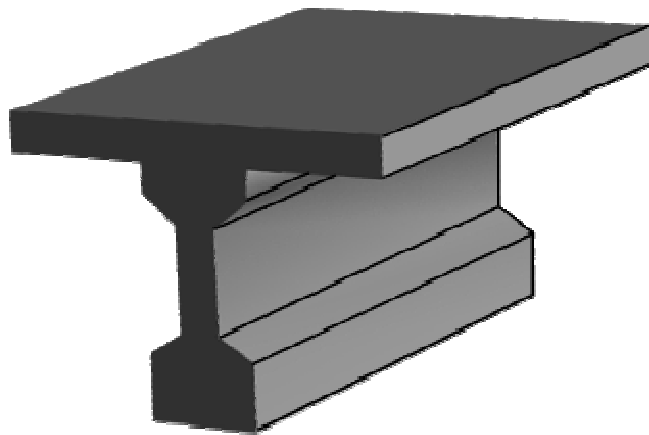


STRUCTWARE[®]
←—————→
Program Documentation

for

PSBEAM

Prestressed Concrete Beam Program



STRUCTWARE

SHEET _____ OF _____

JOB TITLE PSBEAM Documentation ORIGINATOR Bob Matthews DATE 12/31/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

CONTENTS

| ITEM | PAGE |
|----------------------------|------|
| Introduction..... | A-1 |
| Program information | |
| Online help file..... | B1-1 |
| Graphical interface..... | B2-1 |
| Verification problems..... | C-1 |

STRUCTWARE

SHEET A-1 OF _____

JOB TITLE PSBEAM Documentation ORIGINATOR Bob Matthews DATE 12/31/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

INTRODUCTION

PSBEAM may be used to design or review prestressed concrete beams with either pretensioning or post-tensioning reinforcement. Options are available to calculate stresses, deflections, ultimate moment capability and shear stirrup design. This program currently supports English units only. Prestressed concrete beam design may be performed using either AASHTO, AREMA or ACI-318 design criteria.

The online help file and graphical interface is shown in Section B. Verification problems are included in Section C. Additional information is contained in the following files installed in the program directory.

License.txt - The license agreement contains the terms and conditions for use of this program and documentation.

Readme.txt – The installation instructions, copyright notices and version history is contained in this file.

The following steps are recommended for users new to the program or specific features.

1. To learn how to use the program, view the Flash Demonstration Movie that is installed along with the program and read the "Instructions" section of the help file.

To apply this program to a specific problem, find a similar case in the Verification Problems section of this document. Run the program to see if you can reproduce the results. If your problem varies significantly from the Verification Problem, you should perform manual calculations for verification.

STRUCTWARE

SHEET B1-1 OF _____

JOB TITLE PSBEAM Documentation ORIGINATOR Bob Matthews DATE 12/31/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

ONLINE HELP FILE

[Psbeam help](#)

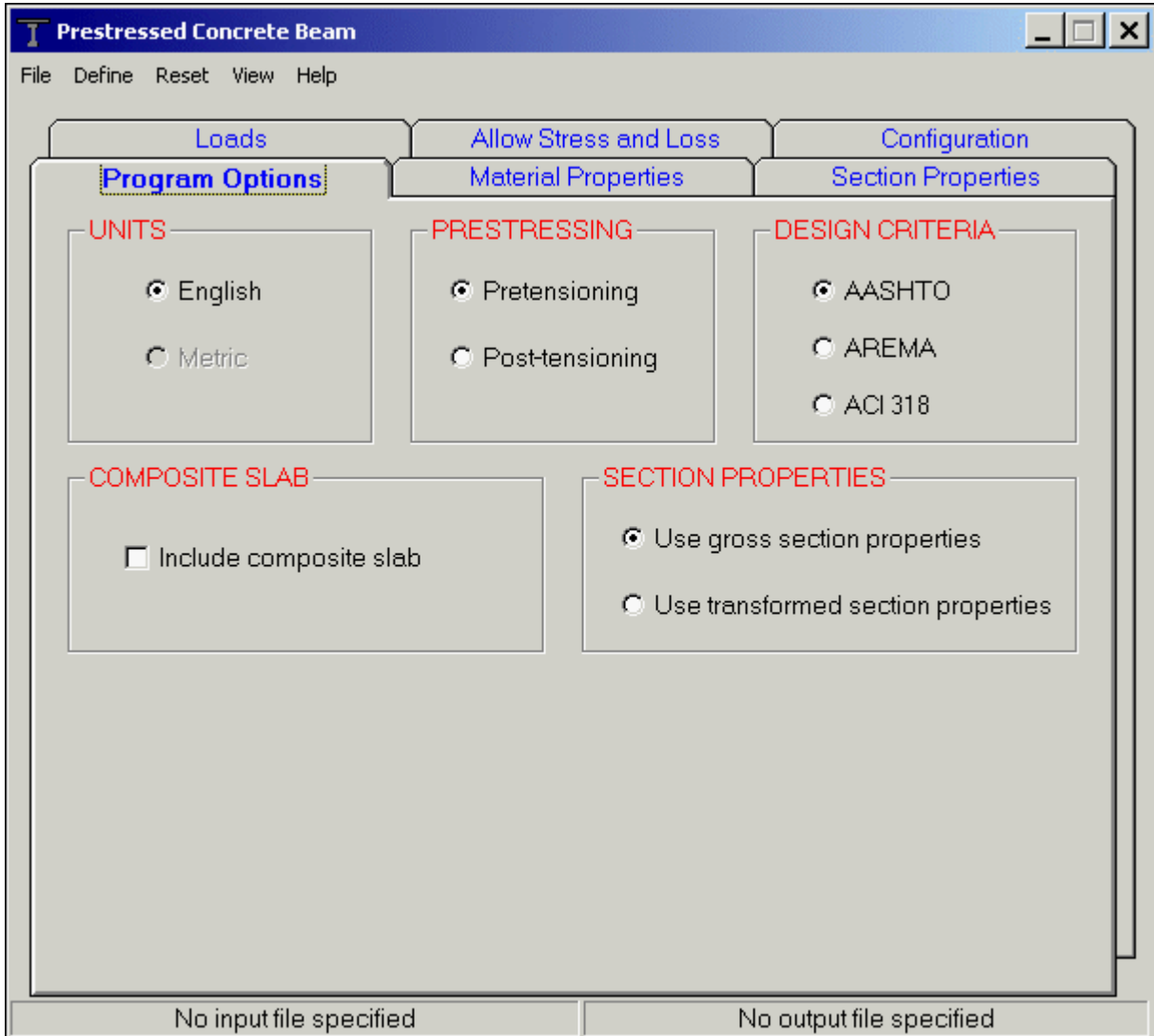
STRUCTWARE

SHEET B2-1 OF

JOB TITLE PSBEAM Documentation ORIGINATOR Bob Matthews DATE 12/31/2005

JOB No. CALCULATION No. REVIEWER DATE

GRAPHICAL INTERFACE



STRUCTWARE

SHEET B2-2 OF

JOB TITLE PSBEAM Documentation ORIGINATOR Bob Matthews DATE 12/31/2005

JOB No. CALCULATION No. REVIEWER DATE

Prestressed Concrete Beam [-] [□] [X]

File Define Reset View Help

Loads Allow Stress and Loss Configuration
Program Options **Material Properties** Section Properties

BEAM CONCRETE

Unit weight:

Compressive strength at 28 days:

Compressive strength at prestressing:

Modulus of elasticity at 28 days:

Modulus of elasticity at prestressing:

SLAB CONCRETE

Unit weight:

Compressive strength at 28 days:

Modulus of elasticity at 28 days:

MILD REINFORCING

Yield strength:

Modulus of elasticity:

PRESTRESSING STEEL

Type: ▼

Diameter:

Ultimate strength:

Yield strength:

Modulus of elasticity:

POST-TENSIONING DUCTS

Friction wobble coeff:

Friction curvature coeff:

No input file specified No output file specified

STRUCTWARE

SHEET B2-3 OF _____

JOB TITLE PSBEAM Documentation ORIGINATOR Bob Matthews DATE 12/31/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

I **Prestressed Concrete Beam** _ □ ×

File Define Reset View Help

LoadsAllow Stress and LossConfiguration

Program OptionsMaterial PropertiesSection Properties

BEAM SECTION

▼

▼

BEAM DIMENSIONS

| | | | |
|------|---------------------------------|--|--|
| | Area | | |
| D | <input type="text" value="66"/> | <input type="text" value="642"/> | |
| Btop | <input type="text" value="19"/> | Mom of Inert | |
| Htop | <input type="text" value="3"/> | <input type="text" value="318000"/> | |
| Bweb | <input type="text" value="7"/> | Ytop | |
| Bbot | <input type="text" value="19"/> | <input type="text" value="34.4"/> | |
| Hbot | <input type="text" value="6"/> | Ybot | |
| Ftop | <input type="text" value="6"/> | <input type="text" value="31.6"/> | |
| Fbot | <input type="text" value="6"/> | <input type="button" value="Calculate"/> | |

The diagram shows a cross-section of an I-girder. The top flange has a width of B_{top} and a thickness of H_{top} . The web has a thickness of B_{web} and a total depth of D . The bottom flange has a width of B_{bot} and a thickness of H_{bot} . The top flange is offset from the web by F_{top} , and the bottom flange is offset by F_{bot} .

No input file specifiedNo output file specified

STRUCTWARE

SHEET B2-4 OF _____

JOB TITLE PSBEAM Documentation ORIGINATOR Bob Matthews DATE 12/31/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

Prestressed Concrete Beam

File Define Reset View Help

Program Options Material Properties Section Properties

Loads Allow Stress and Loss Configuration

Number of Locations: Initial Prestress Force:

LOCATION NO 1

Distance from left end of beam:

| | Axial | Shear | Moment | Factor |
|----------------------|----------------------------------|----------------------------------|--------------------------------|--------------------------------|
| Beam Dead: | <input type="text" value="0.0"/> | <input type="text" value="0.0"/> | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Non-Comp Dead: | <input type="text" value="0.0"/> | <input type="text" value="0.0"/> | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Composite Dead: | <input type="text" value="0.0"/> | <input type="text" value="0.0"/> | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Live plus Impact: | <input type="text" value="0.0"/> | <input type="text" value="0.0"/> | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Prestress: | <input type="text" value="0.0"/> | <input type="text" value="0.0"/> | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Secondary Prestress: | <input type="text" value="0.0"/> | <input type="text" value="0.0"/> | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Miscellaneous: | <input type="text" value="0.0"/> | <input type="text" value="0.0"/> | <input type="text" value="0"/> | <input type="text" value="0"/> |

No input file specified No output file specified

STRUCTWARE

SHEET B2-5 OF _____

JOB TITLE PSBEAM Documentation ORIGINATOR Bob Matthews DATE 12/31/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

The screenshot shows the 'Prestressed Concrete Beam' software window. The title bar includes a menu bar with 'File', 'Define', 'Reset', 'View', and 'Help'. Below the menu bar are three tabs: 'Program Options', 'Material Properties', and 'Section Properties'. Under 'Material Properties', there are sub-tabs: 'Loads', 'Allow Stress and Loss' (which is active and highlighted with a dashed border), and 'Configuration'. The main area contains two sections: 'ALLOWABLE STRESSES' and 'PRESTRESS LOSSES'. The 'ALLOWABLE STRESSES' section has five input fields: 'Initial concrete compressive stress' (2400), 'Initial concrete tensile stress' (190), 'Final concrete compressive stress' (1600), 'Final concrete tensile stress' (379), and 'Initial prestress' (202500). The 'PRESTRESS LOSSES' section has three input fields and two buttons: 'Total prestress losses (excluding friction):' (35000) with a 'Calculate' button, 'Prestress losses at time of transfer:' (16200) with a 'Calculate' button, and 'Anchor set (left):' (0). At the bottom of the window, there are two status boxes: 'No input file specified' and 'No output file specified'.

