DOCUMENTATION FOR

POST-TENSION SPREADSHEET PROGRAM

BY
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DESCRIPTION AND SCOPE OF POST-TENSION SPREADSHEET PROGRAM


THE ULTIMATE BEAM SHEAR PORTION OF THIS PROGRAM FIRST DETERMINES THE REQUIREMENT FOR SHEAR REINFORCEMENT, IF ANY, FOR THE SECTION IN QUESTION. WITH THE EXCEPTION OF dp, SECTION PROPERTIES ARE DERIVED FROM THE APPLICABLE INPUT PARAMETERS FROM
BOTH THE SERVICE STRESS AND ULTIMATE MOMENT PORTIONS OF THE PROGRAM. THE USER IS ABLE TO DETERMINE THE SHEAR REINFORCING REQUIREMENTS AT SIX DIFFERENT SPAN LOCATIONS SIMULTANEOUSLY BY INPUTTING THE CORRESPONDING VALUES OF Vu, Mu AND dp FOR THE SEPARATE SPAN LOCATIONS UNDER CONSIDERATION. THE PROGRAM RESPONDS BY DISPLAYING IF SHEAR REINFORCEMENT IS REQUIRED, IF MINIMUM SHEAR REINFORCEMENT IS REQUIRED OR IF NO STIRRUPS ARE REQUIRED. THE USER THEN INPUTS THE BAR SIZE DESIRED AT EACH SPAN LOCATION AND THE PROGRAM RESPONDS BY DISPLAYING THE STIRRUP SPACING REQUIRED TO SATISFY THE ACI CODE BASED ON A fy OF 60 ksi. THE STIRRUP TYPE ASSUMED BY THE PROGRAM IN CALCULATING THE SPACING REQUIREMENTS IS DISPLAYED GRAPHICALLY ON THE SPREAD SHEET SCREEN AND INCLUDES ONLY TWO VERTICAL LEGS OF THE BAR SIZE INPUT AT EACH STIRRUP LOCATION. THE SCREEN ALSO DISPLAYS MINIMUM STIRRUP SPACING AND MINIMUM Av REQUIRED BY CODE. IN ADDITION, SUPPLEMENTAL VARIABLES USED IN THE SHEAR ANALYSIS CALCULATIONS ARE DISPLAYED FOR REFERENCE PURPOSES ONLY. THESE INCLUDE Vc, Vs AND PhiVn AS DEFINED BY ACI 318-83.

DESIGN ASSUMPTIONS

THE FOLLOWING DESIGN ASSUMPTIONS PROVIDE THE BASIS FOR THE ABILITY OF
THE USER TO SUCCESSFULLY USE THE POST-TENSIONED SPREADSHEET PROGRAM.

IT IS ASSUMED THAT THE USER HAS ACCESS TO A FRAME ANALYSIS PROGRAM IN
ORDER TO PROVIDE MAXIMUM POSITIVE AND NEGATIVE MOMENTS AS WELL AS SHEAR
AND MOMENT VALUES AT TENTH POINTS ALONG THE LENGTH OF THE FRAME MEMBERS
FOR BOTH GRAVITY AND BALANCING LOADS. IN ADDITION, MAXIMUM NEGATIVE MOMENT
VALUES, IF APPLICABLE, SHOULD BE REDUCED TO THE FACE OF THE SUPPORTING MEMBER.

THE USER SHOULD ALSO HAVE AN UNDERSTANDING OF THE LOAD-BALANCING METHOD OF
POST-TENSIONING ANALYSIS. BALANCING LOADS USED IN THE FRAME ANALYSIS OF THE
STRUCTURE SHOULD BE INPUT AS UNITY, i.e. FOR ONE STRAND.

THE USER SHOULD HAVE AN UNDERSTANDING OF THE SEPARATE CALCULATIONS REQUIRED
TO DETERMINE ALL POST-TENSIONING LOSSES. THIS WOULD INCLUDE FRICTION AND
WEDGESET LOSSES AS WELL AS OTHER LONG- AND SHORT-TERM PRESTRESS LOSSES
SUCH AS ELASTIC SHORTENING, CREEP AND SHRINKAGE OF CONCRETE AND RELAXATION
OF TENDON STRESS. THE USER MUST ALSO BE ABLE TO DETERMINE THE VERTICAL STRAND
POSITION WITHIN THE BEAM OR SLAB DUE TO THE PARABOLIC DRAPE NECESSARY TO
IMPART THE LOAD-BALANCING EFFECT OF THE POST-TENSIONING STRAND.

SEPARATE CALCULATIONS ARE ALSO REQUIRED TO DETERMINE THE SECTIONAL PROPERTIES
OF EACH MEMBER TO BE DESIGNED. THIS WOULD INCLUDE $S_d, S_t, A_g, h, y_b$ AND $y_t$.

FINALLY, THE USER SHOULD HAVE ACCESS TO THE THIRD EDITION OF THE PCI DESIGN
HANDBOOK IN ORDER TO UNDERSTAND THE TORSIONAL SECTION PROPERTIES REQUIRED
FOR INPUT FOR A COMBINED SHEAR/TORSION ANALYSIS.
DESIGN METHODOLOGY AND APPROACH

THE FORMAT AND SEQUENCE OF THIS PROGRAM HAVE BEEN BASED ON DESIGN EXPERIENCE DERIVED FROM MANUAL CALCULATIONS AND ANALYSES FOR A VARIETY OF POST-TENSIONED STRUCTURES AND MEMBERS I HAVE ENCOUNTERED DURING MY CAREER AS A STAFF AND PROJECT ENGINEER AT ROSS BRYAN ASSOCIATES INCORPORATED. BECAUSE OUR FIRM TYPICALLY HAS BEEN INVOLVED WITH THE DESIGN AND OR ANALYSIS OF ATYPICAL STRUCTURES, IT HAS BEEN OUR EXPERIENCE THAT CANNED PROGRAMS AVAILABLE ON THE MARKET TODAY FOR THE DESIGN OF POST-TENSIONED STRUCTURAL FRAMES ARE NOT FLEXIBLE ENOUGH TO ENABLE ADEQUATE ANALYSIS OF THE WIDE RANGE OF FRAMING CONDITIONS ENCOUNTERED.


TYPICALLY THE NUMBER OF STRANDS REQUIRED TO SATISFY ALLOWABLE SERVICE STRESS LEVELS CONTROLS POST-TENSIONED DESIGN. BECAUSE OF THIS FACT, THE PROGRAM FIRST DETERMINES THE NUMBER OF POST-TENSIONING STRANDS REQUIRED BASED ON THE INITIAL DATA INPUT. THE NEXT AREA OF DESIGN CONCERN THAT TYPICALLY IS ESTABLISHED DURING POST-TENSIONED ANALYSIS IS THE ULTIMATE MOMENT STRENGTH OF THE SECTION UNDER INVESTIGATION. THE SECOND PORTION OR SCREEN OF THE PROGRAM DEALS WITH THE ULTIMATE MOMENT STRENGTH OF MEMBERS REINFORCED WITH UNBONDED POST-TENSIONING TENDONS. THE ANALYSIS OF BONDED POST-TENSIONING SYSTEMS IS NOT INCLUDED AS A PORTION OF THIS PROGRAM BECAUSE THE MAJORITY OF POST-TENSIONED STRUCTURES CONSTRUCTED IN THIS COUNTRY USE UNBONDED STRAND. THE USE OF BONDED STRAND IS TYPICALLY RESTRICTED TO LARGE TRANSFER GIRDER OR MEMBERS EXPOSED TO CORROSIVE OR EXTREME ENVIRONMENTS, THE FREQUENCY OF WHICH DID NOT JUSTIFY THE INCORPORATION OF THIS SEPARATE TYPE OF ANALYSIS INTO THE PROGRAM. THE SERVICE STRESS AND ULTIMATE MOMENT STRENGTH PORTIONS OF THE PROGRAM WERE DEVELOPED TO INCORPORATE ANALYSIS AT ONLY ONE SPAN LOCATION AT A TIME. THIS RESTRICTION IS DUE TO THE INSUFFICIENT SPACE AVAILABLE ON THE SCREEN MONITOR; HOWEVER THIS IS MORE THAN COMPENSATED FOR BY THE FLEXIBILITY OF THE SPREADSHEET FORMAT AS INDICATED ABOVE.

ULTIMATE SHEAR CAPACITY OF TWO-WAY FLAT PLATE FRAMES IS NOT INCLUDED AS A PORTION OF THIS PROGRAM DUE TO THE COMPLEXITIES OF THE ANALYSIS FOR SUCH A STRUCTURAL SYSTEM.


WITH A FEW EXCEPTIONS, THE DESIGN REQUIREMENTS FOR THE SHEAR/TORSION ANALYSIS SECTION OF THE PROGRAM UTILIZE THE COMPRESSION FIELD THEORY PROCEDURES PROVIDED IN THE THIRD EDITION OF THE PCI DESIGN HANDBOOK. DESIGN PROCEDURES IN ALL OTHER SUBSECTIONS OF THE PROGRAM (SERVICE STRESS AND ULTIMATE MOMENT AND SHEAR ANALYSIS) ADHERE TO THE REQUIREMENTS OF ACI 318-83. THE EXCEPTION TO THIS WOULD BE THE MAXIMUM ALLOWABLE SERVICE TENSILE STRESS AT THE EXTREME TENSION FIBER OF THE SECTION IN REVIEW. THE ACI CODE SPECIFIES A VALUE OF $6\times(f'c)^{1/2}$ WHILE THIS PROGRAM USES A LIMIT OF $7.5\times(f'c)^{1/2}$, THE RUPTURE MODULUS OF THE CONCRETE.
PROGRAM LIMITATIONS

Most of the program limitations are a result of the limits of not only spreadsheet programming but also the size of the screen page available for viewing on the computer terminal.

The spreadsheet programming language used for the development of this program did not provide for the use of for-next loops. Because of this, if-then-else statements provided the bulk of the decision-making process in the design logic of the program. The size of individual cells used for if-then-else statements also limited the complexity of any particular design calculation. For this reason, independent variables used in design calculations are often determined in a portion of the spreadsheet not normally viewed during the use of the program. These isolated cells of calculations are then simply referred to by their spreadsheet address for cell calculations that result in displays within the main screen portions of the program, i.e. cells A0 through J114. Other than the cell audit list file which is provided as a portion of the program documentation, there is no discussion of the isolated cells used for the calculation of the referenced independent variables.

As with any spreadsheet program, error messages may appear on the screen until all appropriate data is input for a particular member to be designed.

Other program design limitations have been previously mentioned and elaborated on in the program output and scope documentation. This would include no design provisions for bonded post-tensioning strand or the shear analysis for slab sections.
### DESCRIPTION OF INPUT PARAMETERS

**SCREEN REFERENCE**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>REFERENCE CODE:</strong></td>
</tr>
<tr>
<td><strong>SPAN (ft)=</strong></td>
</tr>
<tr>
<td><strong>Sb (in³)=</strong></td>
</tr>
<tr>
<td><strong>St (in³)=</strong></td>
</tr>
<tr>
<td><strong>Ag (in²)=</strong></td>
</tr>
<tr>
<td><strong>h (in)=</strong></td>
</tr>
<tr>
<td><strong>yb (in)=</strong></td>
</tr>
<tr>
<td><strong>yt (in)=</strong></td>
</tr>
<tr>
<td><strong>Ms (KF)=</strong></td>
</tr>
<tr>
<td><strong>MsDLi(KF)=</strong></td>
</tr>
<tr>
<td><strong>f'c(psi)=</strong></td>
</tr>
<tr>
<td><strong>f'ci(psi)=</strong></td>
</tr>
<tr>
<td><strong>Mb (KF)=</strong></td>
</tr>
<tr>
<td><strong>P/T(kips)=</strong></td>
</tr>
<tr>
<td><strong>Aps (in²)=</strong></td>
</tr>
</tbody>
</table>

**SPREADSHEET SECTION: POST-TENSION SERVICE STRESS**

- **REFERENCE CODE:** Beam Mark Number or Span Location Reference Information.
- **SPAN (ft)=** Length of span in feet under investigation.
- **Sb (in³)=** Section modulus with respect to bottom of member.
- **St (in³)=** Section modulus with respect to top of member.
- **Ag (in²)=** Total cross-sectional area of member including any slab located on either side of the beam in question with respect to one-half the clear distance to the next adjacent beam. This value may or may not coincide with the cross-sectional value used in calculating other sectional properties such as Sb, St, yb and yt.
- **h (in)=** Total depth or thickness of member.
- **yb (in)=** Distance from centroidal axis of member to extreme bottom fiber of section.
- **yt (in)=** Distance from centroidal axis of member to extreme top fiber of section.
- **Ms (KF)=** Total service moment in kip-feet at span location under investigation. Input positive value for positive moment region or negative value for negative moment region.
- **MsDLi(KF)=** Initial service dead load portion of total moment in kip-feet under investigation. Input positive value for positive moment region or negative value for negative moment region. Include only those loads present at the time of stress transfer.
- **f'c(psi)=** Specified 28-day compressive strength of concrete.
- **f'ci(psi)=** Compressive strength of concrete at time of initial stress transfer.
- **Mb (KF)=** Balancing load moment in kip-feet for one strand at same span location under investigation for total service moment. Typically value will be negative at positive service moment regions or positive at negative service moment regions.
- **P/T(kips)=** Effective post-tensioning force for one strand at span location in question. Value to include all losses as described in ACI 318-83 (18.6).
- **Aps (in²)=** Cross-sectional area of one strand.
INITIAL LOSSES(%) = LOSS OF POST-TENSIONING FORCE BEFORE TIME-DEPENDENT LOSSES. INITIAL ELASTIC SHORTENING AND TENDON RELAXATION WOULD BE EXAMPLES OF ANTICIPATED LOSSES TO BE EXPECTED.

LONGTERM LOSSES(K) = TOTAL LOSSES AS DESCRibED IN ACI 318-83 (18.6) IN KIPS.

DESIRED NO# OF STRANDS = INPUT TOTAL NUMBER OF STRANDS DESIRED USING NUMBER OF STRANDS "REQ'D AND P/A OUTPUT AS GUIDELINES.

SPREADSHEET SECTION: UNBONDED ULTIMATE STRENGTH

ONE-WAY BM/SLAB = INDICATES STRUCTURE TYPE. 0 = NO; 1 = YES

TWO-WAY PLATE = INDICATES STRUCTURE TYPE. 0 = NO; 1 = YES

ULTIMATE LOAD FACTOR = RATIO OF TOTAL ULTIMATE MOMENT TO TOTAL SERVICE MOMENT AT SPAN LOCATION UNDER INVESTIGATION.

bw(in) = WEB WIDTH FOR BEAMS, PANEL WIDTH FOR SLABS.

bf(in) = WIDTH OF EFFECTIVE T-BEAM FLANGE, WIDTH OF RECTANGULAR BEAM OR PANEL WIDTH FOR SLABS.

dp(in) = DISTANCE FROM EXTREME FIBER IN COMPRESSION TO CENTROID OF POST-TENSIONING STRAND.

d (in) = DISTANCE FROM EXTREME FIBER IN COMPRESSION TO CENTROID OF CONVENTIONAL TENSION REINFORCEMENT.

e (in) = DISTANCE BETWEEN CENTROIDAL AXIS OF MEMBER AND CENTROID OF POST-TENSIONING STRAND. INPUT ABSOLUTE VALUE OF STRAND ECCENTRICITY.

hf(in) = THICKNESS OF FLANGE FOR T-BEAM SECTION. INPUT VALUE OF ZERO FOR RECTANGULAR BEAMS AND SLAB SECTIONS. INPUTTING A VALUE EQUAL TO h FOR RECTANGULAR BEAMS AND SLABS WILL RESULT IN OUTPUT DATA FOR REINFORCING RATIOS.

