 2 \cdot y_g \cdot \tan\left(\theta_{end}\right) = 0.18\ \textbf{in}$

Tot. Shortening at Top $\delta_{f.top} := 2 \cdot \left(h_{st} + th_f - y_g\right) \cdot \tan\left(-\theta_{end}\right) = -0.08\ \textbf{in}$

At Bottom $\delta_{bot} := \delta_{CG} + \delta_{f.bot} = 0.49\ \textbf{in}$

At Top $\delta_{top} := \delta_{CG} + \delta_{f.top} = 0.232\ \textbf{in}$