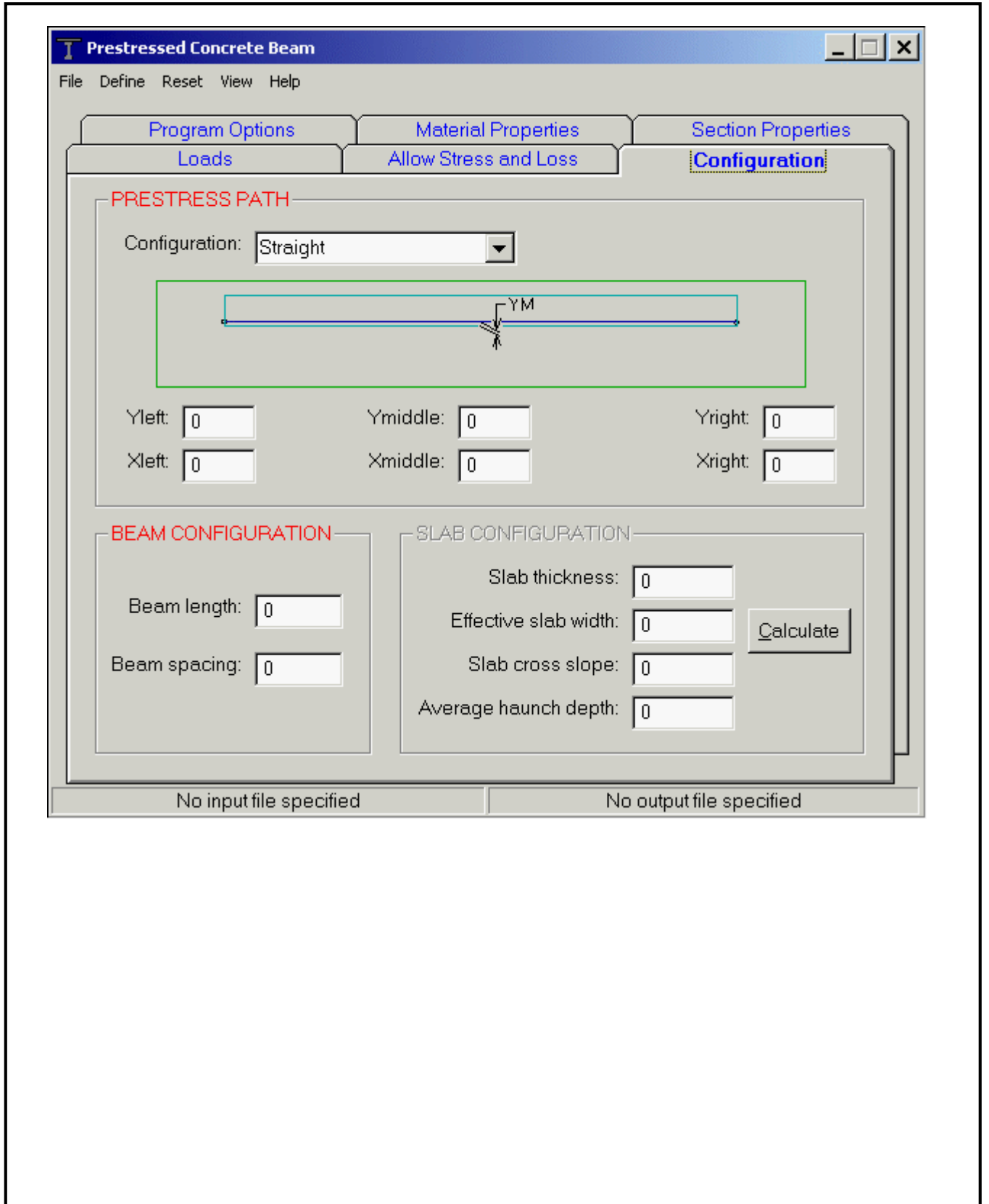
| Parameter | Value |
|---|--------|
| Initial concrete compressive stress | 2400 |
| Initial concrete tensile stress | 190 |
| Final concrete compressive stress | 1600 |
| Final concrete tensile stress | 379 |
| Initial prestress | 202500 |
| Total prestress losses (excluding friction) | 35000 |
| Prestress losses at time of transfer | 16200 |
| Anchor set (left) | 0 |

STRUCTWARE

SHEET B2-6 OF

JOB TITLE PSBEAM Documentation ORIGINATOR Bob Matthews DATE 12/31/2005

JOB No. CALCULATION No. REVIEWER DATE



STRUCTWARE

SHEET C-1 OF _____

JOB TITLE PSBEAM Documentation ORIGINATOR Bob Matthews DATE 12/31/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

VERIFICATION PROBLEMS

1. Verification Problem No. 1
 - a. AREMA design criteria
 - b. Post-tensioned
 - c. Box section (non-composite)
 - d. Simple-simple parabolic prestress path
 - e. Gross section properties

2. Verification Problem No. 2
 - a. ACI-318 design criteria
 - b. Pretensioned
 - c. I-section (non-composite)
 - d. Two-point harped prestress path
 - e. Gross section properties

3. Verification Problem No. 3
 - a. AASHTO design criteria
 - b. Pretensioned
 - c. I-section (composite)
 - d. Straight prestress path
 - e. Transformed section properties

STRUCTWARE

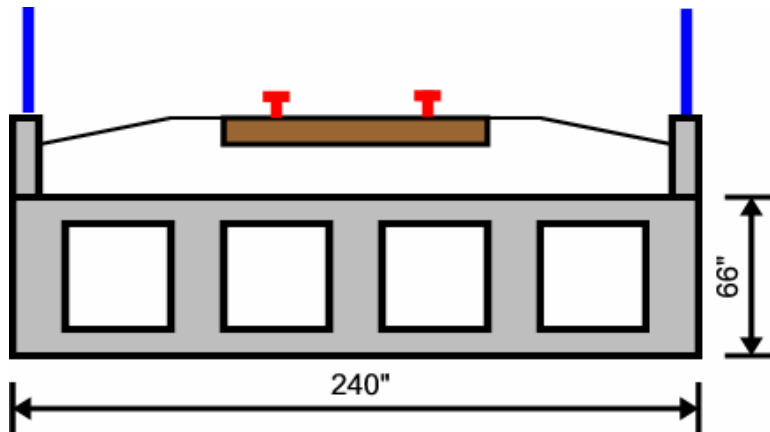
SHEET C1-1 OF _____

JOB TITLE PSBEAM Verification problem no. 1 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

VERIFICATION PROBLEM NO. 1

- AREMA Design Criteria
- Post-tensioned girder



Web thickness = 12"
 Top flange thickness = 10"
 Bottom flange thickness = 6"

- Calculate loads

Span = 70 x 12 = 840"
 $M_L = 3415 \times 2 = 6830$ k-ft (AREMA Table 15-1-16)
 Impact = 26%
 $M_{L+I} = 6830 \times 1.26 = 8605.8$ k-ft
 $V_{L+I} = 221.04 \times 2 \times 1.26 = 557.0$ kips

Area = $240 \times 16 + 12 \times 5 \times 50 = 6840$ in²
 Weight = $6840 \times 0.15 / 144 = 7.125$ k/ft
 $M_{girder} = 7.125 (70)^2 / 8 = 4364.1$ k-ft
 $V_{girder} = 7.125 (70) / 2 = 249.4$ k-ft

Added dead load = 5 k/ft (assumed for track, ballast and curbs)
 $M_{adl} = 5 (70)^2 / 8 = 3062.5$ k-ft
 $V_{adl} = 5 (70) / 2 = 175$ k-ft

LOAD SUMMARY

| DISTANCE | LOAD | SHEAR | MOMENT | FACTOR |
|----------|----------|-------|--------|--------|
| 0" | Girder | 249.4 | 0 | 1.4 |
| | Added DL | 175.0 | 0 | 1.4 |
| | L + I | 557.0 | 0 | 2.333 |
| 420" | Girder | 0 | 4364.1 | 1.4 |
| | Added DL | 0 | 3062.5 | 1.4 |
| | L + I | 0 | 8605.8 | 2.333 |

STRUCTWARE

SHEET C1-2 OF _____

JOB TITLE PSBEAM Verification problem no. 1 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

- Concrete properties

$$f'c = 4000 \text{ psi}$$

$$f'ci = 4000 \text{ psi}$$

- Prestressing steel

$$f's = 270 \text{ ksi (low-lax)}$$

$$k = 0.0000167 \text{ k/in}$$

$$\mu = 0.25$$

- Section properties

$$A = 6840 \text{ in}^2$$

$$y_{\text{bot}} = (10 \times 240 \times 61 + 6 \times 240 \times 3 + 5 \times 12 \times 50 \times 31) / 6840 = 35.63"$$

$$y_{\text{top}} = 66 - 35.63 = 30.37"$$

$$I = 2400 \times (61 - 35.63)^2 + 1440 \times (35.63 - 3)^2 + 3000 \times (35.63 - 31)^2 + 20000 + 24320 + 625000$$

$$I = 3.81 \times 10^6 \text{ in}^4$$

- Allowable stress and loss

$$\text{Initial compression} = 0.6 \times 4000 = 2400 \text{ psi}$$

$$\text{Initial tension} = 3 \times (4000)^{1/2} = 190 \text{ psi}$$

$$\text{Final compression} = 0.4 \times 4000 = 1600 \text{ psi}$$

$$\text{Final tension} = 0 \text{ psi}$$

$$\text{Initial prestress} = 0.75 \times 270 = 202.5 \text{ ksi}$$

$$\text{Total prestress loss} = 24 \text{ ksi}$$

$$\text{Initial prestress loss} = 202.5 - 0.69 \times 270 = 16.2 \text{ ksi}$$

$$\text{Anchor set} = 3/8"$$

- Prestress path

Simple-simple parabolic with $Y = 12"$ at $X = 420"$ and $Y = 33"$ at $X = 0"$ and $840"$

STRUCTWARE

SHEET C1-3 OF _____

JOB TITLE PSBEAM Verification problem no. 1 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

- Verify calculations by comparison with BDS program

File = BDS.OUT

| ITEM | PSBEAM | BDS |
|----------------------------|--------------|---------|
| section properties | | |
| area = | 6840 | 6903 |
| inertia = | 3791552 | 3815000 |
| ytop = | 30.368 | 30.2 |
| ybot = | 35.632 | 35.8 |
| prestress forces @ x = 0 | | |
| initial force = | 6290 | 6290 |
| final force = | 4759.9 | 4761.5 |
| prestress forces @ x = 420 | | |
| initial force = | 6290 | 6290 |
| final force = | 4958.1 | 4962.8 |
| beam stresses @ x = 420 | | |
| prestress loss = | 42879 | 42727 |
| initial ps top = | -246 | -249 |
| initial ps bottom = | 2101 | 2103 |
| final ps top = | -214 | -216 |
| final ps bottom = | 1826 | 1828 |
| beam dead top = | 419 | 418 |
| beam dead bottom = | -492 | -496 |
| non-comp dead top = | 294 | 291 |
| non-comp dead bottom = | -345 | -345 |
| live top = | 827 | 823 |
| live bottom = | -970 | -976 |
| DL + LL + I top = | 1327 | 1316 |
| DL + LL + I bottom = | 18 | 11 |
| moment capacity @ x = 420 | | |
| Mu = | 30475 | 30647 |
| ϕ Mn = | 30823 | 30521 |
| Mild steel = | 0 | 0.46 |
| shear capacity @ x = 0 | | |
| Vu = | 1893.6 | 1955 |
| ϕ Vn = | 1654.8 | 1638 |
| Av/s = | 0.084 | 0.111 |
| deflection @ x = 420 | | |
| Final ps = | 0.606 | 0.612 |

STRUCTWARE

SHEET C1-4 OF _____JOB TITLE PSBEAM Verification problem no. 1 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

The prestress calculations for PSBEAM and BDS match well, however, the mild steel calculations need further investigation.

Moment capability @ x = 420

$$M_u = 1.4 \times (4364.1 + 3062.5) + 2.333 \times 8605.8 = 30474.6 \text{ k-ft}$$

$$\phi M_n = \phi [A_s^* f_{su}^* d \{1 - 0.6(\rho^* f_{su}^* / f'_c)\}]$$

$$\phi = 0.95$$

$$A_s^* = 6290 / 202.5 = 31.06 \text{ in}^2$$

$$\rho^* = 31.06 / (240 \times 54) = 0.002397$$

$$\gamma^* = 0.28 \text{ for low } l/a \text{ and } 0.40 \text{ for stress-rel}$$

$$f_{su}^* = f'_s [1 - (\gamma^* / \beta_1)(\rho^* f'_{su} / f'_c)] = 270 [1 - (0.28 / 0.85)(0.002397 \times 270 / 4)] = 255.61 \text{ ksi}$$

$$a = 31.06 \times 255.61 / (0.85 \times 4 \times 240) = 9.73" < 10" \text{ OK}$$

$$\phi M_n = 0.95 [31.06 \times 255.61 \times 54 \{1 - 0.6 \times 0.002397 \times 255.61 / 4\}] / 12 = 30821 \text{ k-ft}$$

30821 k-ft > 30475 k-ft Therefore no mild reinforcement is required.