DESIRED REINF. As(in2) = INPUT DESIRED TOTAL AREA OF CONVENTIONAL TENSION REINFORCING AT fy OF 60 ksi.

SPREADSHEET SECTION: ULTIMATE BEAM SHEAR ANALYSIS

DISTANCE = DIMENSIONAL REFERENCE INFORMATION. DISTANCE FROM LEFT OR RIGHT SUPPORT POINT TO SPAN LOCATION UNDER INVESTIGATION.

Vu(kips) = FACTORED TOTAL ULTIMATE SHEAR FORCE AT SPAN LOCATION UNDER CONSIDERATION.

Mu(KF) = FACTORED TOTAL ULTIMATE MOMENT IN KIP-FEET AT SPAN LOCATION CORRESPONDING TO Vu UNDER CONSIDERATION. INPUT NEGATIVE OR POSITIVE VALUE FOR REFERENCE ONLY.

dp(in) = DISTANCE FROM EXTREME FIBER IN COMPRESSION TO CENTROID OF POST-TENSIONING STRAND AT SPAN LOCATION CORRESPONDING
TO Vu UNDER CONSIDERATION.

BAR SIZE

ASTM STANDARD REINFORCING BAR SIZE. INPUT RANGE; #3-#6.

SPREADSHEET SECTION: ULTIMATE BEAM SHEAR/TORSION ANALYSIS

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISTANCE</td>
<td>DIMENSIONAL REFERENCE INFORMATION. DISTANCE FROM LEFT OR RIGHT SUPPORT POINT TO SPAN LOCATION UNDER INVESTIGATION.</td>
</tr>
<tr>
<td>Vu(kips)</td>
<td>FACTORED TOTAL ULTIMATE SHEAR FORCE AT SPAN LOCATION UNDER CONSIDERATION.</td>
</tr>
<tr>
<td>Ms(KF)</td>
<td>TOTAL SERVICE MOMENT IN KIP-FEET AT THE SPAN LOCATION CORRESPONDING TO Vu UNDER CONSIDERATION. INPUT POSITIVE VALUE FOR POSITIVE MOMENT REGION OR NEGATIVE VALUE FOR NEGATIVE MOMENT REGION.</td>
</tr>
<tr>
<td>Tu(KF)</td>
<td>FACTORED TOTAL ULTIMATE TORSIONAL MOMENT IN KIP-FEET AT THE SPAN LOCATION CORRESPONDING TO Vu UNDER INVESTIGATION.</td>
</tr>
<tr>
<td>Mb(KF)</td>
<td>THE TOTAL BALANCING LOAD MOMENT IN KIP-FEET AT THE SPAN LOCATION CORRESPONDING TO Vu UNDER INVESTIGATION.</td>
</tr>
<tr>
<td>Ac(in²)</td>
<td>THE AREA ENCLOSED BY THE PERIMETER OF THE CONCRETE CROSS SECTION AS DEFINED BY Pc. THIS GROSS AREA SHOULD INCLUDE THE AREA OF ANY ENCLOSED Voids.</td>
</tr>
<tr>
<td>Pc(in)</td>
<td>THE OUTSIDE PERIMETER OF THE CONCRETE CROSS SECTION. FOR T-BEAM SECTIONS THIS IS AS DEFINED IN ACI 318-83 (11.6.1).</td>
</tr>
<tr>
<td>bv(in)</td>
<td>THE MINIMUM EFFECTIVE WEB WIDTH WITHIN DEPTH dv. THIS VALUE ASSUMES SPALLING OF THE UNRESTRAINED CONCRETE COVER AS SHOWN IN Fig. 4.4.1 OF THE PCI DESIGN HANDBOOK, THIRD EDITION.</td>
</tr>
<tr>
<td>dv(in)</td>
<td>EFFECTIVE SHEAR DEPTH EQUAL TO THE VERTICAL DISTANCE BETWEEN THE CENTERS OF THE LONGITUDINAL BARS IN THE CORNERS OF THE CLOSED BEAM STIRRUPS. SEE Fig. 4.4.1 OF THE PCI DESIGN HANDBOOK.</td>
</tr>
<tr>
<td>dp(in)</td>
<td>DISTANCE FROM EXTREME FIBER IN COMPRESSION TO CENTROID OF POST-TENSIONING STRAND AT THE SPAN LOCATION CORRESPONDING TO Vu UNDER CONSIDERATION.</td>
</tr>
<tr>
<td>e(in)</td>
<td>DISTANCE BETWEEN CENTROIDAL AXIS OF MEMBER AND CENTROID OF POST-TENSIONING STRAND. INPUT ABSOLUTE VALUE OF STRAND ECCENTRICITY.</td>
</tr>
<tr>
<td>Vp(kips)</td>
<td>VERTICAL COMPONENT OF THE EFFECTIVE POST-TENSIONING FORCE AT THE SPAN LOCATION CORRESPONDING TO Vu IN CONSIDERATION.</td>
</tr>
<tr>
<td>As(in²)</td>
<td>INPUT THE TOTAL AREA OF CONVENTIONAL TENSION REINFORCING PROVIDED AT THE CORRESPONDING SPAN LOCATION OF Vu UNDER INVESTIGATION.</td>
</tr>
</tbody>
</table>
d (in)  
DISTANCE FROM EXTREME FIBER IN COMPRESSION TO CENTROID OF CONVENTIONAL TENSION REINFORCING AT THE SPAN LOCATION CORRESPONDING TO Vu UNDER CONSIDERATION.

BAR SIZE  
ASTM STANDARD REINFORCING BAR SIZE. INPUT RANGE; #3 - #6.

BAR TYPE  
INPUT A, B OR C. TYPE A; SINGLE STIRRUP LEG CONTINUOUS AROUND PERIMETER OF BEAM SECTION.
TYPE B; SINGLE STIRRUP LEG CONTINUOUS AROUND PERIMETER OF BEAM SECTION WITH TWO ADDITIONAL INTERIOR VERTICAL STIRRUP LEGS FOR SHEAR CAPACITY ONLY.
TYPE C; DOUBLE STIRRUP LEGS CONTINUOUS AROUND PERIMETER OF BEAM SECTION WITH TWO ADDITIONAL INTERIOR STIRRUP LEGS FOR SHEAR CAPACITY ONLY.
DESCRIPTION OF OUTPUT

SCREEN REFERENCE

(DISCUSION AND MATHEMATICAL FORMULAS)

SPREADSHEET SECTION: POST-TENSION SERVICE STRESS

NUMBER OF STRANDS REQ'D = THE NUMBER OF STRANDS REQUIRED TO PROVIDE A NET TENSILE STRESS EQUAL TO THE RUPTURE MODULUS OF THE SPECIFIED CONCRETE STRENGTH AT THE TENSION FACE OF THE SECTION IN QUESTION.

= \((\text{M} - \text{St} \times 7.5 \times f'c) / \sqrt{2} / (\text{M} \times 12 + (\text{St} \times \text{Fp}) / \text{Ag})\)

WHERE: \text{St} = SECTION MODULUS WITH RESPECT TO THE FLEXURAL TENSION FACE OF SECTION.
\text{Fp} = EFFECTIVE POST-TENSIONING FORCE; \text{P/T}.

fa(P/A) (psi) = THE EFFECTIVE COMPRESSIVE STRESS OF THE SECTION DUE TO THE AXIAL LOADING THAT RESULTS FROM THE POST-TENSION COMPRESSION FORCE AT SERVICE LOADS.

= \text{Fp} / \text{Ag}

WHERE: \text{Fp} = EFFECTIVE POST-TENSION FORCE; \text{P/T}.

NOTE: THE PROGRAM ALSO DISPLAYS THE MINIMUM ALLOWABLE 'P/A' SPECIFIED BY ACI 318-83 (18.12.4). THE USER SHOULD REFER TO SECTION (7.12.3.1) OF THE ACI CODE FOR SECTIONS WHERE SHRINKAGE AND TEMPERATURE REQUIREMENTS CONTROL HOWEVER.

STRESS AT fb (psi) = THE ACTUAL SERVICE AND INITIAL STRESS LEVELS AT THE EXTREME BOTTOM FIBER OF THE SECTION IN QUESTION BASED ON THE DESIRED NUMBER OF STRANDS INPUT. THE SERVICE STRESS VALUE SHOULD BE COMPARED TO THE APPROPRIATE ALLOWABLE STRESS LEVEL TO VERIFY THAT THE NUMBER OF STRANDS INPUT IS ADEQUATE. THE INITIAL STRESS VALUE CALCULATED IS AUTOMATICALLY COMPARED TO THE APPROPRIATE ALLOWABLE STRESS VALUES THAT EXCEED THE ALLOWABLE WILL PROMPT A SCREEN DISPLAY INDICATING EITHER THE BONDED AUXILIARY TENSILE REINFORCEMENT REQUIRED AS PER ACI 318-83 (18.4.1) OR THE MINIMUM f'c'i REQUIRED TO SATISFY THE SAME REFERENCED CODE SECTION.

SERVICE = \((\text{DNS} \times \text{Fp} \times 1000) / \text{Ag}) - (\text{M} \times 12000) / \text{Sb}) - (\text{Mb} \times \text{DNS} \times 12000) / \text{Sb})

INITIAL = (\text{DNS} \times (\text{Fp} \times \text{LTL}) \times (1 - (\text{IL} / 100)) \times (1000 / \text{Ag})) - ((\text{MsDLi} \times 12000) / \text{Sb}) - (\text{Mb} \times ((\text{Fp} \times \text{LTL}) / \text{Fp}) \times (1 - (\text{IL} / 100))) \times \text{DNS} \times 12000 / \text{Sb})

WHERE: DNS = DESIRED NUMBER OF STRANDS INPUT.
\text{Fp} = EFFECTIVE POST-TENSIONING FORCE; \text{P/T}.
STRESS AT ft (psi) = THE ACTUAL SERVICE AND INITIAL STRESS LEVELS AT THE EXTREME TOP FIBER OF THE SECTION IN QUESTION BASED ON THE DESIRED NUMBER OF STRANDS INPUT. THE SERVICE STRESS VALUE SHOULD BE COMPARED TO THE APPROPRIATE ALLOWABLE STRESS LEVEL TO VERIFY THAT THE NUMBER OF STRANDS INPUT IS ADEQUATE. THE INITIAL STRESS VALUE CALCULATED IS AUTOMATICALLY COMPARED TO THE APPROPRIATE ALLOWABLE STRESS. VALUES THAT EXCEED THE ALLOWABLE WILL PROMPT A SCREEN DISPLAY INDICATING EITHER THE BONDED AUXILIARY TENSILE REINFORCEMENT REQUIRED AS PER ACI 318-83 (18.4.1) OR THE MINIMUM f'ci REQUIRED TO SATISFY THE SAME REFERENCED CODE SECTION.

\[
\text{SERVICE} = \left(\frac{(DNS\times F_p\times 1000)}{Ag}\right) + \left(\frac{(Ms\times 12000)}{St}\right) + \left(\frac{(Mb\times DNS\times 12000)}{St}\right)
\]

\[
\text{INITIAL} = \left(\frac{DNS\times (F_p+LTL)\times (1-(IL/100))\times (1000/Ag)}{(MsDLi\times 12000)/St}\right) + \left(\frac{Mb\times ((F_p+LTL)/F_p)\times (1-(IL/100))}{DNS\times 12000/Sp}\right)
\]

WHERE: DNS = DESIRED NUMBER OF STRANDS INPUT.
Fp = EFFECTIVE POST-TENSIONING FORCE; P/T.
LTL = LONGTERM LOSSES.
IL = INITIAL LOSSES.

ALLOWABLE STRESS:

\[
\text{SERVICE}: f/tension(\text{psi}) = \text{TENSILE STRESS EQUAL TO RUPTURE MODULUS OF SPECIFIED CONCRETE STRENGTH.}
\]

\[
= 7.5\times (f'c)^{1/2}
\]

\[
f/\text{comp.}(\text{psi}) = \text{MAXIMUM COMPRESSIVE STRESS SPECIFIED BY ACI 318-83 (18.4.2 (a)).}
\]

\[
= 0.45\times f'c
\]

\[
\text{INITIAL}: f/tension(\text{psi}) = \text{MAXIMUM TENSILE STRESS SPECIFIED BY ACI 318-83 (18.4.1 (b)).}
\]

\[
= 3\times (f'ci)^{1/2}
\]

\[
f/\text{comp.}(\text{psi}) = \text{MAXIMUM COMPRESSIVE STRESS SPECIFIED BY ACI 318-83 (18.4.1 (a)).}
\]

\[
= 0.60\times f'ci
\]

As req'd = BONDED AUXILIARY TENSION REINFORCEMENT REQUIRED WHEN COMPUTED INITIAL TENSILE STRESSES EXCEED THE ALLOWABLE.

\[
w/ \text{RESPECT TO BOTTOM} = \left(\frac{((|fbi|/((|fbi|+|fti|)/h))*|fbi|/2)*bw}{30000}\right)
\]

\[
w/ \text{RESPECT TO TOP} = \left(\frac{((|fti|/(|fti|+|fbi|)/h))*|fti|/2)*bf}{30000}\right)
\]

WHERE: fbi = INITIAL STRESS AT EXTREME BOTTOM FIBER.
fti = INITIAL STRESS AT EXTREME TOP FIBER.
NOTE: FOR T-BEAM SECTIONS, WHEN THE DEPTH OF THE TENSILE STRESS BLOCK EXCEEDS THE FLANGE THICKNESS AT NEGATIVE MOMENT REGIONS OR THE DEPTH OF THE BEAM LESS THE FLANGE THICKNESS AT POSITIVE MOMENT REGIONS A SCREEN DISPLAY OF 'NOT CALC' IS PROMPTED INDICATING MANUAL CALCULATION OF As req'd IS REQUIRED.

\[ f'c_{\text{min}} = \]  

THE MINIMUM \( f'c \) REQUIRED WHEN COMPUTED INITIAL COMpressive STRESS EXCEEDS THE ALLOWABLE.

\[ \text{w/ RESPECT TO BOTTOM} = f_{bi}/.60 \]

\[ \text{w/ RESPECT TO TOP} = f_{ti}/.60 \]

WHERE: \( f_{bi} \)=INITIAL STRESS AT EXTREME BOTTOM FIBER. \( f_{ti} \)=INITIAL STRESS AT EXTREME TOP FIBER.

SPREADSHEET SECTION: UNBONDED ULTIMATE STRENGTH

\[ \text{SPAN/DEPTH RATIO} = \]  

RATIO OF THE SPAN LENGTH TO THE TOTAL DEPTH OF THE MEMBER IN QUESTION.

\[ = (l*12)/h \]

WHERE: \( l \)=SPAN (ft).

\[ \text{MINIMUM BONDED As} (\text{in}^2) = \]  

THE MINIMUM AREA OF BONDED REINFORCEMENT REQUIRED BY ACI 318-83 (18.9) AT A SPECIFIED YIELD STRENGTH OF 60 ksi.

\[ \text{ONE-WAY BEAM/SLAB}= \]  

SEE ACI 318-83 EQUATION (18-6).

\[ \text{TWO-WAY FLAT PLATE}= \]  

SEE ACI 318-83 EQUATION (18-7) FOR POSITIVE MOMENT REGION OR EQUATION (18-8) FOR NEGATIVE MOMENT REGION.

\[ P_{ps} = \]  

RATIO OF POST-TENSIONING REINFORCEMENT.

\[ = A_{ps}/b*dp \]

WHERE: \( A_{ps} \)=TOTAL AREA OF POST-TENSIONING REINFORCEMENT \( b \)=WIDTH OF COMPRESSION FACE OF MEMBER.

\[ f_{se} (\text{ksi}) = \]  

EFFECTIVE STRESS IN POST-TENSIONING REINFORCEMENT AFTER ALLOWANCE FOR ALL LOSSES.

\[ = F_p/A_{ps} \]

WHERE: \( F_p \)=EFFECTIVE POST-TENSIONING FORCE; \( P/T \).

\[ f_{ps} (\text{ksi}) = \]  

STRESS IN POST-TENSIONING REINFORCEMENT AT NOMINAL STRENGTH.

\[ = \text{SEE ACI 318-83 EQUATION (18-4) FOR SPAN-TO-DEPTH RATIO OF 35 OR LESS OR EQUATION (18-5) FOR SPAN-TO-DEPTH RATIO GREATER THAN 35.} \]

\[ w = \]  

AS DEFINED IN ACI 318-83 CHAPTER 18.
\[ wp = \]

\[ w + wp = \]

\[ \text{MAX } w + wp = \]

\[ = 0.36B1 \]

WHERE: \( B1 = \text{FACTOR DEFINED IN ACI 318-83 (10.2.7.3)}. \)

NOTE: IF THE RATIO OF POST-TENSIONED AND BONDED REINFORCEMENT EXCEEDS THE MAXIMUM ALLOWED BY ACI 318-83 (18.8.1) THEN THE SCREEN IS PROMPTED TO DISPLAY A MESSAGE THAT THE SECTION IS OVERREINFORCED. THIS IN TURN PROMPTS THE PROGRAM TO DISPLAY THE VALUE FOR THE MAXIMUM FACTORED ULTIMATE MOMENT STRENGTH OF THE SECTION BASED ON THE COMPRESSION PORTION OF THE MOMENT COUPLE. THIS VALUE IS CALCULATED FROM FORMULAS PROVIDED IN SECTION 18.8.2 OF THE COMMENTARY ON ACI 318-83 AND IS EXPRESSED IN TERMS OF KIP-FEET ADJACENT TO THE DISPLAY 'MAX PhiMn = '.

SECONDARY EFFECT(\( KF \)) =

IN CONTINUOUS OR INDETERMINATE POST-TENSIONED STRUCTURES, THE MOMENTS DUE TO POST-TENSIONING ARE USUALLY NOT DIRECTLY PROPORTIONAL TO THE TENDON ECCENTRICITY WITH RESPECT TO THE NEUTRAL AXIS OF THE MEMBER AS THEY ARE WITH SIMPLE SPAN MEMBERS. THIS DIFFERENCE OCCURS BECAUSE THE DEFORMATIONS IMPOSED BY POST-TENSIONING ARE RESISTED BY THE CONTINUOUS MEMBERS AT THE POINTS OF INTERSECTION (BEAM/COLUMN JOINTS) WITH OTHER MEMBERS IN THE STRUCTURE. THIS RESTRAINT MODIFIES THE REACTIONS AND THEREBY AFFECTS THE ELASTIC MOMENTS AND SHEARS RESULTING FROM THE POST-TENSIONING. THE MOMENTS RESULTING FROM THIS RESTRAINT ARE COMMONLY REFERRED TO AS SECONDARY MOMENTS. THIS TERM IS USED BECAUSE THE MOMENTS ARE INDUCED BY THE PRIMARY POST-TENSIONING MOMENTS, \( Pe \), AND NOT BECAUSE THE SECONDARY MOMENT IS NEGLIGIBLE OR SMALLER THAN THE PRIMARY MOMENT.

\[ + \text{ MOMENT REGION} = ((e/12)*Fp*DNS)+(Mb*DNS) \]

\[ - \text{ MOMENT REGION} = (Mb*DNS)-((e/12)*Fp*DNS) \]

WHERE: \( Fp = \text{EFFECTIVE POST-TENSION FORCE}; P/T \)

\( DNS = \text{DESIREED NUMBER OF STRANDS INPUT}. \)

\( Mu(KF) = \)

THE TOTAL FACTORED ULTIMATE MOMENT INCLUDING ALL SECONDARY EFFECTS IN KIP-FEET.
\[ \Phi Mn (KF) = (M_s ULF) + SE \]

WHERE: ULF = ULTIMATE LOAD FACTOR INPUT.
SE = SECONDARY EFFECT CALCULATED BY PROGRAM.

\[ \Phi Mn (KF) = \]

THE FACTORED ULTIMATE MOMENT CAPACITY IN KIP-FEET
OF THE SECTION UNDER INVESTIGATION BASED ON THE
DESIRED NUMBER OF STRANDS AND BONDED REINFORCEMENT
INPUT BY THE USER.

\[ = \]

THIS VALUE IS CALCULATED FROM FORMULAS PROVIDED IN
SECTION 18.7.1 (A) OF THE COMMENTARY ON ACI 318-83.

NOTE: IF Mu EXCEEDS PhiMn THEN THE PROGRAM PROMPTS THE
SCREEN TO DISPLAY A MESSAGE INDICATING THAT THE
BONDED AND OR POST-TENSIONING REINFORCEMENT
MUST BE INCREASED. IF PhiMn IS GREATER THAN OR
EQUAL TO Mu THEN THE MESSAGE DISPLAYED INDICATES
THAT THE REINFORCEMENT INPUT IS ADEQUATE.

\[ 1.2^* Mocr (KF) = 1.2 * \]

THE PURE FLEXURAL CRACKING STRENGTH AS DEFINED
BY ACI 318-83 (18.8.3).

\[ = \]

SEE EQUATION (4.4.2) OF THE PCI DESIGN HANDBOOK THIRD
EDITION.

NOTE: AS WITH PhiMn THE PROGRAM IS PROMPTED TO DISPLAY
MESSAGES OF COMPLIANCE WITH OR DEVIATION FROM
THE REQUIREMENTS OF ACI 318-83 (18.8.3) IN
ORDER TO DIRECT THE USER TO INCREASE THE
REINFORCEMENT INPUT OR NOT.

SPREADSHEET SECTION: ULTIMATE BEAM SHEAR ANALYSIS

\[ Vc(kips) \]

NOMINAL SHEAR STRENGTH PROVIDED BY THE CONCRETE
SECTION AT SPAN LOCATION UNDER INVESTIGATION.

\[ = \]

SEE ACI 318-83 EQUATION (11-10).

\[ VcMIN(K) \]

MINIMUM NOMINAL SHEAR STRENGTH IN KIPS OF CONCRETE
SECTION AS PER ACI 318-83 (11.4.1).

\[ = 2*(f'c)^1/2*b*w*d \]

WHERE: \(d = dp \) OR \((.8\Delta h)\), WHICHEVER IS GREATER.

\[ VcMAX(K) \]

MAXIMUM NOMINAL SHEAR STRENGTH IN KIPS OF CONCRETE
SECTION AS PER ACI 318-83 (11.4.1).

\[ = 5*(f'c)^1/2*b*w*d \]

WHERE: \(d = dp \) OR \((.8\Delta h)\), WHICHEVER IS GREATER.

STIRRUPS

PROGRAM CALCULATIONS PROMPT ONE OF THE FOLLOWING
SCREEN DISPLAYS; Req'd Min, or N/R. THESE DISPLAYS
CORRESPOND TO; SHEAR REINFORCEMENT IS REQUIRED,
MINIMUM SHEAR REINFORCEMENT IS REQUIRED AND NO SHEAR
REINFORCEMENT IS REQUIRED RESPECTIVELY. THE
Determination of which display is appropriate for the span location under investigation is based on the requirements of ACI 318-83 (11.1.1) in conjunction with the minimum shear reinforcing requirements of section (11.5.5.1). However, the exceptions allowed by articles (b) and (c) of this same code section are not included within the calculation parameters of this program.

= See ACI 318-83 equations (11-1) and (11-2).

**Bar Area**

Based on the standard ASTM reinforcing bar size input, the program displays the appropriate cross-sectional area of one bar (in²).

= .11 for #3, .20 for #4, .31 for #5 and .44 for #6 bar.

Note: The program will prompt a display of 'N/A' if a bar size other than #3, #4, #5 or #6 is used as the bar size input value.

**Min SPCG**

Spacing limits for shear reinforcement specified in ACI 318-83 are displayed in inches.

= See ACI 318-83 (11.5.4.1).

**Req'D SPCG(in)**

Based on the requirements of ACI 318-83 (11.1.1), the program calculates the required spacing of the stirrup size input by the user. If the program has determined previously that no shear reinforcement is required or that minimum shear reinforcement requirements apply at the span location in consideration then the minimum spacing requirements of code section (11.5.4.1) are displayed. A display of 'Req'D' in the 'Stirrup' display row at the span location under review will result in the program calculating the required stirrup spacing in inches.

= See ACI 318-83 equation (11-17), (11-2) and (11-1).

Note: If shear reinforcement is required as indicated by the 'Req'D' display then the spacing value displayed may or may not be greater than the minimum spacing required by the ACI 318-83 code. The user is directed to compare the spacing value displayed to the minimum spacing requirements that are also displayed to insure that the actual stirrup spacing used on contract documents conforms to the ACI code.

**AvMIN(in²)**

To satisfy the requirements of ACI 318-83 (11.5.5.4) the program calculates and displays the minimum area of shear reinforcing, Av as defined in Chapter 11 of the referenced code based on the spacing value displayed in the 'Req'D SPCG(in)' row.

= See ACI 318-83 equation (11-15).
Vs(kips)

The Program calculates and displays the Value for Vs as defined in Chapter 11 of ACI 318-83 based on the bar size input and the spacing value displayed in the 'Req'd SPCG(in)' row.

= See ACI 318-83 Equation (11-17).

PhiVn(K)

The Program displays the value for the factored nominal shear strength as defined in ACI 318-83 (11.1.1) for the section under investigation.

= See ACI 318-83 Equation (11-2).

Spreadsheet Section: Ultimate Beam Shear/Torsion Analysis

Aoh(in²)

The area enclosed by the stirrup centerline. See Fig. 4.4.1 of the PCI Design Handbook Third Edition.

= bv*dv

Ph(in)

The perimeter of the stirrup centerline. See Fig. 4.4.1 of the PCI Design Handbook.

= (2*bv)+(2*dv)

fps(ksi)

Stress in post-tensioning reinforcement at nominal strength at the span location under review.

= See ACI 318-83 Equation (18-4) for span-to-depth ratio of 35 or less or Equation (18-5) for span-to-depth ratio greater than 35.

Mu(KF)

The total factored ultimate moment including all secondary effects in kip-feet at the span location under investigation.

= (Ms*ULF)+SE

Where: ULF=ultimate load factor input in the unbonded ultimate strength spread sheet section. SE=secondary effect calculated by program at span location under consideration.

PhiMn(KF)

The factored ultimate moment capacity in kip-feet of the section in question at the span location under investigation based on the desired number of strands and bonded reinforcement input by the user.

= This value is calculated from formulas provided in section 18.7.1 (A) of the commentary on ACI 318-83.

1.2*Mocr(KF)

1.2 * The pure flexural cracking strength as defined by ACI 318-83 (18.8.3).

= See equation (4.4.2) of the PCI Design Handbook Third Edition.

*Increase Reinf.

Program calculations prompt one of the following
SCREEN DISPLAYS; YES OR NO. THESE DISPLAYS CORRESPOND TO; ADDITIONAL REINFORCEMENT IS REQUIRED OR ADDITIONAL REINFORCEMENT IS NOT REQUIRED TO SATISFY THE REQUIREMENTS OF ACI 318-83 (18.8.3) AT THE SPAN LOCATION UNDER CONSIDERATION. THE ASTERISK TO THE LEFT OF THE ROW HEADING 'INCREASE REINF.' REFERS TO THE DISPLAY AT THE FAR RIGHT OF THE SAME ROW INDICATING THE INCREASED REINFORCING REQUIRED IS 'FLEXURAL'.

= SEE ACI 318-83 (18.8.3) FOR THE CRITERIA OF EVALUATION BETWEEN $\Phi_{imn}$ AND $1.2\times M_{cr}$.

$\Phi_{imn} \times 0.67 \times T_{cr}(KF)$

IN A STATICALLY INDETERMINATE STRUCTURE WHERE REDUCTION OF TORSIONAL MOMENT IN A MEMBER CAN OCCUR DUE TO REDISTRIBUTION OF INTERNAL FORCES THE MAXIMUM FACTORED TORSIONAL MOMENT, $T_u$, AT WHICH TORSION MAY BE NEGLECTED MAY BE REDUCED TO THE STRENGTH REDUCTION FACTOR, $\Phi_{imn} \times (0.67 \times T_{cr})$ PROVIDED THAT THE CORRESPONDING ADJUSTMENTS TO THE MOMENTS AND SHEARS IN ADJOINING MEMBERS ARE MADE. $T_{cr}$ EQUALS THE PURE TORSIONAL CRACKING STRENGTH OF THE MEMBER IN QUESTION.

= SEE EQUATION (4.4.4) OF THE THIRD EDITION OF THE PCI DESIGN HANDBOOK.

$T_u \ REINF. \REQ'D$

PROGRAM CALCULATIONS PROMPT ONE OF THE FOLLOWING SCREEN DISPLAYS; YES OR NO. THESE DISPLAYS CORRESPOND TO; TORSIONAL REINFORCING IS OR IS NOT REQUIRED TO SATISFY THE REQUIREMENTS OF SECTION 4.4.2 OF THE THIRD EDITION OF THE PCI DESIGN HANDBOOK AT THE SPAN LOCATION IN CONSIDERATION. THE ASTERISK TO THE LEFT OF THE ROW HEADING 'T_u REINF. REQ'D' REFERS TO THE DISPLAY AT THE FAR RIGHT OF THE SAME ROW INDICATING THE TORSIONAL REINFORCING REFERRED TO IS CLOSED '(STIRRUPS).


$t_{n}(ksi)$

NOMINAL SHEAR STRESS AT THE SPAN LOCATION IN QUESTION.

= SEE EQUATION (4.4.8) OF THE THIRD EDITION OF THE PCI DESIGN HANDBOOK.

$\Theta_{min}$

MINIMUM ANGLE OF INCLINATION TO LONGITUDINAL AXIS OF MEMBER (IN DEGREES) OF DIAGONAL COMPRESSION STRESS.

= SEE EQUATION (4.4.11) OF THE PCI DESIGN HANDBOOK.

$\Theta_{max}$

MAXIMUM ANGLE OF INCLINATION TO LONGITUDINAL AXIS OF MEMBER (IN DEGREES) OF DIAGONAL COMPRESSION STRESS.

= SEE EQUATION (4.4.12) OF THE PCI DESIGN HANDBOOK.

INCREASE SECTION

PROGRAM CALCULATIONS PROMPT ONE OF THE FOLLOWING SCREEN DISPLAYS; YES OR NO. THESE DISPLAYS CORRESPOND TO; YES, INCREASE THE SIZE OF THE SECTION UNDER REVIEW.
OR NO, THE SECTIONAL SIZE AS INPUT IS ADEQUATE. THE DETERMINATION OF ADEQUACY OF THE SECTION UNDER CONSIDERATION IS BASED ON THE RECOMMENDATIONS OF SECTION 4.4.2 OF THE THIRD EDITION OF THE PCI DESIGN HANDBOOK.