Shear capability @ x = 0

$$V_u = 1.4 \times (249.4 + 175) + 2.333 \times 557 = 1893.6 \text{ kips}$$

$$\phi V_{cw} = \phi [(3.5(f'_c)^{1/2} + 0.3 f_{pc}) \times b_w \times d + V_p]$$

$$\phi = 0.9$$

$$d = 0.8 \times 66 = 52.8"$$

$$V_p = 4759.9 \times \tan(5.71) = 475.9 \text{ kips}$$

$$f_{pc} = 475.9 / 6840 = 696 \text{ psi}$$

$$\phi V_{cw} = 0.9 [(3.5(4000)^{1/2} + 0.3 \times 696) \times 60 \times 52.8 / 1000 + 475.9] = 1654.8 \text{ kips}$$

$$A_v / s = (1893.6 - 1654.8) / (0.9 \times 60 \times 52.8) = 0.084$$

STRUCTWARE

SHEET C1-5 OF _____

JOB TITLE PSBEAM Verification problem no. 1 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

PSBEAM Output file = ver1.out

```
* * * * *
*
*           P R O G R A M   P S B E A M
*
*           I N P U T   D A T A   E C H O
*
* * * * *
```

12/27/02, 1:59 pm

P R O G R A M O P T I O N S

=====

Units = English (inches, pounds)
Design Criteria = AREMA
Prestressing = Post-tensioning
Section Properties = Gross

M A T E R I A L P R O P E R T I E S

=====

BEAM CONCRETE

Unit weight = 0.0868
Compressive strength at 28 days = 4000.00
Compressive strength at prestressing = 4000.00
Modulus of elasticity at 28 days = 3833886.
Modulus of elasticity at prestressing = 3833886.

MILD REINFORCING

Yield strength = 60000.00
Modulus of elasticity = 29000000.

PRESTRESSING STEEL

Type = Low relaxation strand
Diameter = 0.500
Ultimate strength = 270000.00
Yield strength = 243000.00
Modulus of elasticity = 28000000.

POST-TENSIONING DUCTS

Friction wobble coefficient = 0.0000167
Friction curvature coefficient = 0.25

STRUCTWARE

SHEET C1-6 OF _____

JOB TITLE PSBEAM Verification problem no. 1 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

SECTION PROPERTIES

BEAM SECTION AND DIMENSIONS

Box Girder
 User defined
 D = 66.000
 Btop = 240.000
 Htop = 10.000
 Bweb = 30.000
 Bbot = 240.000
 Hbot = 6.000
 Ftop = 0.000
 Fbot = 0.000

BEAM PROPERTIES

Area = 6840.00
 MoI = 3791552.
 Ytop = 30.368
 Ybot = 35.632

LOADS

(Units = kip-ft)

Initial prestress force = 6290.0
 Number of load locations = 2

LOCATION NUMBER 1 AT X = 0

| CASE | AXIAL | SHEAR | MOMENT | FACTOR |
|---------------------|-------|-------|--------|--------|
| BEAM DEAD | 0.0 | 249.4 | 0. | 1.400 |
| NON-COMP DEAD | 0.0 | 175.0 | 0. | 1.400 |
| COMPOSITE DEAD | 0.0 | 0.0 | 0. | 0.000 |
| LIVE PLUS IMPACT | 0.0 | 557.0 | 0. | 2.333 |
| PRESTRESS | 0.0 | 0.0 | 0. | 0.000 |
| SECONDARY PRESTRESS | 0.0 | 0.0 | 0. | 0.000 |
| MISCELLANEOUS | 0.0 | 0.0 | 0. | 0.000 |

LOCATION NUMBER 2 AT X = 420

| CASE | AXIAL | SHEAR | MOMENT | FACTOR |
|---------------------|-------|-------|--------|--------|
| BEAM DEAD | 0.0 | 0.0 | 4364. | 1.400 |
| NON-COMP DEAD | 0.0 | 0.0 | 3063. | 1.400 |
| COMPOSITE DEAD | 0.0 | 0.0 | 0. | 0.000 |
| LIVE PLUS IMPACT | 0.0 | 0.0 | 8606. | 2.333 |
| PRESTRESS | 0.0 | 0.0 | 0. | 0.000 |
| SECONDARY PRESTRESS | 0.0 | 0.0 | 0. | 0.000 |
| MISCELLANEOUS | 0.0 | 0.0 | 0. | 0.000 |

STRUCTWARE

SHEET C1-7 OF _____

JOB TITLE PSBEAM Verification problem no. 1 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

A L L O W A B L E S T R E S S A N D L O S S
=====

ALLOWABLE STRESS

Initial concrete compressive stress = 2200.
Initial concrete tensile stress = 190.
Final concrete compressive stress = 1600.
Final concrete tensile stress = 0.
Initial prestress = 202500.

PRESTRESS LOSS

Total prestress loss = 24000.
Prestress loss at time of transfer = 16200.
Anchor set = 0.375

C O N F I G U R A T I O N
=====

PRESTRESS PATH

Simple-Simple Parabolic
Xleft = 0.0 Yleft = 33.000
Xmiddle = 420.0 Ymiddle = 12.000
Xright = 840.0 Yright = 33.000

BEAM CONFIGURATION

Beam length = 840.000
Beam spacing = 0.000

STRUCTWARE

SHEET C1-8 OF _____

JOB TITLE PSBEAM Verification problem no. 1 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

```
* * * * *
*
*           P R O G R A M   P S B E A M
*
*                   O U T P U T   D A T A
*
* * * * *
```

P R E S T R E S S F O R C E S

=====
(Units = kip-ft)

LOCATION NUMBER 1 AT X = 0

| CASE | VALUE |
|--------------------|--------|
| ----- | ----- |
| INITIAL FORCE | 6290.0 |
| CABLE ECCENTRICITY | -2.63 |
| FORCE AT TRANSFER | 5505.4 |
| MOMENT AT TRANSFER | -1207. |
| FINAL FORCE | 4759.9 |
| FINAL MOMENT | -1044. |

LOCATION NUMBER 2 AT X = 420

| CASE | VALUE |
|--------------------|---------|
| ----- | ----- |
| INITIAL FORCE | 6290.0 |
| CABLE ECCENTRICITY | -23.63 |
| FORCE AT TRANSFER | 5703.6 |
| MOMENT AT TRANSFER | -11232. |
| FINAL FORCE | 4958.1 |
| FINAL MOMENT | -9764. |

B E A M S T R E S S E S

=====
LOCATION NUMBER 1 AT X = 0
Prestress loss = 49259

| CASE | TOP FIBER | BOTTOM FIBER |
|---------------------|-----------|--------------|
| ----- | ----- | ----- |
| INITIAL PRESTRESS | 689. | 941. |
| FINAL PRESTRESS | 596. | 814. |
| SECONDARY PRESTRESS | 0. | 0. |
| BEAM DEAD | 0. | 0. |
| NON-COMP DEAD | 0. | 0. |
| COMPOSITE DEAD | 0. | 0. |
| LIVE PLUS IMPACT | 0. | 0. |
| ----- | ----- | ----- |
| INIT P/S + BEAM DL | 689. | 941. |
| FINAL P/S + TOT DL | 596. | 814. |
| P/S + ALL LOADS | 596. | 814. |

STRUCTWARE

SHEET **C1-9** OF JOB TITLE PSBEAM Verification problem no. 1 ORIGINATOR Bob Matthews DATE 12/30/2005JOB No. CALCULATION No. REVIEWER DATE LOCATION NUMBER 2 AT X = 420
Prestress loss = 42879

| CASE | TOP FIBER | BOTTOM FIBER |
|---------------------|-----------|--------------|
| INITIAL PRESTRESS | -246. | 2101. |
| FINAL PRESTRESS | -214. | 1826. |
| SECONDARY PRESTRESS | 0. | 0. |
| BEAM DEAD | 419. | -492. |
| NON-COMP DEAD | 294. | -345. |
| COMPOSITE DEAD | 0. | 0. |
| LIVE PLUS IMPACT | 827. | -970. |
| INIT P/S + BEAM DL | 174. | 1608. |
| FINAL P/S + TOT DL | 500. | 988. |
| P/S + ALL LOADS | 1327. | 18. |

CHECK CRITICAL CONCRETE STRESSES

| CASE | ACTUAL | ALLOWABLE | |
|-------------------------|--------|-----------|--------|
| TENSION (TOP FIBER) | 174. | -190. | < OK > |
| INITIAL COMPRESSION | 1608. | 2200. | < OK > |
| FINAL TENSION (DL ONLY) | 814. | 0. | < OK > |
| FINAL TENSION | 18. | 0. | < OK > |
| FINAL COMPRESSION | 1327. | 1600. | < OK > |

M O M E N T C A P A C I T Y

=====
(Units = kip-ft)

| X | Mult | 1.2Mcr | phiMn | |
|-----|--------|--------|--------|--------|
| 0 | 0. | 5047. | 17100. | < OK > |
| 420 | 30475. | 5047. | 30823. | < OK > |

B E A M D E F L E C T I O N S

=====
Initial prestress deflection = 0.697
Final prestress deflection = 0.606
Simple beam dead load deflection = 0.265

S H E A R C A P A C I T Y

=====
(Units = kip)

| X | Vult | phiVn | Av/S |
|-----|--------|--------|-------|
| 0 | 1893.6 | 1654.8 | 0.084 |
| 420 | 0.0 | 313.5 | 0.050 |

BDS Output file = BDS.OUT

```
*****
*                               IAI-BDS                               *
*                               Bridge Design System                   *
*                               By: Imbsen and Associates, Inc.         *
*                               VERSION 4.2.4   23-AUG-99             *
*****
```

***** Licensed to: Holmes & Narver, Inc. - Orange, CA *****

LISTING OF THE SORTED INPUT FILE

| CARD NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-------------|-----|---|-------------|------------|---------|-------------------|-----------|------|
| 1 | 000 | POST TENSIONING VERIFICATION PROBLEM NO 1 | | | | | | 000 |
| 2 | 000 | US | | | | | | 001 |
| 3 | 000 | 1 1 | 2PRH 700 | 3834 | 150 | | | 100 |
| 4 | 000 | 1 0 | 200 5501000 | 600 312012 | 012 | | | 200 |
| 5 | 000 | 1 1 | 5000U | | | TRACK AND BALLAST | | 300 |
| 6 | 000 | 1 1000 | 1000 10 | 1026COOPER | E80 | | | 500 |
| 7 | 000 | 4 | | | | E80 | | 1501 |
| 8 | 000 | | 1 | 140 217 | 217 217 | 233 130 | 130 90 95 | 550 |
| 9 | 000 | 101A 1 | 50 275 | 450 275 | 25 20 | L | 4002470 | 600 |

IAI-BDS Version 4.2.4 Licensed to: Holmes & Narver, Inc. - Orange, CA Run time: 27-DEC-02 14:39:49 Page 1

POST TENSIONING VERIFICATION PROBLEM NO 1

FRAME DESCRIPTION

| MEM NO | JT. | | END COND | | DIR | SPAN (FT) | I (FT**4) | SUPPORT OR HINGE | | DEAD LOAD | | | CARRY OVER FACTORS | | RECALL MEM |
|--------|-----|----|----------|----|-----|-----------|-----------|------------------|-------|-----------|-------|------|--------------------|------|------------|
| | LT | RT | LT | RT | | | | E | UNI | SEC | LT | RT | LT | RT | |
| 1 | 1 | 2 | P | R | H | 70.0 | 0.00 | 0.0 | 3834. | 0.000 | 0.150 | 0.00 | 0.00 | 0.00 | 0.00 |

POST TENSIONING VERIFICATION PROBLEM NO 1

SECTION PROPERTIES - INPUT

| MEM NO | RE CALL | Z | Y | W | D | TOP | BOT | NO | W | T | W | FACT | T | W | FACT | L | EX | IN | L | EX | IN | E | STORE |
|--------|---------|------|------|------|------|------|------|---------|---------|-------|---------|-------|------|------|------|------|------|------|------|------|-------|---|-------|
| (FT) | (FT) | (FT) | (FT) | (FT) | (IN) | (IN) | (IN) | (IN) | (IN) | (FT) | (IN) | (FT) | (FT) | (IN) | (FT) | (IN) | (IN) | (FT) | (IN) | (IN) | (KSI) | | |
| | | +/- | CODE | V/D | H | Z | Y | AREA | IZZ | E | E-STORE | STORE | | | | | | | | | | | |
| | | (FT) | (FT) | (FT) | (FT) | (FT) | (FT) | (FT**2) | (FT**4) | (KSI) | | | | | | | | | | | | | |

1 0.0 0.0 0.0 20.0 5.50 10.00 6.00 3 12. 0 12. 0.00 0 12. 0.00 0.0 0. 0. 0.0 0. 0. 3834.