= IF THETA_MIN > THETA_MAX THEN DIAGONAL CRUSHING OF THE CONCRETE SECTION INDICATES THAT THE CROSS-SECTIONAL SIZE OF THE MEMBER IN QUESTION IS INADEQUATE TO CARRY THE APPLIED TORSION.

NOTE: THE DISPLAY AT THE FAR RIGHT OF THIS ROW, '(SEE NOTE 1)', REFERS TO THE NOTE THAT APPEARS AT THE BOTTOM OF THIS SPREAD SHEET SECTION. THIS NOTE REFERS TO SECTION 4.4.2 OF THE PCI DESIGN HANDBOOK WHICH REQUIRES A COMPARISON OF THETA_MAX AND MIN TO ENSURE THAT THE TRANSVERSE REINFORCEMENT WILL YIELD BEFORE DIAGONAL CRUSHING OF THE CONCRETE SECTION OCCURS.

*THETA (DEGREES)

WHEN THETA_MIN IS LESS THAN OR EQUAL TO THETA_MAX
A VALUE OF THETA SHOULD BE CHOSEN SUCH THAT THETA_MIN < THETA < THETA_MAX. SELECTING A LOWER VALUE OF THETA WILL RESULT IN LESS STIRRUP REINFORCEMENT BUT MORE LONGITUDINAL REINFORCEMENT. THEREFORE THE PROGRAM SELECTS THE AVERAGE VALUE OF THETA_MIN AND THETA_MAX THEREBY ENSURING A PRUDENT PORTIONING OF TRANSVERSE TO LONGITUDINAL REINFORCING. THE ASTERISK TO THE LEFT OF THE ROW HEADING 'THETA (DEGREES)' REFERS TO THE DISPLAY AT THE FAR RIGHT OF THE SAME ROW WHICH INDICATES THAT THE THETA VALUE CALCULATED IS IN FACT THE AVERAGE OF THETA_MIN AND MAX.

= (THETA_MIN + THETA_MAX) / 2

Vocr (kips)

PURE SHEAR CRACKING STRENGTH.

= SEE EQUATION (4.4.3) OF THE THIRD EDITION OF THE PCI DESIGN HANDBOOK.

INCREASE SECTION

PROGRAM CALCULATIONS PROMPT ONE OF THE FOLLOWING SCREEN DISPLAYS; YES OR NO*. THESE DISPLAYS CORRESPOND TO; YES, INCREASE THE SIZE OF THE SECTION UNDER REVIEW OR NO THE SECTIONAL SIZE AS INPUT Is ADEQUATE. THE DETERMINATION OF ADEQUACY OF THE SECTION UNDER CONSIDERATION IS BASED ON THE RECOMMENDATIONS OF SECTION 4.4.2 OF THE PCI DESIGN HANDBOOK.

= TO ENSURE ADEQUATE CONTROL OF DIAGONAL CRACKING AT SERVICE LOADING THE CRACKING LOAD SHOULD EXCEED THE SERVICE LOAD. IF THE CRACKING LOAD DOES NOT EXCEED THE SERVICE LOAD, ADEQUATE CONTROL OF DIAGONAL CRACKING AT SERVICE LOAD WILL BE PROVIDED IF THE STRAIN IN THE TRANSVERSE REINFORCEMENT IS NOT EXCESSIVE. THE RELATIONSHIP BETWEEN THE CRACKING LOAD, Vcr, AND THE SERVICE LOAD, (Vu/ULF) IS FIRST COMPARED BY THE PROGRAM WHERE Vcr IS DETERMINED FROM EQUATION (4.4.1) OF THE PCI DESIGN HANDBOOK AND (Vu/ULF) ARE CALCULATED FROM THE INPUT VALUE FOR Vu AT THE APPROPRIATE SPAN LOCATION AND ULF, ULTIMATE LOAD FACTOR, IS DERIVED FROM
THE UNBONDED ULTIMATE STRENGTH PORTION OF THE PROGRAM.

IF $V_{cr}$ IS GREATER THAN OR EQUAL TO $(V_{u}/ULF)$ THEN THE
PROGRAM PROMPTS THE 'NO*' DISPLAY. THE ASTERISK
REFERS TO THE DISPLAY AT THE FAR RIGHT OF THE SAME
ROW WHICH INDICATES '$V_{cr}$=$V_s$' WHERE $V_s$ EQUALS THE
SERVICE LOAD OR SHEAR , $(V_{u}/ULF)$, AT THE SPAN LOCATION
UNDER INVESTIGATION. IF $V_{cr}$ < $V_s$ THEN THE PROGRAM CHECKS
FOR EXCESSIVE STRAIN IN TRANSVERSE REINFORCEMENT BY
COMPARING $\tan(\theta)$ TO THE FORMULA PROVIDED IN STEP
5 (a.) OF SECTION 4.4.2 OF THE PCI DESIGN HANDBOOK
FOR $f_y=60$ ksi. IF THIS PORTION OF THE ANALYSIS IS ALSO
SATISFIED THEN THE PROGRAM AGAIN PROMPTS THE 'NO*
DISPLAY. IF $\tan(\theta)$ IS LESS THAN THE REFERENCED
FORMULA THEN THE PROGRAM COMPARES $\Theta_{max}$ TO THE
SAME FORMULA. IF $\tan(\Theta_{max})$ IS GREATER THAN OR
EQUAL TO THE REFERENCED FORMULA THEN THE PROGRAM
PROMPTS A DISPLAY OF 'NO'. THIS VARIATION OF A 'NO'
DISPLAY SHOULD ALERT THE USER TO THE FACT THAT THE
$\Theta$ ASSUMED BY THE PROGRAM IN SUBSEQUENT CALCULATIONS
EQUALS $\Theta_{max}$ RATHER THAN ($\Theta_{min} + \Theta_{max}$)/2.
A FINAL CONDITION THAT MUST ALSO BE MET TO SATISFY THE
RECOMMENDATIONS OF THE PCI DESIGN HANDBOOK IS THE
REQUIREMENT THAT THE SPACING OF ALL TRANSVERSE AND
LONGITUDINAL REINFORCING NOT EXCEED 12 INCHES.MINIMUM
SPACING REQUIREMENTS OF TRANSVERSE REINFORCEMENT ARE
DISPLAYED IN ANOTHER PORTION OF THIS PART OF THE
PROGRAM. A DISPLAY OF 'YES' DIRECTS THE USER TO
INCREASE THE SECTION UNDER REVIEW AS THE RECOMMENDATIONS
OF THE PCI DESIGN HANDBOOK ARE NOT SATISFIED.

\[
\Theta_{actual}
\]

IF THE DISPLAY IN THE ABOVE ROW IS 'NO' THEN THE
VALUE OF $\Theta$ IS REVISED TO EQUAL $\Theta_{max}$ AS
DESIGNED IN THE ABOVE PARAGRAPH. IF HOWEVER THE DISPLAY
IN THE ABOVE ROW IS 'NO*' THEN THE VALUE FOR $\Theta$
REMAINS EQUAL TO $\Theta$ AVERAGE.

\[
\Theta_{max} = 80 - (122.58*(tn/f'c)); \Theta_{average} = (\Theta_{min} + \Theta_{max})/2.
\]

Equivalent depth of compression in torsion.

\[
\text{ao(in)}
\]

= See equation (4.4.14) of the third edition of the PCI
Design Handbook.

\[
\text{Ao(in2)}
\]

Area enclosed by shear flow path.

\[
\text{At(in2/ft)}
\]

Area of one leg of closed stirrup; inches²/2 per foot
of beam span required at location under investigation.
IF THE DISPLAY IN THE '\(Tu\) REINF. REQ'D' ROW WITHIN
THE SAME SPAN LOCATION COLUMN UNDER REVIEW IS 'NO'
THEN THE PROGRAM IS PROMPTED TO DISPLAY 'N/R'
INDICATING NO TORSIONAL REINFORCEMENT IS REQUIRED.
THE USER SHOULD RETURN TO THE ULTIMATE BEAM SHEAR
ANALYSIS PORTION OF THE SPREAD SHEET PROGRAM TO SIZE
THE APPROPRIATE SHEAR REINFORCEMENT REQUIRED. A DISPLAY
OF 'YES' IN THE REFERENCED '\(Tu\) REINF. REQ'D' ROW WILL
RESULT IN THE PROGRAM CALCULATING THE APPROPRIATE
AMOUNT OF TORSIONAL REINFORCING REQUIRED.
Area of shear reinforcement; inches^2 per foot of beam span required at the location under investigation. As indicated above, if no torsional reinforcement is required as determined by calculations, then the program prompts a '*' display which in turn refers to the display at the far right of this row indicating to '(see above)'. This directs the user to return to the ultimate beam shear analysis portion of the program. If torsional reinforcement is required then the appropriate amount of shear reinforcing required is displayed.

Area of shear reinforcing = \( Av(\text{in}^2/\text{ft}) \)

For prestressed members with an effective prestress force not less than 40% of the tensile strength of the flexural reinforcement, a minimum area of shear reinforcement shall be provided as per ACI 318-83 (11.5.5.4).

\[ \text{Bar area} \]

Based on the standard ASTM reinforcing bar size input the program displays the appropriate cross-sectional area of one bar (in2).

\[ \text{Req'd spacing} \]

Based on the requirements of section 4.4.2 of the third edition of the PCI design handbook the program calculates the required spacing of the stirrup size and type input by the user. If no torsional reinforcement is required as calculated by the program then the display value is '0'.

\[ \text{DeltaNu(kips)} \]

Equivalent factored axial load caused by shear and torsion.

\[ \text{MinMn(KF)} \]

Nominal moment strength of section in kip-feet.

Equation (4.4.16) of the PCI design handbook.

Equation (4.4.17) of the PCI design handbook.

Equation (11-15) of ACI 318-83. Spacing assumed in this equation equals 12 inches therefore the value displayed is in inches^2 per foot of beam at the span location under review.

Equations (4.4.20), (4.4.21) and (4.4.23) of the third edition of the PCI design handbook.
THE TOTAL AMOUNT OF LONGITUDINAL REINFORCEMENT PROVIDED IN A BEAM TYPICALLY INCLUDES SIDE BARS IN EACH FACE OF THE BEAM AND ALL TOP AND BOTTOM FLEXURAL REINFORCEMENT. THE INTENT OF THIS PORTION OF THE PROGRAM IS TO DETERMINE THE CAPACITY OF THE LONGITUDINAL REINFORCEMENT INPUT TO RESIST ALL APPLIED MOMENTS AND AXIAL TENSION CAUSED BY THE SHEAR AND TORSION AT THE SPAN LOCATION UNDER INVESTIGATION. THIS CAPACITY IS CALCULATED BASED ONLY ON THE TOTAL AMOUNT OF FLEXURAL REINFORCEMENT INPUT BY THE USER. IF THE CAPACITY OF THE SECTION AS REINFORCED IS ADEQUATE THEN THE PROGRAM PROMPTS A DISPLAY OF 'NO' INDICATING NO INCREASE IN THE MAIN FLEXURAL REINFORCEMENT IS REQUIRED TO SATISFY THE REQUIREMENTS OF THE PCI DESIGN GUIDELINES. HOWEVER, A MINIMUM AMOUNT OF SIDE BARS SHOULD BE PROVIDED IN THE SECTION UNDER REVIEW SPACED AT A MAXIMUM OF 12 INCHES VERTICALLY IN ORDER TO HELP CONTROL DIAGONAL CRACKING OF THE BEAM IN QUESTION. THE PROGRAM DOES NOT QUANTIFY THE AMOUNT OF SIDE BARS REQUIRED IN THIS SITUATION. THE DESIGNER SHOULD USE HIS OR HER OWN DISCRETION IN SPECIFYING SUCH REINFORCEMENT. IF THE CAPACITY OF THE SECTION AS REINFORCED IS INADEQUATE THEN THE PROGRAM PROMPTS A DISPLAY OF 'YES*' INDICATING ADDITIONAL FLEXURAL REINFORCEMENT AND OR LONGITUDINAL SIDE BARS ARE REQUIRED. THE ASTERISK REFERS TO THE DISPLAY AT THE FAR RIGHT OF THE SAME ROW WHICH INDICATES THAT MINMn > (PhiMn/.90). AGAIN THE PROGRAM DOES NOT QUANTIFY THE AMOUNT OF SUPPLEMENTAL LONGITUDINAL REINFORCING REQUIRED IN THIS SITUATION. HOWEVER, THE DESIGNER IS DIRECTED BY THIS DISPLAY TO REITERATE THE SPREAD SHEET INPUT WITH AN INCREASED AMOUNT OF POST-TENSIONING STRAND AND OR BONDED REINFORCING BARS.

= SEE EQUATIONS (4.4.20, 21 AND 23) OF THE PCI DESIGN HANDBOOK FOR VALUES OF MINMn, PhiMn IS AN OUTPUT VALUE DESCRIBED ABOVE.
OPERATING INSTRUCTIONS AND HARDWARE REQUIREMENTS

THIS PROGRAM WAS ORIGINALLY WRITTEN FOR USE WITH THE 20/20 INTEGRATED SPREADSHEET MODELING PROGRAM, RELEASE 2 FOR DEC VAX AND MICROVAX COMPUTERS. THE PROGRAM HAS BEEN CONVERTED FOR USE WITH A LOTUS 1-2-3 TYPE SPREADSHEET FOR SUBMITTAL IN THE 1990 CRSI SOFTWARE DEVELOPMENT COMPETITION.

DATA ENTRY REQUIREMENTS ARE DESCRIBED IN THE DESCRIPTION OF INPUT PARAMETERS.

THE CELL ADDRESS RANGE REQUIREMENTS FOR THE PROPER HARDCOPY REPRODUCTION OF THE MAJOR DESIGN SCREENS ARE AS FOLLOWS:

POST-TENSION SERVICE STRESS A0..I20
UNBONDED ULTIMATE STRENGTH A21..I41
ULTIMATE BEAM SHEAR ANALYSIS A42..I62
ULTIMATE BEAM SHEAR/TORSION ANALYSIS A63..J114
LIST OF VARIABLES AND DEFINITIONS

**Ac (in²)**

The area enclosed by the outside perimeter of the concrete cross section, including any enclosed voids, as defined by **Fc**.

**Ag (in²)**

The total cross-sectional area of concrete not including any enclosed voids, for beam sections, this includes any slab located on either side of the web with respect to one-half the clear distance to the next adjacent beam.

**Ao (in²)**

The area enclosed by the shear flow path.

**ao (in)**

The equivalent depth of compression in torsion.

**Aoh (in²)**

The area enclosed by the outside perimeter formed by the centerline of a closed stirrup.

**Aps (in²)**

The cross-sectional area of one post-tensioning strand.

**As (in²)**

The cross-sectional area of conventional bonded tension reinforcement.

**Asreq’d (in²)**

The cross-sectional area of conventional bonded auxiliary tension reinforcement located in the compression face of the member.

**At (in²/ft)**

The cross-sectional area of one leg of a closed stirrup required per foot of beam span.

**Av (in²/ft)**

The cross-sectional area of shear reinforcement required per foot of beam span.

**AvMIN (in²)**

The cross-sectional area of the minimum shear reinforcement required at the "req’d sfcg" calculated by the program to satisfy ACI 318-83 (11.5.5.4).

**bf (in)**

The width of the effective T-beam flange for such sections, the web width for rectangular beam sections or the design top width for slab sections.

**bw (in)**

The web width for beam sections or the design soffit width for slab sections.

**dv (in)**

The distance from the extreme fiber in compression to the centroid of the conventional bonded tension reinforcement.