SECTION PROPERTIES - OUTPUT

| MEM NO | LOC. | DEPTH | Z-BAR | Y-BAR | AREA | IZZ | IYY | E |
|--------|------|-------|-------|-------|---------|---------|---------|---------|
| (FT) | (FT) | (FT) | (FT) | (FT) | (FT**2) | (FT**4) | (FT**4) | (KSI) |
| 1 | 0.0 | 5.50 | 10.00 | 2.98 | 47.94 | 183.96 | 1844.62 | 3834.00 |

MEMBER 1 PROPERTIES

LENGTH: 70.0 FT MIN E*I: 0.705E+06 KSI-FT**4 STIFF: 4.000 LT 4.000 RT C.O.: 0.500 LT 0.500 RT

POST TENSIONING VERIFICATION PROBLEM NO 1

FRAME PROPERTIES

| MEM NO | JT | END COND | DIR | SPAN | MIN E*I | SUPPORT OR HINGE | E | CARRY OVER FACTORS | DISTRIBUTION FACTORS |
|---|-------------|-----------|-------|------------|---------|------------------|-------------|--------------------|----------------------|
| (FT) | (KSI-FT**4) | (FT) | (KSI) | LT | RT | LT | RT | LT | RT |
| /---/ /-----/ /-----/ /---/ /-----/ /-----/ /-----/ /-----/ /-----/ /-----/ /-----/ | 1 | 1 2 P R H | 70.0 | 0.7053E+06 | 0.0 | 3834. | 0.000 0.000 | 0.000 0.000 | |

***** IF MEMBER IS HORIZONTAL SUPPORT OR HINGE FIELD EQUALS LOCATION OF HINGE FROM LEFT END OF MEMBER *****
 ***** IF MEMBER IS VERTICAL SUPPORT OR HINGE FIELD EQUALS SUPPORT WIDTH USED FOR MOMENT REDUCTION *****

IAI-BDS Version 4.2.4 Licensed to: Holmes & Narver, Inc. - Orange, CA Run time: 27-DEC-02 14:39:49 Page 4

POST TENSIONING VERIFICATION PROBLEM NO 1

FIXED END MOMENTS TRIAL 0

| MEM NO | FIXED END MOMENTS | | MEM NO | FIXED END MOMENTS | | MEM NO | FIXED END MOMENTS | |
|--------|-------------------|-------------|--------|-------------------|-------------|--------|-------------------|-------------|
| | LT (KIP-FT) | RT (KIP-FT) | | LT (KIP-FT) | RT (KIP-FT) | | LT (KIP-FT) | RT (KIP-FT) |
| 1 | 0. | 0. | | | | | | |

IAI-BDS Version 4.2.4 Licensed to: Holmes & Narver, Inc. - Orange, CA Run time: 27-DEC-02 14:39:49 Page 5

POST TENSIONING VERIFICATION PROBLEM NO 1

SIDESWAY DIAGNOSTICS

ERROR - FRAME MEMBER ARE ALL HORIZONT. OR ALL VERTICAL.

IAI-BDS Version 4.2.4 Licensed to: Holmes & Narver, Inc. - Orange, CA Run time: 27-DEC-02 14:39:49 Page 6

POST TENSIONING VERIFICATION PROBLEM NO 1

*** SIDESWAY NOT CONSIDERED. SIDESWAY DIAGNOSTICS PRESENT. ***

HORIZONTAL MEMBER MOMENTS (KIP-FT) TRIAL 0

| MEM NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0. | 1586. | 2819. | 3700. | 4229. | 4405. | 4229. | 3700. | 2819. | 1586. | 0. |

HORIZONTAL MEMBER STRESSES(PSI) TRIAL 0 BOTTOM FIBER

| | | | | | | | | | | | |
|---|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|
| 1 | 0. | -179. | -318. | -417. | -476. | -496. | -476. | -417. | -318. | -179. | 0. |
|---|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|

HORIZONTAL MEMBER STRESSES(PSI) TRIAL 0 TOP FIBER

| | | | | | | | | | | | |
|---|----|------|------|------|------|------|------|------|------|------|----|
| 1 | 0. | 151. | 268. | 351. | 402. | 418. | 402. | 351. | 268. | 151. | 0. |
|---|----|------|------|------|------|------|------|------|------|------|----|

HORIZONTAL MEMBER SHEARS(KIPS) TRIAL 0

| | | | | | | | | | | | |
|---|-------|-------|-------|-------|------|-----|-------|--------|--------|--------|--------|
| 1 | 251.7 | 201.4 | 151.0 | 100.7 | 50.3 | 0.0 | -50.3 | -100.7 | -151.0 | -201.4 | -251.7 |
|---|-------|-------|-------|-------|------|-----|-------|--------|--------|--------|--------|

POST TENSIONING VERIFICATION PROBLEM NO 1

TRIAL 0

TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE

| SPAN | LT. END | RT. END | SPAN | LT. END | RT. END | SPAN | LT. END | RT. END |
|------|----------|-----------|------|---------|---------|------|---------|---------|
| 1 | 0.001012 | -0.001012 | | | | | | |

HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE

| MEMBER | E= | 0.000 | 0.016 | 0.022 | 0.016 | 0.000 |
|--------|-----------|-------|-------|-------|-------|-------|
| 1 | 3834. KSI | | | | | |

POST TENSIONING VERIFICATION PROBLEM NO 1

LOAD DATA TRIAL 1

| LINE | MEM | LOAD | | FIXED END MOMENTS | | | COMMENTS | |
|------|-----|----------|-------|-------------------|------|----------|----------|-------------------|
| | | W OR P | CODE | A | B | LEFT | | RIGHT |
| | | (KIP/FT) | (KIP) | (FT) | (FT) | (KIP-FT) | (KIP-FT) | |
| 1 | | 5.000 | U | 0.0 | 0.0 | 0. | 0. | TRACK AND BALLAST |
| | | | | ASSUMED DATA | 70.0 | | | |

FIXED END MOMENTS TRIAL 1

| MEM NO | FIXED END MOMENTS | | MEM NO | FIXED END MOMENTS | | MEM NO | FIXED END MOMENTS | |
|--------|-------------------|----------|--------|-------------------|----------|--------|-------------------|----------|
| | LT | RT | | LT | RT | | LT | RT |
| | (KIP-FT) | (KIP-FT) | | (KIP-FT) | (KIP-FT) | | (KIP-FT) | (KIP-FT) |
| 1 | 0. | 0. | | | | | | |

POST TENSIONING VERIFICATION PROBLEM NO 1

*** SIDESWAY NOT CONSIDERED. SIDESWAY DIAGNOSTICS PRESENT. ***

HORIZONTAL MEMBER MOMENTS (KIP-FT) TRIAL 1

MEM

| NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|----|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0. | 1102. | 1960. | 2572. | 2940. | 3062. | 2940. | 2572. | 1960. | 1102. | 0. |

HORIZONTAL MEMBER STRESSES(PSI) TRIAL 1 BOTTOM FIBER

| | | | | | | | | | | | |
|---|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|
| 1 | 0. | -124. | -221. | -290. | -331. | -345. | -331. | -290. | -221. | -124. | 0. |
|---|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|

HORIZONTAL MEMBER STRESSES(PSI) TRIAL 1 TOP FIBER

| | | | | | | | | | | | |
|---|----|------|------|------|------|------|------|------|------|------|----|
| 1 | 0. | 105. | 186. | 244. | 279. | 291. | 279. | 244. | 186. | 105. | 0. |
|---|----|------|------|------|------|------|------|------|------|------|----|

HORIZONTAL MEMBER SHEARS(KIPS) TRIAL 1

| | | | | | | | | | | | |
|---|-------|-------|-------|------|------|-----|-------|-------|--------|--------|--------|
| 1 | 175.0 | 140.0 | 105.0 | 70.0 | 35.0 | 0.0 | -35.0 | -70.0 | -105.0 | -140.0 | -175.0 |
|---|-------|-------|-------|------|------|-----|-------|-------|--------|--------|--------|

POST TENSIONING VERIFICATION PROBLEM NO 1

TRIAL 1

TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE

SPAN LT. END RT. END SPAN LT. END RT. END SPAN LT. END RT. END

| | | | | | | | | |
|---|----------|-----------|--|--|--|--|--|--|
| 1 | 0.000704 | -0.000704 | | | | | | |
|---|----------|-----------|--|--|--|--|--|--|

HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE

| | | | | | | |
|----------|--------------|-------|-------|-------|-------|-------|
| MEMBER 1 | E= 3834. KSI | 0.000 | 0.011 | 0.015 | 0.011 | 0.000 |
|----------|--------------|-------|-------|-------|-------|-------|

POST TENSIONING VERIFICATION PROBLEM NO 1

LIVE LOAD DIAGNOSTICS

LIVE LOAD GENERATOR COOPER E80

| MEM NO. | NUMBER OF LIVE LOAD LANES | | | | RESISTING MOMENT OF UNIT STEEL | | PLOT M ENV. | PLOT S SCALE | INFLU- ENCE LINES | GEN | | | | | | | |
|--------------|------------------------------------|--------|--------|--------|--------------------------------|----------|-------------|--------------|-------------------|-----|-----------|-----|--------|------|--------------|--|---|
| | LT.END | RT.END | LT.END | RT.END | POSITIVE | NEGATIVE | | | | | | | | | | | |
| 1 | 1.000 | 1.000 | 1.0 | 1.0 | 0. | 0. | 0 | 0 | NO | NO | | | | | | | |
| ----- | | | | | | | | | | | | | | | | | |
| LIVE LOAD NO | ----- TRUCK OR TRAIN LOADING ----- | | | | | | | | | | OVER LOAD | RRL | IMPACT | COMB | CARD CONTROL | | |
| 4. | P1 | D1 | P2 | D2 | P3 | D3 | P4 | D4 | P5 | D5 | P6 | D6 | 20. | E80 | YES | | 1 |
| | P7 | D7 | P8 | D8 | P9 | D9 | P10 | D10 | P11 | D11 | P12 | D12 | | | | | |
| | 52.0 | 6.0 | 52.0 | 5.0 | 52.0 | 8.0 | 40.0 | 8.0 | 80.0 | 5.0 | 80.0 | 5.0 | | | | | |
| | P13 | D13 | P14 | D14 | P15 | D15 | P16 | D16 | P17 | D17 | P18 | D18 | | | | | |
| | 80.0 | 5.0 | 80.0 | 9.0 | 52.0 | 5.0 | 52.0 | 6.0 | 52.0 | 5.0 | 52.0 | 5.0 | | | | | |
| | P19 | D19 | P20 | D20 | P21 | D21 | P22 | D22 | P23 | D23 | P24 | D24 | | | | | |
| | 100.0 | 7.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | |
| | P25 | D25 | P26 | D26 | P27 | D27 | P28 | D28 | P29 | D29 | P30 | D30 | | | | | |
| | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | |

POST TENSIONING VERIFICATION PROBLEM NO 1

LL NO. 4. NEGATIVE LIVE LOAD MOMENT(KIP-FT) ENVELOPE AND ASSOCIATED SHEARS (KIPS)
 *** COOPERS LOADING WITH 20 AXLES WAS USED FOR THIS LIVE LOAD ***

| MEM NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| SHEAR | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

HORIZONTAL MEMBER STRESSES(PSI) LL MAX NEG BOTTOM FIBER

| | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|----|----|----|
| 1 | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
|---|----|----|----|----|----|----|----|----|----|----|----|

HORIZONTAL MEMBER STRESSES(PSI) LL MAX NEG TOP FIBER

| | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|----|----|----|
| 1 | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
|---|----|----|----|----|----|----|----|----|----|----|----|

POST TENSIONING VERIFICATION PROBLEM NO 1

LL NO. 4. DEAD LOAD PLUS NEGATIVE LIVE LOAD MOMENT(KIP-FT) ENVELOPE
 *** COOPERS LOADING WITH 20 AXLES WAS USED FOR THIS LIVE LOAD ***

| MEM NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0. | 1586. | 2819. | 3700. | 4229. | 4405. | 4229. | 3700. | 2819. | 1586. | 0. |

HORIZONTAL MEMBER STRESSES(PSI) FOR DL+LL MAX NEG BOTTOM FIBER

| | | | | | | | | | | | |
|---|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|
| 1 | 0. | -179. | -318. | -417. | -476. | -496. | -476. | -417. | -318. | -179. | 0. |
|---|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|

HORIZONTAL MEMBER STRESSES(PSI) FOR DL+LL MAX NEG TOP FIBER

| | | | | | | | | | | | |
|---|----|------|------|------|------|------|------|------|------|------|----|
| 1 | 0. | 151. | 268. | 351. | 402. | 418. | 402. | 351. | 268. | 151. | 0. |
|---|----|------|------|------|------|------|------|------|------|------|----|

POST TENSIONING VERIFICATION PROBLEM NO 1

LL NO. 4. POSITIVE LIVE LOAD MOMENT(KIP-FT) ENVELOPE AND ASSOCIATED SHEARS (KIPS)
 *** COOPERS LOADING WITH 20 AXLES WAS USED FOR THIS LIVE LOAD ***

| MEM NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|------|-------|-------|-------|-------|-------|--------|--------|--------|--------|-------|
| 1 | 0. | 3416. | 6001. | 7740. | 8588. | 8666. | 8588. | 7740. | 6001. | 3416. | 0. |
| SHEAR | 0.0 | 487.9 | 360.2 | 231.8 | 103.3 | 35.4 | -103.3 | -231.8 | -360.2 | -487.9 | 0.0 |

HORIZONTAL MEMBER STRESSES(PSI) LL MAX POS BOTTOM FIBER

| | | | | | | | | | | | |
|---|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|
| 1 | 0. | -385. | -676. | -872. | -967. | -976. | -967. | -872. | -676. | -385. | 0. |
|---|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|

HORIZONTAL MEMBER STRESSES(PSI) LL MAX POS TOP FIBER

| | | | | | | | | | | | |
|---|----|------|------|------|------|------|------|------|------|------|----|
| 1 | 0. | 324. | 570. | 735. | 816. | 823. | 816. | 735. | 570. | 324. | 0. |
|---|----|------|------|------|------|------|------|------|------|------|----|

POST TENSIONING VERIFICATION PROBLEM NO 1

LL NO. 4. DEAD LOAD PLUS POSITIVE LIVE LOAD MOMENT(KIP-FT) ENVELOPE
 *** COOPERS LOADING WITH 20 AXLES WAS USED FOR THIS LIVE LOAD ***

| MEM NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|------|-------|-------|--------|--------|--------|--------|--------|-------|-------|-------|
| 1 | 0. | 5001. | 8820. | 11440. | 12817. | 13071. | 12817. | 11440. | 8820. | 5001. | 0. |

HORIZONTAL MEMBER STRESSES(PSI) FOR DL+LL MAX POS BOTTOM FIBER

| | | | | | | | | | | | |
|---|----|-------|-------|--------|--------|--------|--------|--------|-------|-------|----|
| 1 | 0. | -563. | -994. | -1289. | -1444. | -1472. | -1444. | -1289. | -994. | -563. | 0. |
|---|----|-------|-------|--------|--------|--------|--------|--------|-------|-------|----|

HORIZONTAL MEMBER STRESSES(PSI) FOR DL+LL MAX POS TOP FIBER

| | | | | | | | | | | | |
|---|----|------|------|-------|-------|-------|-------|-------|------|------|----|
| 1 | 0. | 475. | 838. | 1087. | 1217. | 1242. | 1217. | 1087. | 838. | 475. | 0. |
|---|----|------|------|-------|-------|-------|-------|-------|------|------|----|

IAI-BDS Version 4.2.4 Licensed to: Holmes & Narver, Inc. - Orange, CA Run time: 27-DEC-02 14:39:49 Page 16

POST TENSIONING VERIFICATION PROBLEM NO 1

LL NO. 4. LIVE LOAD SHEAR(KIPS) ENVELOPES AND ASSOCIATED MOMENTS (KIP-FT)
 *** COOPERS LOADING WITH 20 AXLES WAS USED FOR THIS LIVE LOAD ***

| MEMBER | 1 LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|--------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|
| POS. V | 582.6 | 487.9 | 391.9 | 302.6 | 228.2 | 169.6 | 118.2 | 75.2 | 39.7 | 12.6 | 0.0 |
| MOM. | 0. | 3416. | 5789. | 6355. | 6389. | 5935. | 4962. | 3683. | 2222. | 794. | 0. |
| NEG. V | 0.0 | -12.6 | -39.7 | -75.2 | -118.2 | -169.6 | -228.2 | -302.6 | -391.9 | -487.9 | -582.6 |
| MOM. | 0. | 794. | 2222. | 3683. | 4962. | 5935. | 6389. | 6355. | 5789. | 3416. | 0. |
| RANGE | 582.6 | 500.5 | 431.6 | 377.8 | 346.3 | 339.1 | 346.3 | 377.8 | 431.6 | 500.5 | 582.6 |

IAI-BDS Version 4.2.4 Licensed to: Holmes & Narver, Inc. - Orange, CA Run time: 27-DEC-02 14:39:49 Page 17

POST TENSIONING VERIFICATION PROBLEM NO 1

LL NO. 4. DEAD LOAD PLUS LIVE LOAD SHEAR(KIPS) ENVELOPE
 *** COOPERS LOADING WITH 20 AXLES WAS USED FOR THIS LIVE LOAD ***

| MEMBER | 1 LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|--------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|
| POS. V | 834.3 | 689.3 | 542.9 | 403.3 | 278.5 | 169.6 | 67.8 | -25.5 | -111.4 | -188.8 | -251.7 |
| NEG. V | 251.7 | 188.8 | 111.4 | 25.5 | -67.8 | -169.6 | -278.5 | -403.3 | -542.9 | -689.3 | -834.3 |

IAI-BDS Version 4.2.4 Licensed to: Holmes & Narver, Inc. - Orange, CA Run time: 27-DEC-02 14:39:49 Page 18

POST TENSIONING VERIFICATION PROBLEM NO 1

*** COOPERS LOADING WITH 20 AXLES WAS USED FOR THIS LIVE LOAD ***

LL NO. 4. LIVE LOAD SUPPORT RESULTS

| | MAX. AXIAL LOAD (KIPS) | MAX. AXIAL LOAD | | MAX. LONGITUDINAL MOMENT | | |
|---------------|------------------------|-----------------|-------------|--------------------------|------------|-------------|
| | | TOP (K-FT) | BOT. (K-FT) | AXIAL LOAD (KIPS) | TOP (K-FT) | BOT. (K-FT) |
| SUPPORT JT. 1 | | | | | | |
| POSITIVE | 582.6 | 0. | 0. | 0.0 | 0. | 0. |
| NEGATIVE | 0.0 | 0. | 0. | 0.0 | 0. | 0. |
| SUPPORT JT. 2 | | | | | | |
| POSITIVE | 582.6 | 0. | 0. | 0.0 | 0. | 0. |
| NEGATIVE | 0.0 | 0. | 0. | 0.0 | 0. | 0. |

THE RATIO OF SUBSTRUCTURE / SUPERSTRUCTURE LOADING IS 1.000

POST TENSIONING VERIFICATION PROBLEM NO 1

PRESTRESS COMBINATION DATA

INPUT:

| | L.L. (1) | L.L. (2) | L.L. (3) | L.L. (4) | L.L. (5) | L.L. (6) |
|----------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | ----- | ----- | ----- | ----- | ----- | ----- |
| LIVE LOADS TO BE COMBINED: | 0 | 0 | 0 | 1 | 0 | 0 |
| LIVE LOAD LOAD FACTORS: | 2.17 | 2.17 | 2.17 | 2.33 | 1.30 | 1.30 |
| DEAD LOAD LOAD FACTOR: | 1.40 | | | | | |
| PHI FACTOR FOR SHEAR : | 0.90 | | | | | |
| PHI FACTOR FOR MOMENT: | 0.95 | | | | | |

ULTIMATE MOMENT APPLIED = 1.40 X (DL+ADL)
+ 2.33 X LL(4)
+ 1.00 X (P/S SEC. MOMENT)

ULTIMATE SHEAR APPLIED = 1.40 X (DL+ADL)
+ 2.33 X LL(4)
+ 1.00 X (P/S SEC. SHEAR)

PHI FACTOR FOR SHEAR = 0.90; PHI FACTOR FOR MOMENT = 0.95

IAI-BDS Version 4.2.4 Licensed to: Holmes & Narver, Inc. - Orange, CA Run time: 27-DEC-02 14:39:49 Page 20

POST TENSIONING VERIFICATION PROBLEM NO 1

INPUT PRESTRESSED DATA

TRIAL 10 FRAME 1 PATH A

| MEM NO. | LLT/X (% / FT) | LLP/Y (% / FT) | LRT/Z (% / FT) | YLT/TYPE (FT /) | YLP/SLOPE (FT/) | YRT (FT) | U | K |
|------------|-------------------|-------------------|-------------------|---------------------|---------------------|-------------|------|--------|
| 1 | 0.00 | 0.50 | 0.00 | 2.75 | 4.50 | 2.75 | 0.25 | 0.0002 |

XLT(FT) = 0.0 XRT(FT) = 0.0 STEEL STRESS(KSI) = 270. JACKING % = 0.75 JACKING ENDS = L

ANCHOR SET(IN); LEFT = 0.375 RIGHT = 0.000 CONC. STRENGTH(PHI) = 4000. ALLOW. TENSION(PHI) = 0.

P-JACK(KIPS) = 0. SHORTENING PERCENT= 0 TOTAL LOSSES(KSI) = 24 RELATIVE HUMIDITY % = 70.

LOW-LAX = YES PLOT PATHS = NO PLOT STRESSES = NO

CABLE PATH OFFSETS (FT)

| MEMBER | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 2.75 | 3.38 | 3.87 | 4.22 | 4.43 | 4.50 | 4.43 | 4.22 | 3.87 | 3.38 | 2.75 |

CABLE PATH ECCENTRICITIES (FT)

| | | | | | | | | | | | |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0.234 | 0.864 | 1.354 | 1.704 | 1.914 | 1.984 | 1.914 | 1.704 | 1.354 | 0.864 | 0.234 |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|

FORCE COEFFICIENTS

| | | | | | | | | | | | |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0.757 | 0.763 | 0.770 | 0.776 | 0.782 | 0.789 | 0.795 | 0.801 | 0.807 | 0.813 | 0.819 |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|

THE POINT OF NO MOVEMENT FOR PRESTRESSING IS IN SPAN 1, 70.00 FEET FROM THE LEFT END OF THE SPAN

THE LEFT ANCHOR SET LENGTH IS 70.00 FEET THE RIGHT ANCHOR SET LENGTH IS 0.00 FEET

THE FORCE COEF. AT THE LEFT END IS 0.757 THE FORCE COEF. AT THE RIGHT END IS 0.819

INITIAL FORCE COEFF. AT POINT OF NO MOVEMENT = 0.938

***** LEFT ANCHOR SET LENGTH ACTUALLY EXTENDS BEYOND END OF TENDON PATH. *****

POST TENSIONING VERIFICATION PROBLEM NO 1

SECONDARY MOMENT DUE TO PJACK = 1

TRIAL 10 FRAME 1 PATH A

FEM'S(K-FT) DUE TO SECONDARY EFFECTS BEFORE BALANCING

| MEMBER | LEFT END | RIGHT END | MEMBER | LEFT END | RIGHT END | MEMBER | LEFT END | RIGHT END |
|--------|----------|-----------|--------|----------|-----------|--------|----------|-----------|
| 1 | 0.000 | 0.000 | | | | | | |

FEM'S DUE TO SECONDARY EFFECTS --- UNIT = K-FT

| | | |
|---|-------|-------|
| 1 | 0.000 | 0.000 |
|---|-------|-------|

P/S MOMENT COEF.(FT)

*** SIDESWAY NOT CONSIDERED. SIDESWAY DIAGNOSTICS PRESENT. ***
ADJUSTED FOR LOSSES & SECONDARY MOMENTS BUT NO SHORTENING

MEM

| MEM NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1 | -0.1771 | -0.6596 | -1.0423 | -1.3224 | -1.4974 | -1.5645 | -1.5211 | -1.3647 | -1.0926 | -0.7025 | -0.1916 |

POST TENSIONING VERIFICATION PROBLEM NO 1

TRIAL 10 FRAME 1 PATH A

HORIZONTAL MEMBER STRESSES (PSI) PRESTRESS ONLY BOTTOM FIBER AFTER ALL LOSSES

MEM

| MEM NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 816. | 1164. | 1441. | 1645. | 1775. | 1828. | 1803. | 1698. | 1510. | 1239. | 883. |

HORIZONTAL MEMBER STRESSES (PSI) PRESTRESS ONLY TOP FIBER AFTER ALL LOSSES

| | | | | | | | | | | | |
|---|------|------|-----|------|-------|-------|-------|------|-----|------|------|
| 1 | 584. | 302. | 79. | -83. | -182. | -216. | -185. | -86. | 83. | 321. | 632. |
|---|------|------|-----|------|-------|-------|-------|------|-----|------|------|