**DeltaNu (kips)**

The equivalent factored axial load caused by shear and torsion.

**dp (in)**

The distance from the extreme fiber in compression to
THE CENTROID OF THE POST-TENSIONING REINFORCEMENT.

dv (in) THE EFFECTIVE SHEAR DEPTH EQUAL TO THE VERTICAL DISTANCE BETWEEN THE CENTERS OF THE LONGITUDINAL BARS LOCATED IN THE CORNERS OF THE CLOSED STIRRUPS.


fa(P/A) (psi) THE EFFECTIVE COMpressive STRESS OF THE SECTION DUE TO THE AXIAL LOADING THAT RESULTS FROM THE POST-TENSION COMPRESSION FORCE.

fb (psi) THE NET SERVICE STRESS AT THE EXTREME BOTTOM FIBER OF THE SECTION DUE TO FLEXURAL BENDING AND AXIAL LOADING AS A RESULT OF GRAVITY AND BALANCING LOADS AND POST-TENSION COMPRESSION FORCE,P/A.

f'c (psi) THE SPECIFIED 28-DAY COMpressive STRENGTH OF CONCRETE.

f'ci (psi) THE COMpressive STRENGTH OF CONCRETE AT THE TIME OF INITIAL POST-TENSION STRESS TRANSFER.

f'cimin (psi) THE MINIMUM f'ci REQUIRED WHEN THE COMPUTED INITIAL COMpressive STRESS EXCEEDS THE ALLOWABLE.

f/comp. (psi) THE MAXIMUM COMpressive STRESS SPECIFIED BY ACI 318-83 (18.4.2(a)) AT SERVICE LOADS AND (18.4.1(a)) AT TIME OF INITIAL POST-TENSION STRESS TRANSFER.

fps (ksi) THE STRESS IN THE POST-TENSIONING REINFORCEMENT AT NOMINAL STRENGTH.

fse (ksi) THE EFFECTIVE STRESS IN THE POST-TENSIONING REINFORCEMENT AFTER ALLOWANCE FOR ALL LOSSES.

ft (psi) THE NET SERVICE STRESS AT THE EXTREME TOP FIBER OF THE SECTION DUE TO FLEXURAL BENDING AND AXIAL LOADING AS A RESULT OF GRAVITY AND BALANCING LOADS AND POST-TENSION COMPRESSION FORCE,P/A.

f/tension (psi) THE MAXIMUM TENSILE STRESS SPECIFIED BY ACI 318-83 (18.4.1(b)) AT TIME OF INITIAL POST-TENSION STRESS TRANSFER.THE TENSILE STRESS EQUAL TO THE RUPTURE MODULUS OF THE SPECIFIED CONCRETE STRENGTH AT SERVICE LOADS.

fy (ksi) THE YIELD STRENGTH ASSUMED BY THE PROGRAM FOR ALL CONVENTIONAL BONDED REINFORCEMENT INCLUDING AUXILIARY TENSILE BARS AND FLEXURAL AND SHEAR REINFORCEMENT;60 ksi.

h (in) THE TOTAL DEPTH OR THICKNESS OF THE DESIGN MEMBER.

hf (in) THE THICKNESS OF THE FLANGE OR SLAB PORTION OF A T-BEAM SECTION.

Mb (KF) THE BALANCING LOAD MOMENT IN KIP-FEET.

MinMn (KF) THE NOMINAL MOMENT STRENGTH IN KIP-FEET AT WHICH SUPPLEMENTAL LONGITUDINAL REINFORCEMENT IS REQUIRED.
Mo (KF)

THE PURE FLEXURAL CRACKING STRENGTH IN KIP-FEET OF THE DESIGN MEMBER.

Ms (KF)

THE TOTAL SERVICE OR UNFACTORED MOMENT IN KIP-FEET OF THE DESIGN MEMBER.

MsDLi (KF)

THE INITIAL SERVICE OR UNFACTORED DEAD LOAD PORTION OF Ms IN KIP-FEET.

Mu (KF)

THE TOTAL FACTORED OR ULTIMATE MOMENT IN KIP-FEET OF THE DESIGN MEMBER.

Pc (in)

THE OUTSIDE PERIMETER OF THE CONCRETE CROSS SECTION AS DEFINED IN ACI 318-83 (11.6.1).

ph (in)

THE PERIMETER OF A CLOSED STIRRUP AS DEFINED BY THE CENTERLINE OF THE REINFORCING BAR.

PhiMn (KF)

THE FACTORED ULTIMATE MOMENT STRENGTH CAPACITY IN KIP-FEET OF THE DESIGN MEMBER.

PhiVn (K)

THE FACTORED ULTIMATE SHEAR STRENGTH CAPACITY IN KIPS OF THE DESIGN MEMBER.

Pps

THE RATIO OF THE POST-TENSION REINFORCEMENT; Aps/(b*dp).

P/T (kips)

THE EFFECTIVE POST-TENSIONING FORCE PER STRAND.

Sb (in3)

THE SECTION MODULUS WITH RESPECT TO THE BOTTOM OF THE DESIGN MEMBER.

St (in3)

THE SECTION MODULUS WITH RESPECT TO THE TOP OF THE DESIGN MEMBER.

THETA

THE ANGLE OF INCLINATION TO THE LONGITUDINAL AXIS OF THE MEMBER IN DEGREES OF THE DIAGONAL COMPRESSION STRESS.

tn (ksi)

THE NOMINAL SHEAR STRESS OF THE DESIGN MEMBER.

Tocr (KF)

THE PURE TORSIONAL CRACKING STRENGTH IN KIP-FEET OF THE DESIGN MEMBER.

Tu (KF)

THE TOTAL FACTORED OR ULTIMATE TORSIONAL MOMENT IN KIP- FEET OF THE DESIGN MEMBER.

Vc (kips)

THE NOMINAL SHEAR STRENGTH PROVIDED BY THE CONCRETE SECTION.

VcMAX (kips)

THE MAXIMUM NOMINAL SHEAR STRENGTH OF THE CONCRETE SECTION AS PER ACI 318-83 (11.4.1).

VcMIN (kips)

THE MINIMUM NOMINAL SHEAR STRENGTH OF THE CONCRETE SECTION AS PER ACI 318-83 (11.4.1)

Vocr (kips)

THE PURE SHEAR CRACKING STRENGTH OF THE DESIGN MEMBER.

Vp (kips)

THE VERTICAL COMPONENT OF THE EFFECTIVE POST-TENSIONING FORCE.
Vs (kips)  THE NOMINAL SHEAR STRENGTH PROVIDED BY SHEAR REINFORCEMENT.

Vu (kips)  THE TOTAL FACTORED OR ULTIMATE SHEAR ON THE DESIGN MEMBER.

w  THE RATIO OF CONVENTIONAL BONDED REINFORCEMENT, \( \frac{A_s}{b*d} \), MULTIPLIED BY THE RATIO \( f_y / f'_c \).

wp  THE RATIO OF POST-TENSIONING REINFORCEMENT, \( P_{ps} \), MULTIPLIED BY THE RATIO \( f_{ps} / f'_c \).

yb (in)  THE DISTANCE FROM THE CENTROIDAL AXIS OF THE MEMBER TO THE EXTREME BOTTOM FIBER OF THE SECTION.

yt (in)  THE DISTANCE FROM THE CENTROIDAL AXIS OF THE MEMBER TO THE EXTREME TOP FIBER OF THE SECTION.
DESIGN EXAMPLE

DESIGN ASSUMPTIONS:

- ONE- STORY BRACED PARKING GARAGE STRUCTURE. NO LATERAL LOADS.
- LIVE LOAD = 50 PSF.
- REGULAR WEIGHT CONCRETE; $f_c = 4000$ psi.
- POST-TENSION REINFORCEMENT; 1/2"-270K LO-LAX STRAND.
- DESIGN TYPICAL 18"x30" BEAM AND 48"x30" TRANSFER BEAM.

![Plan View Diagram]

PLAN VIEW
DESIGN EXAMPLE

TYPICAL BEAM 18"x30"

SECTION PROPERTIES:

\[
y_b = \frac{(130 \times 7 \times 26.5) + (23 \times 18 \times 11.5)}{910 + 414} = 21.8"; \quad y_t = 8.2"
\]

\[
I_g = \left[ \frac{(130 \times (7)^3)}{12} \right] + \left[ \frac{(910 \times (4.7)^2)}{12} \right] + \left[ \frac{(18 \times (23)^3)}{12} \right] + \left[ \frac{(414 \times (10.3)^2)}{12} \right] = 85989.5 \text{in}^4
\]

\[
S_b = 3944.5 \text{in}^3; \quad S_t = 10486.5 \text{in}^3
\]

\[
A_g = (25 \times 12 \times 7) + (23 \times 18) = 2514 \text{in}^2
\]

STRAND DRAPE/BEAM DIAGRAM:

COVER REQUIRED = CODE MINIMUM + #4 STIRRUP DIAMETER
+ ONE-HALF STRAND DIAMETER.

\[
= 1.5 + 0.5 + 0.25 = 2.25"\]

(USE 2.5" FOR BONDED REINFORCEMENT)

[Diagram showing strand drape and beam layout with dimensions and labels]
DESIGN EXAMPLE

LOADING:

LIVE LOAD REDUCTION =→ CONTRIBUTORY AREA = (50*25) = 1250 SF

(1250 * .08%) > 40% MAXIMUM

USE =→ 60%*50 PSF = 30 PSF

ws-DL = (25*87.5 PSF) + (431.25 PLF) = 2.62 KLF

beam

LL = (25*30 PSF) = .75 KLF

TOTAL =→ 3.37 KLF (77.7% DL)

ULTIMATE LOAD FACTOR = ((1.4*2.62) + (1.7*.75))/3.37 = 1.47

NOTES:

-SEE POST-TENSION LOSS PROGRAM PRINTOUT FOR ALL P/T LOSSES, wb AND STRAND DRAPE LOCATION. (SHEET NO# 4&5)

-SEE ONE-STORY FRAME ANALYSIS PROGRAM PRINTOUT FOR ALL GRAVITY AND BALANCING LOAD MOMENTS AND SHEARS. (SHEET NO# 6)
TYPICAL BEAM 18"x 30"/CRSI DESIGN EXAMPLE

JACKING FROM EACH END; SPANS NUMBERED RIGHT TO LEFT

NUMBER OF SPANS = 2
LEFT CANTILEVER NO
RIGHT CANTILEVER NO
STRAND SIZE = 1/2 inch
fpu = 270 ksi
Aps = .153 in^2
E = 28500 ksi
WEDGE SET = .25 inch
FRICITION COEFFICIENT(u) = .07
WOBBLE FACTOR(k) = .0014
LOW-LAX STRAND YES
STRESS-RELIEVED STRAND NO
SLAB SECTION NO
BEAM OR JOIST SECTION YES

<table>
<thead>
<tr>
<th>SPAN</th>
<th>LENGTH (ft)</th>
<th>LEFT SUPPORT ECC.(inch)</th>
<th>MIDSPAN ECC.(in)</th>
<th>RIGHT SUPPORT ECC.(inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>0</td>
<td>-19.75</td>
<td>5.75</td>
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<tr>
<td>2</td>
<td>50</td>
<td>5.75</td>
<td>-19.75</td>
<td>0</td>
</tr>
</tbody>
</table>

JACKING FORCE = .8 fpuAps = 33.048 kips
ANCHOR SET LOSS = 4.69823 kips
LIVE END ANCHORED FORCE = 28.3498 kips
MAXIMUM LE ANCHORAGE FORCE = .70 fpuAps = 28.917 kips
LENGTH OF STRAND INFLUENCED BY ANCHOR SET = 38.6714 ft.
DEAD END ANCHORED FORCE = 26.9734 kips
TOTAL ANGULAR CHANGE = .895833 radians

LONGTERM LOSSES = 3.06 kips

BALANCING LOADS

<table>
<thead>
<tr>
<th>SPAN</th>
<th>h(inch)</th>
<th>P/T(kips) (AVE.NET)</th>
<th>wb(klf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22.625</td>
<td>28.45</td>
<td>.171</td>
</tr>
<tr>
<td>2</td>
<td>22.625</td>
<td>28.45</td>
<td>.171</td>
</tr>
<tr>
<td>SPAN</td>
<td>FACE OF</td>
<td>h/2 FROM</td>
<td>2/10</td>
</tr>
<tr>
<td>------</td>
<td>---------</td>
<td>----------</td>
<td>------</td>
</tr>
<tr>
<td>NO#</td>
<td>LEFT</td>
<td>FOS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SUPPORT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-1.93</td>
<td>-4.20</td>
<td>-14.82</td>
</tr>
<tr>
<td>2</td>
<td>5.64</td>
<td>5.23</td>
<td>-2.26</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>SPAN</th>
<th>6/10</th>
<th>7/10</th>
<th>8/10</th>
<th>h/2 FROM</th>
<th>FACE OF</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO#</td>
<td></td>
<td></td>
<td></td>
<td>FOS</td>
<td>RIGHT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SUPPORT</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-15.38</td>
<td>-9.91</td>
<td>-2.26</td>
<td>5.23</td>
<td>5.64</td>
</tr>
<tr>
<td>2</td>
<td>-19.75</td>
<td>-18.52</td>
<td>-14.82</td>
<td>-4.20</td>
<td>-1.93</td>
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</table>
ONE-STORY FRAME ANALYSIS:

<table>
<thead>
<tr>
<th>SPAN</th>
<th>X SHEAR</th>
<th>MOMENT</th>
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<tbody>
<tr>
<td>0.00</td>
<td>69.97</td>
<td>-797.49</td>
</tr>
<tr>
<td>5.00</td>
<td>73.12</td>
<td>-389.75</td>
</tr>
<tr>
<td>10.00</td>
<td>56.27</td>
<td>-66.25</td>
</tr>
<tr>
<td>15.00</td>
<td>39.42</td>
<td>173.00</td>
</tr>
<tr>
<td>20.00</td>
<td>22.57</td>
<td>328.00</td>
</tr>
<tr>
<td>25.00</td>
<td>5.72</td>
<td>389.74</td>
</tr>
<tr>
<td>30.00</td>
<td>-11.13</td>
<td>385.24</td>
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<tr>
<td>35.00</td>
<td>-27.98</td>
<td>287.48</td>
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<tr>
<td>40.00</td>
<td>-44.83</td>
<td>105.48</td>
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<tr>
<td>45.00</td>
<td>-61.63</td>
<td>-160.77</td>
</tr>
<tr>
<td>50.00</td>
<td>-78.53</td>
<td>-511.27</td>
</tr>
</tbody>
</table>

INFLATION POINTS:
11.38 ft 41.98 ft
MAX. DEFLECTION = 0.389 in +

LOAD OPTIONS
1=UNIFORM LOAD (5)
2=CONCENTRATED LOAD (12)
3=TRIANGULAR LOAD (5)
4=CONCENTRATED MOMENT (5)
5=DUPILATE LOADS
6=END LOADING
O INDICATES THE MAX. NO.
OF LOADS+O+PER SPAN

<table>
<thead>
<tr>
<th>LOAD</th>
<th>BEGIN</th>
<th>ENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>K/FT</td>
<td>FT</td>
<td>FT</td>
</tr>
<tr>
<td>SPAN 1</td>
<td>3.37</td>
<td>0.00</td>
</tr>
<tr>
<td>SPAN 2</td>
<td>3.37</td>
<td>0.00</td>
</tr>
</tbody>
</table>