POST TENSIONING VERIFICATION PROBLEM NO 1

TRIAL 10 FRAME 1 PATH A

HORIZONTAL MEMBER MOMENTS DUE TO P/S (KIP-FT)

| MEM | NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|-----|----|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | 1 | -1115. | -4152. | -6560. | -8324. | -9425. | -9847. | -9574. | -8590. | -6877. | -4421. | -1206. |

TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE

| SPAN | LT. END | RT. END | SPAN | LT. END | RT. END | SPAN | LT. END | RT. END |
|------|-----------|----------|------|---------|---------|------|---------|---------|
| 1 | -0.002374 | 0.002416 | | | | | | |

HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE

| MEMBER | 1 | E= 3834. KSI | 0.000 | -0.036 | -0.051 | -0.037 | 0.000 |
|--------|---|--------------|-------|--------|--------|--------|-------|
| | | | | | | | |

POST TENSIONING VERIFICATION PROBLEM NO 1

TRIAL 10 FRAME 1

HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS BEFORE LOSSES BOTTOM FIBER (PSI)

| MEM | NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|-----|----|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 1 | 944. | 1344. | 1663. | 1896. | 2044. | 2103. | 2072. | 1949. | 1732. | 1420. | 1010. |

HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS BEFORE LOSSES TOP FIBER (PSI)

| | | | | | | | | | | | |
|---|------|------|-----|------|-------|-------|-------|------|-----|------|------|
| 1 | 676. | 349. | 91. | -96. | -209. | -249. | -212. | -98. | 95. | 368. | 724. |
|---|------|------|-----|------|-------|-------|-------|------|-----|------|------|

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POST TENSIONING VERIFICATION PROBLEM NO 1

TRIAL 10 FRAME 1

HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS AFTER ALL LOSSES BOTTOM FIBER (PSI)

MEM

| NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|----|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 816. | 1164. | 1441. | 1645. | 1775. | 1828. | 1803. | 1698. | 1510. | 1239. | 883. |

HORIZONTAL MEMBER STRESSES FOR ALL P/S PATHS AFTER ALL LOSSES TOP FIBER (PSI)

| | | | | | | | | | | | |
|---|------|------|-----|------|-------|-------|-------|------|-----|------|------|
| 1 | 584. | 302. | 79. | -83. | -182. | -216. | -185. | -86. | 83. | 321. | 632. |
|---|------|------|-----|------|-------|-------|-------|------|-----|------|------|

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POST TENSIONING VERIFICATION PROBLEM NO 1

TRIAL 10 FRAME 1

HORIZONTAL MEMBER STRESSES DL + P/S BEFORE ALL LOSSES BOTTOM FIBER (PSI)

MEM

| NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|----|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 944. | 1166. | 1345. | 1480. | 1567. | 1607. | 1596. | 1532. | 1415. | 1241. | 1010. |

HORIZONTAL MEMBER STRESSES DL + P/S BEFORE ALL LOSSES TOP FIBER (PSI)

| | | | | | | | | | | | |
|---|------|------|------|------|------|------|------|------|------|------|------|
| 1 | 676. | 499. | 359. | 256. | 192. | 169. | 189. | 253. | 362. | 519. | 724. |
|---|------|------|------|------|------|------|------|------|------|------|------|

POST TENSIONING VERIFICATION PROBLEM NO 1

TRIAL 10 FRAME 1

HORIZONTAL MEMBER STRESSES DL + P/S AFTER ALL LOSSES BOTTOM FIBER (PSI)

| MEM NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 816. | 985. | 1123. | 1228. | 1299. | 1332. | 1327. | 1281. | 1193. | 1061. | 883. |

HORIZONTAL MEMBER STRESSES DL + P/S AFTER ALL LOSSES TOP FIBER (PSI)

| | | | | | | | | | | | |
|---|------|------|------|------|------|------|------|------|------|------|------|
| 1 | 584. | 452. | 346. | 268. | 220. | 202. | 217. | 266. | 350. | 472. | 632. |
|---|------|------|------|------|------|------|------|------|------|------|------|

HORIZONTAL MEMBER STRESSES DL + ADDED DL + P/S AFTER ALL LOSSES BOTTOM FIBER (PSI)

| | | | | | | | | | | | |
|---|------|------|------|------|------|------|------|------|------|------|------|
| 1 | 816. | 861. | 902. | 939. | 967. | 987. | 996. | 991. | 972. | 936. | 883. |
|---|------|------|------|------|------|------|------|------|------|------|------|

HORIZONTAL MEMBER STRESSES DL + ADDED DL + P/S AFTER ALL LOSSES TOP FIBER (PSI)

| | | | | | | | | | | | |
|---|------|------|------|------|------|------|------|------|------|------|------|
| 1 | 584. | 557. | 533. | 513. | 499. | 493. | 496. | 510. | 536. | 577. | 632. |
|---|------|------|------|------|------|------|------|------|------|------|------|

POST TENSIONING VERIFICATION PROBLEM NO 1

TRIAL 10 FRAME 1

HORIZONTAL MEMBER STRESSES DL + ADDED DL + MAX POS LL + I + P/S BOTTOM FIBER (PSI)

| MEM NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|--------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 816. | 476. | 227. | 67. | 0. | 11. | 28. | 119. | 296. | 552. | 883. |

HORIZONTAL MEMBER STRESSES DL + ADDED DL + MAX POS LL + I + P/S TOP FIBER (PSI)

| | | | | | | | | | | | |
|---|------|------|-------|-------|-------|-------|-------|-------|-------|------|------|
| 1 | 584. | 881. | 1103. | 1248. | 1315. | 1316. | 1312. | 1245. | 1106. | 901. | 632. |
|---|------|------|-------|-------|-------|-------|-------|-------|-------|------|------|

HORIZONTAL MEMBER STRESSES DL + ADDED DL + MAX NEG LL + I + P/S BOTTOM FIBER (PSI)

| | | | | | | | | | | | |
|---|------|------|------|------|------|------|------|------|------|------|------|
| 1 | 816. | 861. | 902. | 939. | 967. | 987. | 996. | 991. | 972. | 936. | 883. |
|---|------|------|------|------|------|------|------|------|------|------|------|

HORIZONTAL MEMBER STRESSES DL + ADDED DL + MAX NEG LL + I + P/S FOR TOP FIBER (PSI)

| | | | | | | | | | | | |
|---|------|------|------|------|------|------|------|------|------|------|------|
| 1 | 584. | 557. | 533. | 513. | 499. | 493. | 496. | 510. | 536. | 577. | 632. |
|---|------|------|------|------|------|------|------|------|------|------|------|

**** MIN PJACK = 6290. KIPS CONC STRENGTH AT 28 DAYS = 3290. PSI AT STRESSING = 2921. PSI ****

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POST TENSIONING VERIFICATION PROBLEM NO 1

TOTAL PE MOMENTS FOR ALL MEMBERS. (KIP-FT)

MEM

| NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|----|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1 | -1115. | -4152. | -6560. | -8324. | -9425. | -9847. | -9574. | -8590. | -6877. | -4421. | -1206. |

TOTAL P/S DEFLECTION FOR TRIAL

TANGENTIAL ROTATIONS - RADIANS - CLOCKWISE POSITIVE

| SPAN | LT. END | RT. END | SPAN | LT. END | RT. END | SPAN | LT. END | RT. END |
|------|-----------|----------|------|---------|---------|------|---------|---------|
| 1 | -0.002374 | 0.002416 | | | | | | |

HORIZONTAL MEMBER DEFLECTIONS IN FEET AT 1/ 4 POINTS FROM LEFT END - DOWNWARD POSITIVE

| | | | | | | |
|----------|--------------|-------|--------|--------|--------|-------|
| MEMBER 1 | E= 3834. KSI | 0.000 | -0.036 | -0.051 | -0.037 | 0.000 |
|----------|--------------|-------|--------|--------|--------|-------|

IAI-BDS Version 4.2.4 Licensed to: Holmes & Narver, Inc. - Orange, CA Run time: 27-DEC-02 14:39:49 Page 30

POST TENSIONING VERIFICATION PROBLEM NO 1

TOTAL TOP PF FOR TRIAL (KIPS)

MEM

| NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|----|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |

TOTAL BOTTOM PF FOR TRIAL (KIPS)

| | | | | | | | | | | | |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 4765. | 4805. | 4845. | 4885. | 4924. | 4963. | 5002. | 5041. | 5079. | 5117. | 5155. |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|

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POST TENSIONING VERIFICATION PROBLEM NO 1

LONG TERM LOSSES

TOTAL LOSS (KSI) = SH + ES + CRC + CRS

| MEM NO | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|-----------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 20.9 | 22.2 | 23.9 | 25.5 | 26.8 | 27.4 | 27.3 | 26.5 | 25.2 | 23.7 | 22.7 |

SHEAR (KIPS) DESIGN - AASHTO 1980

| MEMBER: 1 | LEFT | .1 PT | .2 PT | .3 PT | .4 PT | .5 PT | .6 PT | .7 PT | .8 PT | .9 PT | RIGHT |
|----------------|-------|-------|--------|-------|-------|-------|--------|-------|-------|-------|--------|
| V-CABLE | 462. | 383. | 290. | 195. | 98. | 0. | 100. | 201. | 304. | 408. | 500. |
| SECONDARY | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| VU | 1955. | 1615. | 1272. | 944. | 651. | 395. | 651. | 944. | 1272. | 1615. | 1955. |
| VC | 1820. | 1746. | 1058. | 642. | 349. | 341. | 352. | 656. | 1094. | 1814. | 1911. |
| REQD WEB(IN) | 60. | 60. | 60. | 60. | 60. | 60. | 60. | 60. | 60. | 60. | 60. |
| AS(IN**2)/(FT) | 1.33 | 0.60 | * 1.34 | 1.54 | 1.42 | 0.60 | * 1.41 | 1.49 | 1.21 | 0.60 | * 0.99 |

NOTE: * AFTER REQD WEB INDICATES ADDITIONAL WEB WIDTH REQD. * AFTER AS(IN**2)/(FT) INDICATES MINIMUM REQD.

POST TENSIONING VERIFICATION PROBLEM NO 1
AASHTO ULTIMATE MOMENT

| | SECOND MOMENT (K-FT) | ULT MOM APPLD (K-FT) | ULT MOM P/S CAP (K-FT) | AVERAGE FSU (KSI) | NEUTRAL AXIS (IN) | MILD STEEL REQD (SQ.IN) | COMBINED REINFORCEMENT INDEX | ULT MOM MILD CAP (K-FT) | ULT MOM TOTAL CAP (K-FT) |
|-----------|----------------------------|----------------------------|------------------------------|-------------------------|-------------------------|-------------------------------|------------------------------------|-------------------------------|--------------------------------|
| MEMBER: 1 | | | | | | | | | |
| 0.0 PT. | 0. | 0. | 0. | 0.00 | 0.00 | 0.00 | 0.000 | 0. | 0. |
| 0.1 PT. | 0. | 11722. | 21991. | 249.65 | 11.20 | 0.00 | 0.199 | 0. | 21991. |
| 0.2 PT. | 0. | 20672. | 25724. | 250.83 | 11.20 | 0.00 | 0.175 | 0. | 25724. |
| 0.3 PT. | 0. | 26816. | 28412. | 251.67 | 11.20 | 0.00 | 0.161 | 0. | 28412. |
| 0.4 PT. | 0. | 30046. | 29991. | 252.07 | 11.31 | 0.21 | 0.154 | 57. | 30048. |
| 0.5 PT. | 0. | 30647. | 30521. | 252.21 | 11.34 | 0.46 | 0.152 | 128. | 30650. |
| 0.6 PT. | 0. | 30046. | 29991. | 252.07 | 11.31 | 0.21 | 0.154 | 57. | 30048. |
| 0.7 PT. | 0. | 26816. | 28412. | 251.67 | 11.20 | 0.00 | 0.161 | 0. | 28412. |
| 0.8 PT. | 0. | 20672. | 25724. | 250.83 | 11.20 | 0.00 | 0.175 | 0. | 25724. |
| 0.9 PT. | 0. | 11722. | 21991. | 249.65 | 11.20 | 0.00 | 0.199 | 0. | 21991. |
| 1.0 PT. | 0. | 0. | 0. | 0.00 | 0.00 | 0.00 | 0.000 | 0. | 0. |

TENDON ELONGATION

| PATH NO. | P-JACK (KIPS) | % JACK | FY (KSI) | AS (SQ IN) | AVE STRESS (KSI) | TENDON LENGTH (FT) * | ELONGATION (IN) |
|----------|------------------|--------|-------------|---------------|---------------------|-------------------------|--------------------|
| A | 6290. | 75. | 270. | 31.06 | 196.16 | 74.00 | 6.22 |

NOTE: TENDON LENGTH INCLUDES 4 FEET FOR JACKS.

MODULUS USED FOR P/S STEEL IS 28000. KSI

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Run time: 27-DEC-02 14:39:49 Page 33

POST TENSIONING VERIFICATION PROBLEM NO 1

'APPROXIMATE QUANTITY'

=====

| | | |
|----------------------|-----------|-------|
| ***** CONCRETE SUPER | 124 C.Y. | ***** |
| ***** CONCRETE SUB | 0 C.Y. | ***** |
| ***** P/S TRIAL | 7397 LBS. | ***** |

THE SUPERSTRUCTURE CONCRETE QUANTITY IS BASED ON THE UNIT WEIGHT OF CONCRETE SUPPLIED ON THE FRAME DESCRIPTION CARD. IT ASSUMES THAT ALL THE DEAD LOAD IS GIVEN IN TRIAL 0.

THE CONCRETE SUBSTRUCTURE QUANTITY IS BASED ON TRIAL 0 ONLY.

THE P/S QUANTITIES FOR STRAND ONLY ARE FOR EACH TRIAL, THAT WAS ENTERED AND IN THAT ORDER. STRAND USE IS BASED ON THE LENGTH FROM ANCHOR TO ANCHOR.

END OF JOB - 022086

INCREMENTED CLOCK TIME (SECONDS)= 0.

STRUCTWARE

SHEET C2-1 OF _____

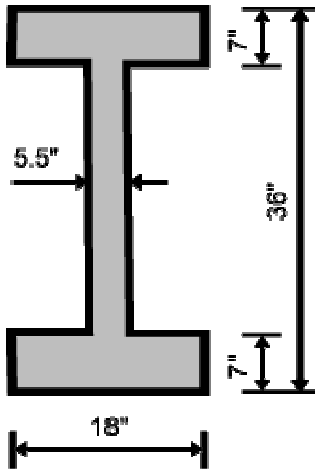
JOB TITLE PSBEAM Verification problem no. 2 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

VERIFICATION PROBLEM NO. 2

(From TY Lin, "Design of Prestressed Concrete Structures", 3rd edition, Example 7-4)

- ACI 318 Design Criteria
- Pretensioned girder



LOAD SUMMARY

| DISTANCE | LOAD | SHEAR | MOMENT | FACTOR |
|----------|--------|--------|--------|--------|
| 18" | Girder | 9.142 | 14.15 | 1.4 |
| *(30") | Live | 56.071 | 86.79 | 1.7 |
| 240" | Girder | 1.945 | 116.7 | 1.4 |
| | Live | 11.93 | 715.8 | 1.7 |

*Note: Use 30" rather than 18" from the original example problem to avoid complication from development of strands at end of girder (TY Lin example did not include any reduction for strand development but PSBEAM will calculate it automatically at ends of girder).

Beam length = 600"

- Concrete properties

$f'_c = 7000$ psi

$f'_{ci} = 5500$ psi

- Prestressing steel

Area = 2.75 in²

$f'_s = 270$ ksi (stress-rel)

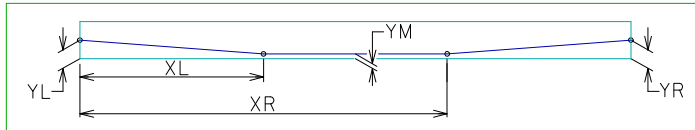
- Allowable stress and loss

Initial compression = $0.6 \times 5500 = 3300$ psi
 Initial tension = $6 \times (5500)^{1/2} = 445$ psi
 Final compression = $0.45 \times 7000 = 3150$ psi
 Final tension = $6 \times (7000)^{1/2} = 502$ psi
 Initial prestress = $0.7 \times 270 = 189$ ksi

Total prestress loss = 29 ksi
 Initial prestress loss = 13 ksi
 Pjack = $2.75 \times 189 = 519.75$ kips

- Prestress path

Two-point harped path:



XL = 240" YL = 6.12"
 XM = 300" YM = 4.5"
 XR = 360" YR = 6.12"

- Section properties

A = 373 in²
 y_{bot} = 18"
 y_{top} = 18"
 $I = 2 \times 18 \times (7)^3 / 12 + 5.5 \times (22)^3 / 12 + 2 \times 126 \times (14.5)^2 = 58892$ in⁴

STRUCTWARE

SHEET C2-3 OF _____

JOB TITLE PSBEAM Verification problem no. 2 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

- Verify shear capacity calculations by comparison with TY Lin example

| ITEM | PSBEAM | TY Lin |
|---------------------------|--------|---------------|
| shear capacity @ x = 30" | | |
| Vu = 108.1 φVn = 93.5 | | 108.1 93.2 |
| shear capacity @ x = 240" | | |
| Vu = 23.0 φVn = 20.9 | | 23.0 20.9 |

- Verify stress values at x = 240" with hand calculations

Force at transfer = $(189 - 13) \times 2.75 = 484$ kips
 Moment at transfer = $-484 \times (18 - 4.5) / 12 = -544.5$ k-ft

Final force = $(189 - 29) \times 2.75 = 440$ kips
 Final moment = $-440 \times (18 - 4.5) / 12 = -495$ k-ft

Initial P/S + Beam DL (top) = $484/373 + (116.7 - 544.5) \times 12 \times 18 / 58892 = -0.271$ ksi
 Initial P/S + Beam DL (bot) = $484/373 + (-116.7 + 544.5) \times 12 \times 18 / 58892 = 2.867$ ksi

Final P/S + Total DL (top) = $440/373 + (116.7 - 495) \times 12 \times 18 / 58892 = -0.208$ ksi
 Final P/S + Total DL (bot) = $440/373 + (-116.7 + 495) \times 12 \times 18 / 58892 = 2.567$ ksi

P/S + All loads (top) = $440/373 + (116.7 + 715.8 - 495) \times 12 \times 18 / 58892 = 2.417$ ksi
 P/S + All loads (bot) = $440/373 + (-116.7 - 715.8 + 495) \times 12 \times 18 / 58892 = -0.058$ ksi

STRUCTWARE

SHEET C2-4 OF _____

JOB TITLE PSBEAM Verification problem no. 2 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

PSBEAM Output file = ver2.out

```
* * * * *
*
*           P R O G R A M   P S B E A M
*
*           I N P U T   D A T A   E C H O
*
* * * * *
```

12/27/02, 10:37 pm

P R O G R A M O P T I O N S

=====

Units = English (inches, pounds)
Design Criteria = ACI-318
Prestressing = Pretensioning
Section Properties = Gross

M A T E R I A L P R O P E R T I E S

=====

BEAM CONCRETE

Unit weight = 0.0868
Compressive strength at 28 days = 7000.00
Compressive strength at prestressing = 5500.00
Modulus of elasticity at 28 days = 5071754.
Modulus of elasticity at prestressing = 4495630.

MILD REINFORCING

Yield strength = 60000.00
Modulus of elasticity = 29000000.

PRESTRESSING STEEL

Type = Stress relieved strand
Diameter = 0.500
Ultimate strength = 270000.00
Yield strength = 243000.00
Modulus of elasticity = 28000000.

STRUCTWARE

SHEET C2-5 OF _____

JOB TITLE PSBEAM Verification problem no. 2 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

SECTION PROPERTIES

BEAM SECTION AND DIMENSIONS

I Girder
User defined
D = 36.000
Btop = 18.000
Htop = 7.000
Bweb = 5.500
Bbot = 18.000
Hbot = 7.000
Ftop = 0.000
Fbot = 0.000

BEAM PROPERTIES

Area = 373.00
MoI = 58892.
Ytop = 18.000
Ybot = 18.000

LOADS

(Units = kip-ft)

Initial prestress force = 519.8
Number of load locations = 2

LOCATION NUMBER 1 AT X = 30

| CASE | AXIAL | SHEAR | MOMENT | FACTOR |
|---------------------|-------|-------|--------|--------|
| BEAM DEAD | 0.0 | 9.1 | 14. | 1.400 |
| NON-COMP DEAD | 0.0 | 0.0 | 0. | 0.000 |
| COMPOSITE DEAD | 0.0 | 0.0 | 0. | 0.000 |
| LIVE PLUS IMPACT | 0.0 | 56.1 | 87. | 1.700 |
| PRESTRESS | 0.0 | 0.0 | 0. | 0.000 |
| SECONDARY PRESTRESS | 0.0 | 0.0 | 0. | 0.000 |
| MISCELLANEOUS | 0.0 | 0.0 | 0. | 0.000 |

LOCATION NUMBER 2 AT X = 240

| CASE | AXIAL | SHEAR | MOMENT | FACTOR |
|---------------------|-------|-------|--------|--------|
| BEAM DEAD | 0.0 | 1.9 | 117. | 1.400 |
| NON-COMP DEAD | 0.0 | 0.0 | 0. | 0.000 |
| COMPOSITE DEAD | 0.0 | 0.0 | 0. | 0.000 |
| LIVE PLUS IMPACT | 0.0 | 11.9 | 716. | 1.700 |
| PRESTRESS | 0.0 | 0.0 | 0. | 0.000 |
| SECONDARY PRESTRESS | 0.0 | 0.0 | 0. | 0.000 |
| MISCELLANEOUS | 0.0 | 0.0 | 0. | 0.000 |

STRUCTWARE

SHEET C2-6 OF _____

JOB TITLE PSBEAM Verification problem no. 2 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

A L L O W A B L E S T R E S S A N D L O S S
=====

ALLOWABLE STRESS

Initial concrete compressive stress = 3300.
Initial concrete tensile stress = 445.
Final concrete compressive stress = 3150.
Final concrete tensile stress = 502.
Initial prestress = 189000.

PRESTRESS LOSS

Total prestress loss = 29000.
Prestress loss at time of transfer = 13000.
Anchor set = 0.000

C O N F I G U R A T I O N
=====

PRESTRESS PATH

| | | |
|---------|---------|-----------------|
| Harped | | |
| Xleft | = 240.0 | Yleft = 6.120 |
| Xmiddle | = 300.0 | Ymiddle = 4.500 |
| Xright | = 360.0 | Yright = 6.120 |

BEAM CONFIGURATION

Beam length = 600.000
Beam spacing = 60.000

STRUCTWARE

SHEET C2-8 OF _____

JOB TITLE PSBEAM Verification problem no. 2 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

LOCATION NUMBER 2 AT X = 240
 Prestress loss = 29000

| CASE | TOP FIBER | BOTTOM FIBER |
|---------------------|-----------|--------------|
| INITIAL PRESTRESS | -699. | 3295. |
| FINAL PRESTRESS | -636. | 2995. |
| SECONDARY PRESTRESS | 0. | 0. |
| BEAM DEAD | 428. | -428. |
| NON-COMP DEAD | 0. | 0. |
| COMPOSITE DEAD | 0. | 0. |
| LIVE PLUS IMPACT | 2625. | -2625. |
| INIT P/S + BEAM DL | -271. | 2867. |
| FINAL P/S + TOT DL | -208. | 2567. |
| P/S + ALL LOADS | 2417. | -58. |

CHECK CRITICAL CONCRETE STRESSES

| CASE | ACTUAL | ALLOWABLE | |
|-------------------------|--------|-----------|--------|
| TENSION (TOP FIBER) | -438. | -445. | < OK > |
| INITIAL COMPRESSION | 3033. | 3300. | < OK > |
| FINAL TENSION (DL ONLY) | 2567. | 0. | < OK > |
| FINAL TENSION | -58. | -502. | < OK > |
| FINAL COMPRESSION | 2434. | 3150. | < OK > |

S H E A R C A P A C I T Y

=====
 (Units = kip)

| X | Vult | phiVn | Av/S |
|-----|-------|-------|-------|
| 30 | 108.1 | 93.5 | 0.010 |
| 240 | 23.0 | 20.9 | 0.005 |

STRUCTWARE

SHEET C3-1 OF _____

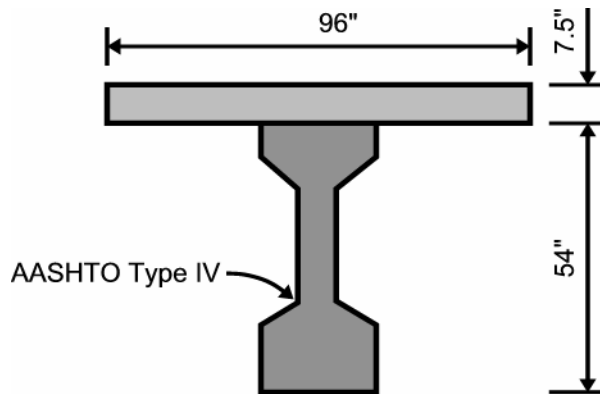
JOB TITLE PSBEAM Verification problem no. 3 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