JOINT 0
COLUMN ABOVE 255.63 kft
COLUMN BELOW 255.63 kft
CLOCKWISE +

SPAN 2

<table>
<thead>
<tr>
<th>X SHEAR</th>
<th>MOMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>78.53</td>
</tr>
<tr>
<td>5.00</td>
<td>61.68</td>
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<td>10.00</td>
<td>44.83</td>
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<td>20.00</td>
<td>11.13</td>
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<td>25.00</td>
<td>-5.72</td>
</tr>
<tr>
<td>30.00</td>
<td>-22.57</td>
</tr>
<tr>
<td>35.00</td>
<td>-39.42</td>
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<tr>
<td>40.00</td>
<td>-56.27</td>
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<tr>
<td>45.00</td>
<td>-73.12</td>
</tr>
<tr>
<td>50.00</td>
<td>-89.97</td>
</tr>
</tbody>
</table>

INFLATION POINTS:
41.98 ft 11.38 ft
MAX. DEFLECTION = 0.389 in +

LOAD OPTIONS
1=UNIFORM LOAD (5)
2=CONCENTRATED LOAD (12)
3=TRIANGULAR LOAD (5)
4=CONCENTRATED MOMENT (5)
5=DUPILATE LOADS
6=END LOADING
O INDICATES THE MAX. NO.
OF LOADS+O+PER SPAN

<table>
<thead>
<tr>
<th>LOAD</th>
<th>BEGIN</th>
<th>ENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>K/FT</td>
<td>FT</td>
<td>FT</td>
</tr>
<tr>
<td>SPAN 1</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>SPAN 2</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

JOINT 0
COLUMN ABOVE -12.97 kft
COLUMN BELOW -12.97 kft
CLOCKWISE +
## POST-TENSION SERVICE STRESS

### Reference Code
- **Typ. BM.** 18"x30"/Max positive moment/CRSI

### Material Properties
- **Span (ft):** 50
- **h (in):** 30
- **Sb (in3):** 3944.5
- **yb (in):** 21.8
- **St (in3):** 10486.5
- **yt (in):** 8.2
- **Ag (in2):** 2514
- **Ms (KF):** 398.74
- **MsDLi (KF):** 309.82
- **f'c (psi):** 4000
- **f'ci (psi):** 2400

### Initial Losses
- **FOR 1 STRAND:**
  - **Mb (KF):** -20.23
  - **Initially losses (%):** 3
  - **P/T (kips):** 28.45
  - **Long Term losses (k):** 3.06

### Strand Requirements
- **Number of strands required:** 10.1387 \( \times [7.5 \times \text{sqrt} f'c] \)
- **Desired No. of strands:** 12
- **fa (P/A):** 135.8
- **P/Amin:** 125 psi

### Stress Calculation
- **Stress at fb (psi):** -338.72
- **Allowable f/tension (psi):** -474.34
- **Stress:** 1800

### Ultimate Strength

<table>
<thead>
<tr>
<th>UNBONDED ULTIMATE STRENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO=0; YES=1</td>
</tr>
<tr>
<td>ONE-WAY BM/SLAB</td>
</tr>
<tr>
<td><strong>ULTIMATE LOAD FACTOR</strong></td>
</tr>
<tr>
<td><strong>bw (in):</strong></td>
</tr>
<tr>
<td><strong>bf (in):</strong></td>
</tr>
<tr>
<td><strong>dp (in):</strong></td>
</tr>
<tr>
<td><strong>d (in):</strong></td>
</tr>
<tr>
<td><strong>e (in):</strong></td>
</tr>
<tr>
<td><strong>hf (in):</strong></td>
</tr>
<tr>
<td><strong>MINIMUM BONDED</strong></td>
</tr>
<tr>
<td><strong>DESIRED REINF.</strong></td>
</tr>
<tr>
<td><strong>fy (ksi):</strong></td>
</tr>
<tr>
<td><strong>Pps:</strong></td>
</tr>
<tr>
<td><strong>fps (ksi):</strong></td>
</tr>
<tr>
<td><strong>SECONDARY EFFECT (KF):</strong></td>
</tr>
<tr>
<td><strong>Mu (KF):</strong></td>
</tr>
<tr>
<td><strong>PhiMn (KF):</strong></td>
</tr>
<tr>
<td><strong>1.2 Mocr (KF):</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adeq. Reinf. Provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADEQ. REINF. PROVIDED</td>
</tr>
<tr>
<td>ADEQ. REINF. PROVIDED</td>
</tr>
</tbody>
</table>
POST-TENSION SERVICE STRESS

REFERENCE CODE: TYP. BM. 18"X30"/-Ms @ FACE OF INT. SUPPORT/CRSI
SPAN (ft) = 50 h (in) = 30
Sb (in3) = 3944.5 yb (in) = 21.8
St (in3) = 10486.5 yt (in) = 8.2
Ag (in2) = 2514
Ms (KF) = -709.21 MsDLi (KF) = -551.1
f’c (psi) = 4000 f’ci (psi) = 2400
FOR 1 STRAND:
Mb (KF) = 35.98 INITIAL LOSSES (%) = 3
P/T (kips) = 28.45 LONGTERM LOSSES (K) = 3.06
Aps (in2) = 0.153

NUMBER OF STRANDS REQ’D = 6.42455 [7.5*SQRT f’c]
DESIR ED NO# OF STRANDS = 12 fa (P/A) = 135.8 P/Amin = 125 psi

STRESS AT fb (psi) = 979.846
12 STRANDS: ft (psi) = -181.69
ALLOWABLE f/tension (psi) = -474.34
STRESS: f /comp. (psi) = 1800

UNBONDED ULTIMATE STRENGTH

<table>
<thead>
<tr>
<th>NO=0; YES=1</th>
<th>ONE-WAY BM/SLAB</th>
<th>TWO-WAY PLATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ULTIMATE LOAD FACTOR</td>
<td>1.47</td>
<td>0</td>
</tr>
<tr>
<td>bw (in)</td>
<td>18</td>
<td>SPAN/DEPTH RATIO = 20</td>
</tr>
<tr>
<td>bf (in)</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>dp (in)</td>
<td>27.64</td>
<td></td>
</tr>
<tr>
<td>d (in)</td>
<td>27.5</td>
<td></td>
</tr>
<tr>
<td>e (in)</td>
<td>5.64</td>
<td></td>
</tr>
<tr>
<td>hf (in)</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>MINIMUM BONDED As (in2)</td>
<td>3.7264</td>
<td></td>
</tr>
<tr>
<td>DESIRED REINF. As (in2)</td>
<td>3.96</td>
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</tr>
<tr>
<td>Pps</td>
<td>0.00369</td>
<td>fy (ksi) = 60</td>
</tr>
<tr>
<td>fse (ksi)</td>
<td>185.948</td>
<td>w = 0.12</td>
</tr>
<tr>
<td>fps (ksi)</td>
<td>206.787</td>
<td>w + wp = 0.19078</td>
</tr>
<tr>
<td>SECONDARY EFFECT (KF) = 271.302 [w + wp = 0.31078] OVERREINFORCED SECTION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mu (KF)</td>
<td>-771.23</td>
<td>MAX PhiMn = -1023.9 &gt; -771.23</td>
</tr>
<tr>
<td>PhiMn (KF)</td>
<td>-1043.6</td>
<td></td>
</tr>
<tr>
<td>1.2 Mocr (KF)</td>
<td>-1157.9</td>
<td></td>
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</tbody>
</table>

N.A. - SECTION WOULD FAIL AT POSITIVE MOMENT REGION DUE TO OVERLOAD PRIOR TO FAILURE AT SUPPORT. AS SECTION MEETS THIS CRITERIA AT POSITIVE REGION, SAY O.K.
<table>
<thead>
<tr>
<th>LOCATION</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td>25</td>
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<tr>
<td>Vu(kips)</td>
<td>121.11</td>
<td>107.49</td>
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<td>57.95</td>
<td>33.18</td>
<td>8.41</td>
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<tr>
<td>Mu(KF)</td>
<td>-887.27</td>
<td>-572.93</td>
<td>-97.38</td>
<td>254.31</td>
<td>482.16</td>
<td>586.14</td>
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<tr>
<td>dp(in)</td>
<td>27.23</td>
<td>22</td>
<td>19.74</td>
<td>17.91</td>
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<td>26.66</td>
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<tr>
<td>Vc(kips)</td>
<td>124.869</td>
<td>120.407</td>
<td>318.793</td>
<td>119.239</td>
<td>56.9376</td>
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<td>VcMIN(K)</td>
<td>61.9984</td>
<td>54.6442</td>
<td>54.6442</td>
<td>54.6442</td>
<td>54.6442</td>
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<tr>
<td>VcMAX(K)</td>
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<td>136.61</td>
<td>136.61</td>
<td>136.61</td>
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<td>STIRRUPS</td>
<td>REQ'D</td>
<td>REQ'D</td>
<td>MIN</td>
<td>MIN</td>
<td>MIN</td>
<td>N/R</td>
</tr>
<tr>
<td>BAR SIZE</td>
<td>4</td>
<td>4</td>
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<td>BAR AREA</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>MIN SPCG</td>
<td>22.5</td>
<td>22.5</td>
<td>22.5</td>
<td>22.5</td>
<td>22.5</td>
<td>22.5</td>
</tr>
<tr>
<td>AvMIN(in2)</td>
<td>0.17306</td>
<td>0.47288</td>
<td>0.1118</td>
<td>0.1118</td>
<td>0.1118</td>
<td>N/A</td>
</tr>
<tr>
<td>STIRRUP TYPE</td>
<td>[_]</td>
<td>[_]</td>
<td>[_]</td>
<td>[_]</td>
<td>[_]</td>
<td>[_]</td>
</tr>
<tr>
<td>Vs(kips)</td>
<td>17.6151</td>
<td>6.05233</td>
<td>25.6</td>
<td>25.6</td>
<td>25.6</td>
<td>28.4373</td>
</tr>
<tr>
<td>PhiVn(K)</td>
<td>121.112</td>
<td>107.49</td>
<td>137.879</td>
<td>123.113</td>
<td>70.157</td>
<td>75.7672</td>
</tr>
</tbody>
</table>
### POST-TENSION SERVICE STRESS

**REFERENCE CODE:** TYP. BM. 18"X30"/-Ms @ FACE OF EXT. SUPPORT/CRSI

<table>
<thead>
<tr>
<th>SPAN (ft)</th>
<th>50</th>
<th>h (in)</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sb (in3)</td>
<td>3944.5</td>
<td>yb (in)</td>
<td>21.8</td>
</tr>
<tr>
<td>St (in3)</td>
<td>10486.5</td>
<td>yt (in)</td>
<td>8.2</td>
</tr>
<tr>
<td>Ag (in2)</td>
<td>2514</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ms (KF)</td>
<td>-434.43</td>
<td>MsDLi (KF)=</td>
<td>-337.6</td>
</tr>
<tr>
<td>f'(psi)</td>
<td>4000</td>
<td>f'(psi)</td>
<td>2400</td>
</tr>
</tbody>
</table>

**FOR 1 STRAND:**

| Mb (KF) | 22.05 | INITIAL LOSSES(%)= | 3 |
| P/T(kips) | 28.45 | LONGTERM LOSSES(K)= | 3.06 |
| Aps(in2) | 0.153 | |

**NUMBER OF STRANDS REQ'D =** 0.62352 [7.5*SQR T f'c]

**DESIRED NO# OF STRANDS =** 12

| fa(P/A) | 135.8 | P/Amin= | 125psi |
| SERVICE | INITIAL | |

**STRESS AT:**

| fb (psi) | 652.458 | 308.141 |
| 12 STRANDS: ft (psi) | -58.542 | 84.864 |
| ALLOWABLE f/tension (psi) | -474.34 | -146.97 |
| STRESS: f/compr. (psi) | 1800 | 1440 |

### UNBONDED ULTIMATE STRENGTH

<table>
<thead>
<tr>
<th>ONE-WAY BM/SLAB</th>
<th>TWO-WAY PLATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO=0;YES=1</td>
<td>1</td>
</tr>
<tr>
<td>ULTIMATE LOAD FACTOR</td>
<td>1.47</td>
</tr>
<tr>
<td>bw(in)</td>
<td>18</td>
</tr>
<tr>
<td>bf(in)</td>
<td>130</td>
</tr>
<tr>
<td>dp(in)</td>
<td>20.07</td>
</tr>
<tr>
<td>d (in)</td>
<td>27.5</td>
</tr>
<tr>
<td>e (in)</td>
<td>0</td>
</tr>
<tr>
<td>hf (in)</td>
<td>7</td>
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<tr>
<td>MINIMUM BONDED As(in2)</td>
<td>3.7264</td>
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<td>DESIRED REINF. As(in2)</td>
<td>3.96</td>
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<tr>
<td>Pps</td>
<td>0.00508</td>
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<tr>
<td>fse (ksi)=</td>
<td>185.948</td>
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<tr>
<td>fps (ksi)=</td>
<td>203.818</td>
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<td>SECONDARY EFFECT(KF)</td>
<td>264.6</td>
</tr>
<tr>
<td>Mu (KF)</td>
<td>-374.01</td>
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<tr>
<td>PhiMn (KF)</td>
<td>-823.97</td>
</tr>
<tr>
<td>1.2*Mocr (KF)</td>
<td>-957.34</td>
</tr>
<tr>
<td>LOCATION</td>
<td>1</td>
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<tr>
<td>----------</td>
<td>-----</td>
</tr>
<tr>
<td>DISTANCE</td>
<td>2.25</td>
</tr>
<tr>
<td>Vu(kips)</td>
<td>104.3</td>
</tr>
<tr>
<td>Mu(KF)</td>
<td>-504.37</td>
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<tr>
<td>dp(in)</td>
<td>17.8</td>
</tr>
<tr>
<td>Vc(kips)</td>
<td>109.152</td>
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<tr>
<td>VcMIN(K)</td>
<td>54.6442</td>
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<tr>
<td>VcMAX(K)</td>
<td>136.61</td>
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<tr>
<td>STIRRUPS</td>
<td>Req'D</td>
</tr>
<tr>
<td>BAR SIZE</td>
<td>4</td>
</tr>
<tr>
<td>BAR AREA</td>
<td>0.2</td>
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<tr>
<td>MIN SP CG</td>
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<tr>
<td>REQ'D SP CG(in)</td>
<td>42.5</td>
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<td>AvMIN(in2)</td>
<td>0.21117</td>
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<td>STIRRUP TYPE</td>
<td>[]</td>
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<tr>
<td>Vs(kips)</td>
<td>13.5529</td>
</tr>
<tr>
<td>PhiVn(K)</td>
<td>104.299</td>
</tr>
</tbody>
</table>
DESIGN EXAMPLE

TRANSFER BEAM 48"x30"

SECTION PROPERTIES:

\[ b_f = 75" \]

\[ (l_n/12) \]

\[ y_b = \frac{(75\times7\times26.5) + (48\times23\times11.5)}{(525 + 1104)} = 16.33; \ y_t = 13.67 \]

\[ I_g = \left[ \left( \frac{75\times(7)^3}{12} \right) + \left( 525 \times (10.17)^2 \right) \right] + \left[ \left( \frac{48\times(23)^3}{12} \right) + \left( 1104 \times (2.17)^2 \right) \right] = 110310.5 \text{in}^4 \]

\[ S_b = 6755.1 \text{in}^3; \ S_t = 8069.5 \text{in}^3 \]

THE 7" SLAB IS POST-TENSIONED PARALLEL TO THIS BEAM THEREFORE; \[ A_g = (525 + 1104) = 1629 \text{in}^2. \]

STRAIGHT DRAPE/BEAM DIAGRAM:

STRAND ANCHOR ECCENTRIC TO N.A. C SUPPORT.
DESIGN EXAMPLE

LOADING:

\[ \text{ws-DL} = \left( \frac{1629}{144} \right) \times 150 \text{ PCF} = 1.7 \text{ KLF} \]

beam

\[ \text{LL} = \left( \frac{75}{12} \right) \times 30 \text{ PSF} = 0.1875 \text{ KLF} \]

ASSUME: BEAM REACTION IS THE SAME AS TYPICAL BEAM AT EXTERIOR COLUMN.

\[ \text{Ps-DL} = 78.53 \times 77.7\% = 61.02 \text{ KIPS} \]

\[ \text{LL} = 78.53 \times 22.3\% = 17.51 \text{ KIPS} \]

\[ \text{Ts-DL} = 511.27 \times 77.7\% = 397.26 \text{ KF} \]

\[ \text{LL} = 511.27 \times 22.3\% = 114.01 \text{ KF} \]

ASSUME: UNIFORM DISTRIBUTION OF Ts TO SUPPORTING COLUMNS.

\[ \text{Tu} = \left( 1.47 \times 511.27 \right) / 2 = 375.78 \text{ KF} \]

NOTES:

- SEE POST-TENSION LOSS PROGRAM PRINTOUT FOR ALL P/T LOSSES, wb AND STRAND DRAPE LOCATION. (SHEET NO# 14&15)

- SEE ONE STORY FRAME ANALYSIS PROGRAM PRINTOUT FOR ALL GRAVITY AND BALANCING LOAD MOMENTS AND SHEARS. (SHEET NO# 16)
TRANSFER BEAM 48" x 30"/CRSI

NUMBER OF SPANS = 1
LEFT CANTILEVER NO
RIGHT CANTILEVER NO
STRAND SIZE = 1/2 inch
fpu = 270 ksi
Aps = .153 in^2
E = 28500 ksi
WEDGE SET = .25 inch
FRICITION COEFFICIENT(u) = .07
WOBBLE FACTOR(k) = .0014
LOW-LAX STRAND YES
STRESS-RELIEVED STRAND NO
SLAB SECTION NO
BEAM OR JOIST SECTION YES

<table>
<thead>
<tr>
<th>SPAN (ft)</th>
<th>LENGTH</th>
<th>LEFT SUPPORT ECC. (inch)</th>
<th>MIDSPAN ECC. (in.)</th>
<th>RIGHT SUPPORT ECC. (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>6.75</td>
<td>-14</td>
<td>6.75</td>
</tr>
</tbody>
</table>

JACKING FORCE = .75 fpuAps = 30.9825 kips
ANCHOR SET LOSS = 3.63375 kips
LIVE END ANCHORED FORCE = 27.3487 kips
MAXIMUM LE ANCHORAGE FORCE = .70fpuAps = 28.917 kips
LENGTH OF STRAND INFLUENCED BY ANCHOR SET > 25 ft.
DEAD END ANCHORED FORCE = 27.943 kips
TOTAL ANGULAR CHANGE = .276667 radians

LONGTERM LOSSES = 3.06 kips

BALANCING LOADS

<table>
<thead>
<tr>
<th>SPAN</th>
<th>h (inch)</th>
<th>P/T (kips) (AVE.NET)</th>
<th>wb (klf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.75</td>
<td>24.58</td>
<td>.544</td>
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</tbody>
</table>
STRAND LOCATION  
(PARABOLIC DRAPE)

CAS MEASURED FROM N.A.:+ ABOVE/- BELOW (inches)

<table>
<thead>
<tr>
<th>SPAN</th>
<th>FACE OF</th>
<th>h/2 FROM</th>
<th>2/10</th>
<th>3/10</th>
<th>4/10</th>
<th>5/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO#</td>
<td>LEFT</td>
<td>SUPPORT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3.56</td>
<td>-0.05</td>
<td>-6.53</td>
<td>-10.68</td>
<td>-13.17</td>
<td>-14.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPAN</th>
<th>FACE OF</th>
<th>h/2 FROM</th>
<th>2/10</th>
<th>3/10</th>
<th>4/10</th>
<th>5/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO#</td>
<td>LEFT</td>
<td>SUPPORT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-13.17</td>
<td>-10.68</td>
<td>-6.53</td>
<td>-0.05</td>
<td>3.56</td>
<td></td>
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</table>
### ONE STORY FRAME ANALYSIS:

<table>
<thead>
<tr>
<th>Joint 0</th>
<th>Column Above</th>
<th>94.41 kft</th>
<th>Column Below</th>
<th>94.41 kft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column Above</td>
<td>21.80 kft</td>
<td>Column Below</td>
<td>21.80 kft</td>
<td></td>
</tr>
<tr>
<td>Clockwise</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Joint 1</th>
<th>Column Above</th>
<th>-94.41 kft</th>
<th>Column Below</th>
<th>-94.41 kft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column Above</td>
<td>-21.80 kft</td>
<td>Column Below</td>
<td>-21.80 kft</td>
<td></td>
</tr>
<tr>
<td>Clockwise</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**Ultimate Load Factor**

\[
\text{Ultimate Load Factor} = \left( 1.4 \times 325.00 + 1.7 \times 80.48 \right) / 409.34 = 1.40
\]
POST-TENSION SERVICE STRESS

REFERENCE CODE: TRANSFER BEAM/MAX POSITIVE MOMENT/CSRI

SPAN (ft) = 25 h (in) = 30
Sb (in) = 6755.1 yb (in) = 16.33
St (in) = 8069.5 yt (in) = 13.67
Ag (in) = 1629
Ms (KF) = 405.84 MsDLi (KF) = 325.36
f'c (psi) = 4000 f'ci (psi) = 2400
FOR 1 STRAND:
Mb (KF) = -23.34 INITIAL LOSSES (%) = 3
P/T (kips) = 24.58 LONGTERM LOSSES (K) = 3.06
Aps (in) = 0.153

NUMBER OF STRANDS REQ'D = 4.36079 [7.5*SQRT f'c]
DESIRE NO# OF STRANDS = 9 fa(P/A) = 135.801 P/Amin = 125psi

STRESS AT SERVICE INITIAL
9 STRANDS: ft (psi) = 426.942 291.236
ALLOWABLE f/tension (psi) = -474.34 -146.97
STRESS: f/comp. (psi) = 1800 1440

UNBONDED ULTIMATE STRENGTH

<table>
<thead>
<tr>
<th>ONE-WAY BM/SLAB</th>
<th>TWO-WAY PLATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO=0; YES=1</td>
<td>1</td>
</tr>
<tr>
<td>ULTIMATE LOAD FACTOR</td>
<td>1.46</td>
</tr>
<tr>
<td>span/depth ratio</td>
<td>10</td>
</tr>
<tr>
<td>bw (in)</td>
<td>48</td>
</tr>
<tr>
<td>bf (in)</td>
<td>75</td>
</tr>
<tr>
<td>dp (in)</td>
<td>27.75</td>
</tr>
<tr>
<td>d (in)</td>
<td>27.5</td>
</tr>
<tr>
<td>e (in)</td>
<td>14</td>
</tr>
<tr>
<td>hf (in)</td>
<td>7</td>
</tr>
<tr>
<td>MINIMUM BONDED As (in)</td>
<td>3.13536</td>
</tr>
<tr>
<td>DESIRED REINF. As</td>
<td>3.52</td>
</tr>
<tr>
<td>Pps</td>
<td>0.00066</td>
</tr>
<tr>
<td>fse (ksi)</td>
<td>160.654 w = 0.0256</td>
</tr>
<tr>
<td>fps (ksi)</td>
<td>231.111 w + wp = 0.03823</td>
</tr>
<tr>
<td>SECONDARY EFFECT(KF)</td>
<td>48.03</td>
</tr>
<tr>
<td>Mu (KF)</td>
<td>640.556</td>
</tr>
<tr>
<td>PhilMn (KF)</td>
<td>1056.72 ADEQ. REINF. PROVIDED</td>
</tr>
<tr>
<td>1.2*Mocr (KF)</td>
<td>664.23 ADEQ. REINF. PROVIDED</td>
</tr>
</tbody>
</table>
POST-TENSION SERVICE STRESS

REFERENCE CODE: TRANSFER BEAM/-Ms @ FACE OF SUPPORT/CRSI

SPAN (ft) = 25
Sb (in3) = 6755.1
St (in3) = 8069.5
Ag (in2) = 1629
Ms (KF) = -170.51
f’c (psi) = 4000
FOR 1 STRAND:
Mb (KF) = 12.63
P/T (kips) = 24.58
Aps (in2) = 0.153

NUMBER OF STRANDS REQ’D = -6.5183 [7.5√f’c]
SERIAL INITIAL
DESIRED NO# OF STRANDS = 9
fa(P/A) = 135.801
P/Amin = 125 psi

STRESS AT SERVICE
fb (psi) = 236.774
172.86
9 STRANDS: ft (psi) = 51.2754
127.42
ALLOWABLE f/tension (psi) = -474.34
-146.97
STRESS: f/comp. (psi) = 1800
1440

UNBONDED ULTIMATE STRENGTH

<table>
<thead>
<tr>
<th>ONE-WAY BM/SLAB</th>
<th>TWO-WAY PLATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO=0; YES=1</td>
<td>1</td>
</tr>
<tr>
<td>ULTIMATE LOAD FACTOR = 1.46</td>
<td>SPAN/DEPTH RATIO = 10</td>
</tr>
<tr>
<td>bw (in) = 48</td>
<td>f(y) (ksi) = 60</td>
</tr>
<tr>
<td>bf (in) = 75</td>
<td>(w = 0.04)</td>
</tr>
<tr>
<td>dp (in) = 19.81</td>
<td>(w = 0.07178)</td>
</tr>
<tr>
<td>d (in) = 27.5</td>
<td>(w + wp = 0.11178)</td>
</tr>
<tr>
<td>e (in) = 3.56</td>
<td>(MAX w + wp = 0.306)</td>
</tr>
<tr>
<td>hf (in) = 7</td>
<td>(w = 0.04)</td>
</tr>
<tr>
<td>MINIMUM BONDED As (in2) = 3.38064</td>
<td>(f_{se} (ksi) = 160.654)</td>
</tr>
<tr>
<td>DESIRED REINF. As (in2) = 3.52</td>
<td>(fps (ksi) = 198.275)</td>
</tr>
<tr>
<td>Pps = 0.00145</td>
<td>Mu (KF) = (-200.9)</td>
</tr>
<tr>
<td>fse (ksi) = 160.654</td>
<td>PhiMn (KF) = (-787.37) ADEQ. REINF. PROVIDED</td>
</tr>
<tr>
<td>fps (ksi) = 198.275</td>
<td>1.2(\mu_{ocr}) (KF) = (-628.76) ADEQ. REINF. PROVIDED</td>
</tr>
</tbody>
</table>
TORSIONAL SECTION PROPERTIES:

\[ P_c = (48 + 30 + 69 + 7 + 21 + 23) = 198 \text{in}^2 \]

\[ A_c = (48 \times 30) + (21 \times 7) = 1587 \text{in}^2 \]

\[ d_v = 30 - [(2 \times 1.5) + (2 \times 0.625) + 0.75] = 25 \text{in} \]

\[ b_v = 48 - (2 \times 1.5) = 45 \text{in} \]

DETERMINE \( V_p \):

\[ \tan \theta = \frac{20.75''}{150''} = 0.1383; \ \theta = 7.876 \text{ DEGREES} \]

\[ V_p = (9 \times 24.58) \times \sin \theta = 30.313 \text{ KIPS} \]
### Ultimate Beam Shear/Torsion Analysis

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td>DISTANCE</td>
<td>2.25</td>
<td>2.5</td>
<td>5</td>
<td>7.5</td>
<td>10</td>
<td>12.5</td>
</tr>
<tr>
<td>Vu(kips)</td>
<td>85.26</td>
<td>84.56</td>
<td>77.84</td>
<td>71.09</td>
<td>64.34</td>
<td>57.59</td>
</tr>
<tr>
<td>Ms(KE)</td>
<td>-95.76</td>
<td>-81.19</td>
<td>58.27</td>
<td>185.92</td>
<td>301.79</td>
<td>405.84</td>
</tr>
<tr>
<td>Tu(KE)</td>
<td>375.78</td>
<td>375.78</td>
<td>375.76</td>
<td>375.78</td>
<td>375.78</td>
<td>375.78</td>
</tr>
<tr>
<td>(TOTAL)Tu(KE)</td>
<td>47.13</td>
<td>24.74</td>
<td>-72.36</td>
<td>-146.86</td>
<td>-194.76</td>
<td>-210.36</td>
</tr>
<tr>
<td>Ac(in²)</td>
<td>1587</td>
<td>1587</td>
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<td>1587</td>
<td>1587</td>
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<tr>
<td>Pto(in²)</td>
<td>198</td>
<td>198</td>
<td>198</td>
<td>198</td>
<td>198</td>
<td>198</td>
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<tr>
<td>bv(in)</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>dv(in)</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Aoh(in²)</td>
<td>1125</td>
<td>1125</td>
<td>1125</td>
<td>1125</td>
<td>1125</td>
<td>1125</td>
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<tr>
<td>ph(in)</td>
<td>140</td>
<td>140</td>
<td>140</td>
<td>140</td>
<td>140</td>
<td>140</td>
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<tr>
<td>dp(in)</td>
<td>16.2</td>
<td>16.1</td>
<td>20.28</td>
<td>24.43</td>
<td>26.92</td>
<td>27.75</td>
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<tr>
<td>e(in)</td>
<td>0</td>
<td>0</td>
<td>6.53</td>
<td>10.58</td>
<td>13.17</td>
<td>14</td>
</tr>
<tr>
<td>Vp(kips)</td>
<td>30.313</td>
<td>30.313</td>
<td>30.313</td>
<td>30.313</td>
<td>30.313</td>
<td>30.313</td>
</tr>
<tr>
<td>fps(ksi)</td>
<td>193.242</td>
<td>193.102</td>
<td>214.837</td>
<td>223.878</td>
<td>229.303</td>
<td>231.111</td>
</tr>
<tr>
<td>As(in²)</td>
<td>3.52</td>
<td>3.52</td>
<td>3.52</td>
<td>3.52</td>
<td>3.52</td>
<td>3.52</td>
</tr>
<tr>
<td>d(in)</td>
<td>27.5</td>
<td>27.5</td>
<td>27.5</td>
<td>27.5</td>
<td>27.5</td>
<td>27.5</td>
</tr>
<tr>
<td>Mu(KF)</td>
<td>-92.68</td>
<td>-83.797</td>
<td>133.095</td>
<td>319.469</td>
<td>488.642</td>
<td>640.256</td>
</tr>
<tr>
<td>Phin(KF)</td>
<td>-706.56</td>
<td>-704.37</td>
<td>847.752</td>
<td>960.781</td>
<td>1032.26</td>
<td>1056.72</td>
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<tr>
<td>1.2thocr(KF)</td>
<td>-548.91</td>
<td>-534.04</td>
<td>498.99</td>
<td>590.79</td>
<td>645.87</td>
<td>664.59</td>
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<tr>
<td>INCREASE REINF.</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO (FLEXURAL)</td>
</tr>
<tr>
<td>Phi.67%toocr(KF)</td>
<td>189.322</td>
<td>189.322</td>
<td>189.322</td>
<td>189.322</td>
<td>189.322</td>
<td>189.322</td>
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<tr>
<td>Xto REINF. RED'D</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES (STIRRUPS)</td>
</tr>
<tr>
<td>tn(KSI)</td>
<td>0.64905</td>
<td>0.64832</td>
<td>0.6413</td>
<td>0.63424</td>
<td>0.62718</td>
<td>0.62012</td>
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<tr>
<td>THETA MIN</td>
<td>23.5896</td>
<td>23.5743</td>
<td>23.4271</td>
<td>23.2752</td>
<td>23.1315</td>
<td>22.9837</td>
</tr>
<tr>
<td>THETA MAX</td>
<td>60.1097</td>
<td>60.1321</td>
<td>60.3475</td>
<td>60.5638</td>
<td>60.7801</td>
<td>60.9965</td>
</tr>
<tr>
<td>INCREASE SECTION</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO (SEE NOTE 1)</td>
</tr>
<tr>
<td>ATHETA(degrees)</td>
<td>41.8496</td>
<td>41.8532</td>
<td>41.8873</td>
<td>41.9216</td>
<td>41.9558</td>
<td>41.9901 (AVERAGE)</td>
</tr>
<tr>
<td>Vocr(kips)</td>
<td>391.599</td>
<td>391.599</td>
<td>391.599</td>
<td>398.072</td>
<td>435.556</td>
<td>448.05</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Theta/Actual</td>
<td>41.8496</td>
<td>41.8532</td>
<td>41.8873</td>
<td>41.9216</td>
<td>41.9558</td>
<td>41.9901</td>
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<tr>
<td>aot(in)</td>
<td>1.54366</td>
<td>1.54364</td>
<td>1.54341</td>
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<td>Aaot(in²)</td>
<td>1016.94</td>
<td>1016.95</td>
<td>1016.96</td>
<td>1016.98</td>
<td>1016.99</td>
<td>1017.01</td>
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<tr>
<td>Att2(ft)</td>
<td>0.46724</td>
<td>0.46723</td>
<td>0.46785</td>
<td>0.46841</td>
<td>0.46897</td>
<td>0.46952</td>
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<tr>
<td>Att2(ft)</td>
<td>0.50152</td>
<td>0.49568</td>
<td>0.49955</td>
<td>0.38304</td>
<td>0.32638</td>
<td>0.26959</td>
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<tr>
<td>Av2(ft)</td>
<td>0.02738</td>
<td>0.02738</td>
<td>0.02738</td>
<td>0.02714</td>
<td>0.02586</td>
<td>0.02547</td>
</tr>
</tbody>
</table>