VERIFICATION PROBLEM NO. 3

(From PCI, "Design Supplement to: Precast Prestressed Concrete Short Span Bridges", 1st edition, Example 3)

- AASHTO Design Criteria
- Pretensioned girder with composite slab
- Transformed section properties



LOAD SUMMARY

| DISTANCE | LOAD | SHEAR | MOMENT |
|----------|--------------|-------|--------|
| 450" | Girder | 0 | 578 |
| | Non-comp DL | 0 | 527 |
| | Composite DL | 0 | 241 |
| | Live | 0 | 977 |

Beam span = 900"

- Concrete properties

Girder $f'_c = 5000$ psi

Girder $f'_{ci} = 4000$ psi

Slab $f'_c = 4000$ psi

- Prestressing steel

Area = 3.672 in²

$f'_s = 270$ ksi (stress-rel)

STRUCTWARE

SHEET C3-2 OF _____

JOB TITLE PSBEAM Verification problem no. 3 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

- Allowable stress and loss

$$\text{Initial compression} = 0.6 \times 5000 = 3000 \text{ psi}$$

$$\text{Initial tension} = 3 \times (4000)^{1/2} = 190 \text{ psi}$$

$$\text{Final compression} = 0.4 \times 5000 = 2000 \text{ psi}$$

$$\text{Final tension} = 6 \times (5000)^{1/2} = 424 \text{ psi}$$

$$\text{Initial prestress} = 0.7 \times 270 = 189 \text{ ksi}$$

$$\text{Total prestress loss} = 39.6 \text{ ksi}$$

$$\text{Initial prestress loss} = 18.9 \text{ ksi}$$

$$P_{\text{jack}} = 3.672 \times 189 = 674 \text{ kips}$$

- Prestress path

$$\text{Straight path: } Y_M = 4" \text{ (distance from bottom fiber)}$$

- Gross section properties (given)

$$A = 789 \text{ in}^2$$

$$y_{\text{bot}} = 24.73"$$

$$y_{\text{top}} = 29.27"$$

$$I = 260730 \text{ in}^4$$

- Calculate transformed beam section properties

$$E_{\text{ps}} = 28000 \text{ ksi}$$

$$E_{\text{girder}} = 4286 \text{ ksi}$$

$$n = 28000 / 4286 = 6.533$$

$$A = 789 + (6.533 - 1) \times 3.672 = 809.3 \text{ in}^2$$

$$y_{\text{bot}} = (789 \times 24.73 + 20.32 \times 4) / 809.3 = 24.21"$$

$$y_{\text{top}} = 29.79"$$

$$I = 260730 + 789(0.52)^2 + 20.32(20.21)^2 = 269243 \text{ in}^4$$

- Calculate transformed composite section properties

$$E_{\text{slab}} = 3834 \text{ ksi}$$

$$n_{\text{slab}} = 3834 / 4286 = 0.894$$

$$I_o = 0.894 \times 96 (7.5)^3 / 12 = 3017 \text{ in}^4$$

$$A = 809.3 + 0.894(720) = 1453 \text{ in}^2$$

$$y_{\text{bot}} = (809.3 \times 24.21 + 644 \times 57.75) / 1453 = 39.08 \text{ in}$$

$$y_{\text{top}} = 22.42 \text{ in}$$

$$I = 269243 + 809.3 (14.87)^2 + 3017 + 644 (18.67)^2 = 675688 \text{ in}^4$$

STRUCTWARE

SHEET C3-3 OF _____

JOB TITLE PSBEAM Verification problem no. 3 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

- Verify stress values with hand calculations

$$\text{Force at transfer} = (189 - 18.9) \times 3.672 = 624.6 \text{ kips}$$

$$\text{Moment at transfer} = -624.6 \times (24.21 - 4) / 12 = -1051.9 \text{ k-ft}$$

$$\text{Final force} = (189 - 39.6) \times 3.672 = 548.6 \text{ kips}$$

$$\text{Final moment} = -548.6 \times (24.21 - 4) / 12 = -923.9 \text{ k-ft}$$

$$\text{Initial P/S + Beam DL (top)} = 624.6/809.3 + (578 - 1051.9) \times 12 \times 29.79 / 269243 = 0.143 \text{ ksi}$$

$$\text{Initial P/S + Beam DL (bot)} = 624.6/809.3 + (-578 + 1051.9) \times 12 \times 24.21 / 269243 = 1.283 \text{ ksi}$$

$$\text{Final P/S + Total DL (top)} = 548.6/809.3 + (1105 - 923.9) \times 12 \times 29.79 / 269243 + 241 \times 12 \times 14.92 / 675688 = 0.982 \text{ ksi}$$

$$\text{Final P/S + Total DL (bot)} = 548.6/809.3 + (-1105 + 923.9) \times 12 \times 24.21 / 269243 - 241 \times 12 \times 39.08 / 675688 = 0.315 \text{ ksi}$$

$$\text{Final P/S + All loads (top)} = 548.6/809.3 + (1105 - 923.9) \times 12 \times 29.79 / 269243 + 1218 \times 12 \times 14.92 / 675688 = 1.241 \text{ ksi}$$

$$\text{Final P/S + All loads (bot)} = 548.6/809.3 + (-1105 + 923.9) \times 12 \times 24.21 / 269243 - 1218 \times 12 \times 39.08 / 675688 = -0.363 \text{ ksi}$$

$$\text{LL + (P/S + Total DL)/2 (top)} = 0.982 / 2 + 977 \times 12 \times 14.92 / 675688 = 0.750 \text{ ksi}$$

STRUCTWARE

SHEET C3-4 OF _____

JOB TITLE PSBEAM Verification problem no. 3 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

PSBEAM Output file = ver3.out

```
* * * * *
*
*           P R O G R A M   P S B E A M
*
*           I N P U T   D A T A   E C H O
*
* * * * *
```

12/28/02, 11:48 am

P R O G R A M O P T I O N S

=====

Units = English (inches, pounds)
Design Criteria = AASHTO
Prestressing = Pretensioning
Section Properties = Transformed

M A T E R I A L P R O P E R T I E S

=====

BEAM CONCRETE

Unit weight = 0.0868
Compressive strength at 28 days = 5000.00
Compressive strength at prestressing = 4000.00
Modulus of elasticity at 28 days = 4286415.
Modulus of elasticity at prestressing = 3833886.

SLAB CONCRETE

Unit weight = 0.0868
Compressive strength at 28 days = 4000.00
Modulus of elasticity at 28 days = 3833886.

MILD REINFORCING

Yield strength = 60000.00
Modulus of elasticity = 29000000.

PRESTRESSING STEEL

Type = Stress relieved strand
Diameter = 0.500
Ultimate strength = 270000.00
Yield strength = 243000.00
Modulus of elasticity = 28000000.

STRUCTWARE

SHEET C3-5 OF _____

JOB TITLE PSBEAM Verification problem no. 3 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

SECTION PROPERTIES

BEAM SECTION AND DIMENSIONS

I Girder
AASHTO d = 54
D = 54.000
Btop = 20.000
Htop = 8.000
Bweb = 8.000
Bbot = 26.000
Hbot = 8.000
Ftop = 6.000
Fbot = 9.000

BEAM PROPERTIES

Area = 789.00
MoI = 260730.
Ytop = 29.270
Ybot = 24.730

LOADS

(Units = kip-ft)

Initial prestress force = 694.0
Number of load locations = 1

LOCATION NUMBER 1 AT X = 450

| CASE | AXIAL | SHEAR | MOMENT | FACTOR |
|---------------------|-------|-------|--------|--------|
| BEAM DEAD | 0.0 | 0.0 | 578. | 1.300 |
| NON-COMP DEAD | 0.0 | 0.0 | 527. | 1.300 |
| COMPOSITE DEAD | 0.0 | 0.0 | 241. | 1.300 |
| LIVE PLUS IMPACT | 0.0 | 0.0 | 977. | 2.170 |
| PRESTRESS | 0.0 | 0.0 | 0. | 0.000 |
| SECONDARY PRESTRESS | 0.0 | 0.0 | 0. | 0.000 |
| MISCELLANEOUS | 0.0 | 0.0 | 0. | 0.000 |

ALLOWABLE STRESS AND LOSS

ALLOWABLE STRESS

Initial concrete compressive stress = 2400.
Initial concrete tensile stress = 190.
Final concrete compressive stress = 2000.
Final concrete tensile stress = 424.
Initial prestress = 189000.

STRUCTWARE

SHEET C3-6 OF _____JOB TITLE PSBEAM Verification problem no. 3 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

PRESTRESS LOSS

Total prestress loss = 39600.
Prestress loss at time of transfer = 18900.
Anchor set = 0.000

C O N F I G U R A T I O N

=====

PRESTRESS PATH

| | | |
|----------|-------|-----------------|
| Straight | | |
| Xleft | = 0.0 | Yleft = 0.000 |
| Xmiddle | = 0.0 | Ymiddle = 4.000 |
| Xright | = 0.0 | Yright = 0.000 |

BEAM CONFIGURATION

Beam length = 900.000
Beam spacing = 96.000

SLAB CONFIGURATION

Slab thickness = 7.500
Effective width = 96.000
Cross slope = 0.000
Average haunch depth = 0.000

```
* * * * *
*
*           P R O G R A M   P S B E A M
*
*           O U T P U T   D A T A
*
* * * * *
```

C O M P O S I T E P R O P E R T I E S

=====

Area = 1433.
MoI = 650353.
Ytop = 21.93
Ybot = 39.57

STRUCTWARE

SHEET C3-7 OF _____JOB TITLE PSBEAM Verification problem no. 3 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. _____ CALCULATION No. _____ REVIEWER _____ DATE _____

TRANSFORMED PROPERTIES

=====

LOCATION NUMBER 1 AT X = 450
P/S STEEL LOCATED AT 4.00 FROM BOTTOM FIBER

| ITEM | BEAM | COMPOSITE |
|------|---------|-----------|
| Area | 809. | 1453. |
| MoI | 269241. | 675694. |
| Ytop | 29.79 | 22.43 |
| Ybot | 24.21 | 39.07 |

PRESTRESS FORCES

=====

(Units = kip-ft)

LOCATION NUMBER 1 AT X = 450

| CASE | VALUE |
|--------------------|--------|
| INITIAL FORCE | 694.0 |
| CABLE ECCENTRICITY | -20.21 |
| FORCE AT TRANSFER | 624.6 |
| MOMENT AT TRANSFER | -1052. |
| FINAL FORCE | 548.6 |
| FINAL MOMENT | -924. |

BEAM STRESSES

=====

LOCATION NUMBER 1 AT X = 450
Prestress loss = 39600

| CASE | TOP FIBER | BOTTOM FIBER |
|---------------------|-----------|--------------|
| INITIAL PRESTRESS | -625. | 1907. |
| FINAL PRESTRESS | -549. | 1675. |
| SECONDARY PRESTRESS | 0. | 0. |
| BEAM DEAD | 767. | -624. |
| NON-COMP DEAD | 700. | -569. |
| COMPOSITE DEAD | 64. | -167. |
| LIVE PLUS IMPACT | 259. | -678. |
| INIT P/S + BEAM DL | 143. | 1283. |
| FINAL P/S + TOT DL | 982. | 315. |
| LL + (P/S + DL)/2 | 750. | -520. |
| P/S + ALL LOADS | 1241. | -363. |

STRUCTWARE

SHEET **C3-8** OF

JOB TITLE PSBEAM Verification problem no. 3 ORIGINATOR Bob Matthews DATE 12/30/2005

JOB No. CALCULATION No. REVIEWER DATE

CHECK CRITICAL CONCRETE STRESSES

| CASE | ACTUAL | ALLOWABLE | |
|--------------------------|--------|-----------|--------|
| TENSION (TOP FIBER) | 143. | -190. | < OK > |
| INITIAL COMPRESSION | 1283. | 2400. | < OK > |
| FINAL TENSION (DL ONLY) | 315. | 0. | < OK > |
| COMP @ (LL + [PS+DL])/2) | 750. | 2000. | < OK > |
| FINAL TENSION | -363. | -424. | < OK > |
| FINAL COMPRESSION | 1241. | 2000. | < OK > |