**STIRRUP TYPES:**
- A;[1]
- B;[II]
- C;[[11],[11]]

**BAR SIZE:**
- 5
- 5
- 5
- 5
- 5
- 5

**BAR AREA:**
- 0.31
- 0.31
- 0.31
- 0.31
- 0.31
- 0.31
- (in²/LEG)

**BAR TYPE:**
- B B B B B B

**RED'D SPACING:**
- 10.36
- 10.4
- 10.82
- 11.27
- 11.77
- 12
- (in.)

**DELTAu (kips):**
- 337.864
- 337.668
- 335.885
- 334.261
- 332.805
- 331.519

**MINMn(KE):**
- -508.95
- -499.02
- 559.597
- 764.599
- 950.786
- 1117.67

**LONG.REINF.RED'D**
- NO
- NO
- NO
- NO
- NO
- NO
- (MINMn>Phimn/.90)

**NOTE 1:** Check to insure that the transverse reinforcement yields before diagonal crushing of the concrete.
DESIGN EXAMPLE: TRANSFER BEAM 48" X 30" - M_o @ FACE OF SUPPORT

NOTE: SEE SHEET NO. 12, 19 & 20 FOR PROGRAM OUTPUT VALUES CORRESPONDING TO FOLLOWING HAND CALCULATIONS.

NUMBER OF STRANDS REQ'D = \[ \frac{(12 \times 12) + ((807.9 \times 24.58) / 1029)}{-6.02} \]

\[ f_o = \frac{(24.58 \times 9)}{1029 \times 1000} = 199.8 \text{ psi} \]

\[ f_b = \left( \frac{(24.58 \times 9 \times 1000)}{1029} \right) - \left( \frac{(170.51 \times 12000)}{6759.1} \right) - \left( \frac{(12.69 \times 9 \times 12000)}{6759.1} \right) \]

\[ = 290.77 \text{ psi (SERVICE)} \]

\[ f_b = \left( \frac{9 \times ((24.58 + 9.00) \times (1 - (9.0 / 100)) \times (1000 / 1029)) - ((170.51 \times 12000) / 6759.1)}{172.80 \text{ psi (INITIAL)}} \]

\[ f_t = \left( \frac{(24.58 \times 9 \times 1000)}{1029} \right) + \left( \frac{(170.51 \times 12000)}{8069.5} \right) + \left( \frac{(12.69 \times 9 \times 12000)}{8069.5} \right) \]

\[ = 512.27 \text{ psi (SERVICE)} \]

\[ f_t = \left( \frac{9 \times ((24.58 + 9.00) \times (1 - (9.0 / 100)) \times (1000 / 1029)) + ((170.51 \times 12000) / 8069.5)}{127.42 \text{ psi (INITIAL)}} \]

ALLOWABLE STRESSES:

\[ f_{tension} = \frac{1.5 \times \sqrt{1000}}{1474.94 \text{ psi (SERVICE)}} \]

\[ = \frac{9 \times \sqrt{2400}}{1410.97 \text{ psi (INITIAL)}} \]

\[ f_{comp} = \frac{.45 \times 4000}{1800 \text{ psi (SERVICE)}} \]

\[ = \frac{.10 \times 2400}{1440 \text{ psi (INITIAL)}} \]

SPAN/DEPTH RATIO = \( \frac{29 \times 12}{30} = 10 \)

MINIMUM BONDED A_o = .004 \times ((7^* - 7^*) + ((15.67 - 7^*) \times 43^*)) = 9.38 \text{ in}^2

C_o = \left( \frac{9 \times 133}{(48 \times 19.81)} \right) = .00145

\[ f_{o_c} = 24.58 / 133 = 180.60 \text{ ksi} ; \quad f_o = 180.60 + 10 + \left( \frac{4000}{100 \times C_o} \right) = 198.27 \text{ ksi} \]

\[ w = \left( \frac{(8.072 \times (43 \times 1.5))}{100 \times 4} \right) = 0.04 \]

\[ w_p = C_o \times f_{p_o} / 4 \text{ ksi} \]

\[ = 0.0718 \]

\[ w + w_p < .90 \times (C_1 = .90 \times .85 = .765) \]

\[ 1.118 = w + w_p < .765 \times .765 = .586 \]
SECONDARY EFFECT = \((12.08 \times 9) - ((2.50/12) \times 24.88 \times 9)\) \(= 48.04\) KF

\[M_u = (1.140 \times -170.51) + 48.04 = -200.9\) KF

\[M_n = \phi M_n = \frac{(1.59 \times 9 \times f_p \times (d - \alpha/2)) + (3.52 \times 60 \times (d - \alpha/2))}{12} = -187.81\) KF

\[1.2 \times Moor = 1.2 \times \left(\frac{400 \times 4.5}{12000} \times \left(\frac{1.5 \times 4000}{100} \right) + ((24.88 \times 9)/1024) + \right)
\left(\frac{(12.08 \times 9 \times 12000)}{8009.5} \times 1000\right)\] \(= -628.76\) KF

ULTIMATE BEAM SHEAR/TORSION ANALYSIS

\[A_{ch} = (45^\circ \times 25^\circ) = 1125\) in²

\[\phi h = (2 \times 45^\circ) + (2 \times 25^\circ) = 140^\circ\]

\[f_p = 0.0018; f_p = 199.24\) KSI

\[M_u = (1.140 \times -99.76) + (47.15\) KF - ((\(-0.12) \times 24.88 \times 9))) = -92.68\) KF

\[\phi M_n = \text{CALCULATED THE SAME AS PHI MN ABOVE}; \text{ SUBSTITUTE } \phi = 0.2^\circ\]

\[\phi M_n = 477.29\) KF; \(\alpha = 1.925^\circ; \phi M_n = -706.95\) KF

\[1.2 \times Moor = \text{CALCULATED THE SAME AS 1.2 \times Moor ABOVE}; \text{ SUBSTITUTE } M_{\phi} = 47.15\) KF

\[= -543.91\) KF

\[\phi \times 0.67 \times T_{oor} = 0.85 \times 0.67 \times \left(\frac{((1987/12)/198) \times (4 \times \sqrt{4000})}{(\sqrt{1 + (((24.88 \times 9)/1629) \times 1000)/(4 \times (24.88 \times 9)))}}\right) \times 12000\] \(= 189.92\) KF

\[t_n = \left(\frac{(29.20 \times 0.85 - 30.313)}{(45 \times 25)} + ((375.78 \times 25 \times 12 \times 140)/1125)\right) = 19.989\) KSI

\[\text{THETA MIN} = 10 + (29.15 \times (t_n/(4000/1000))) = 19.989^\circ\]

\[\text{THETA MAX} = 80 - (12.62 \times (t_n/(4000/1000))) = 60.11^\circ\]

\[39.7/2 = 41.85^\circ\) ANGLE
\[ V_{oc} = \frac{((48 \times 14 \times (4 \times \sqrt{4000})) \times (-1 + \frac{((24.98 \times 9) / 1029) \times 1000)}{(4 \times \sqrt{4000})))}{1000} \]
\[ = 9.61.27 + 30.312 = 391.60 \text{ K} \]

\[ a_o = \left( \frac{11.25 / 140}{(1 - \sqrt{1 - (((375.78 / 85) \times 12000) / 85 \times 4000 \times 1125^2)})} \right) \times (\tan 41.85^\circ) + (1 / (\tan 41.85^\circ))) \]
\[ = 1.0497 \]

\[ A_0 = 1125 - \left( a_o \times 140 / 2 \right) = 1010.94 \]

\[ A_f = 12 \times (((375.78 / 85) \times 12 \times (\tan 41.85^\circ)) / (2 \times A_0 \times 60)) = 4.673 \text{ in}^2 / \text{FT} \]

\[ A_r = 12 \times \left( (((85.10 / 85) - 30.313) \times (\tan 41.85^\circ)) / (60 \times 25) \right) = 0.015 \text{ in}^2 / \text{FT} \]

\[ A_{min} = 2A_f = \left( 1.153 \times 9 / 80 \right) \times (270 / 60) \times (12 / 24) \times \sqrt{24 / 48} = 0.0274 \text{ in}^2 / \text{FT} \]

\[ \text{Req'd Spacing} = 0.91 \text{ in}^2 / \left( ((0.9015 / 24) + (0.4075 / 12)) / 2 \right) = 10.96'' \]

\[ \text{(Type B stirrup)} \]

\[ \Delta N_o = \left( \frac{1}{(\tan 41.85^\circ))} \times \sqrt{(((85.10 - (85 \times 30.313))^2) + (((375.78 \times 12 \times \left( 140 - (4 \times a_o)) / (2 \times A_0))^2))}{1000} \]
\[ = 393.80 \text{ K} \]

\[ \text{MINM} = \left( (25 \times 375.78 \times 12 \times (140 - (4 \times a_o)) / (2 \times (\tan 41.85^\circ) \times 85 \times 2 \times A_0)) \right. \]
\[ - (12 \times -92.6796 / 90) / 12 \]
\[ = 508.94 \text{ KF} \]
CHECK: SERVICE STRESS PORTION OF PROGRAM FOR CALCULATION OF BONDED AUXILIARY TENSION REINFORCEMENT AND $f'_{ci \min}$. SEE SHT. # 5 FOR CORRESPONDING PROGRAM PRINTOUT OF ADAPTATION OF EXAMPLE USED ON SHT. # 1.

INITIAL STRESS $\sigma'_{k} >$ ALLOWABLE

\[
\sigma'_{k} = \left(\frac{1 - 147.71}{(1 - 147.71 + 1005.21)/90^\circ}}\right) \times \left(147.71/2 \times 48^\circ\right)
\]
\[
= \frac{2987}{10000} \text{ psi}
\]

\( \sigma'_{k} > \) ALLOWABLE

\[
f'_{ci \min} = \frac{1005.21}{400} = 2675.52 \text{ psi}
\]
**POST-TENSION SERVICE STRESS**

<table>
<thead>
<tr>
<th>Reference Code: Transfer Beam/-Ms @ Face of Support/CRSI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Span (ft)</strong> = 25</td>
</tr>
<tr>
<td><strong>Sb (in3)</strong> = 6755.1</td>
</tr>
<tr>
<td><strong>St (in3)</strong> = 8069.5</td>
</tr>
<tr>
<td><strong>Ag (in2)</strong> = 1629</td>
</tr>
<tr>
<td><strong>Ms (KF)</strong> = -170.51</td>
</tr>
<tr>
<td><strong>f'c (psi)</strong> = 4000</td>
</tr>
</tbody>
</table>

**For 1 Strand:**

- **Mb (KF)** = 12.63
- **P/T (kips)** = 24.58
- **Aps (in2)** = 0.153

**Number of Strands Req'd** = $-6.5183 \times 7.5 \times SQRT \ f'c$

**Desired No# of Strands** = 49

**Stress at fb (psi)** = -57.121

**Allowable f/tension (psi)** = -474.34

**Stress: f/comp. (psi)** = 1800

**Service:**

**f/a (P/A)** = 739.362

**P/Amin** = 125 psi

**Asreq’d** 0.29871

**f’cimín** 2675.36

**Initial:**

**-147.71**
CHECK: ULTIMATE BEAM SHEAR PORTION OF PROGRAM. SEE SHEET #7 FOR CORRESPONDING PROGRAM PRINTOUT FOR DESIGN EXAMPLE USED ON SHEET #1 ASSUMING $V_0 = -0$ AND $V$ AT W/2 FROM THE FACE OF THE SUPPORT EQUALS $941.04 \text{k}$. 

\[
V_c \geq \left( \frac{V_0}{d} \right)_{M_0} = \left( \frac{941.04 \text{k} \times 162}{1 \times (159.81 \text{k} \times 12)} \right) = 9.29 > 1.0 \\
1000 = \left( \frac{60 \times \sqrt{4000} + (100 \times 1)}{(24 \times 48)} \right) \times 860.12 \text{k} \\
\text{WHERE: } d_{\text{MIN}} = 8 \text{in} = 24 \text{in} \\
\]

\[
V_c_{\text{MIN}} = \left( \frac{2 \times \sqrt{4000} \times (24 \times 48) \times 1000}{1000} \right) = 145.72 \text{k} \\
\]

\[
V_c_{\text{MAX}} = \frac{5 \times V_c}{b \times d} = 904.29 \text{k} \\
\]

ARE STIRRUPS REQ'D? \( 85 \times V_c_{\text{MAX}} = 909.65 \text{k} < V_0 \), YES/REQ'D 

\[
\text{MIN SPACING = } 75 \times h = 22.5'' < 24'' \\
\]

\[
\text{MIN } = \left( \frac{(24 \times 2) \times (60 \times 24)}{(941.04 \text{k} \times 2) \times (15.59 \text{k} \times 24) \times \sqrt{24 \times 48} \text{k} \times 1000} \right) = 0.0946 \text{ in}^2 \\
\]

\[
V_c = \left( \frac{24 \times 2 \times (60 \times 24)}{15.59 \text{k}} \right) = 90.92 \text{k} \\
\]

\[
\text{MIN } = (30.92 + 304.29) = 341.04 \text{k} \\
\]
<table>
<thead>
<tr>
<th>LOCATION</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td>DISTANCE</td>
<td>2.25</td>
<td>2.5</td>
<td>5</td>
<td>7.5</td>
<td>10</td>
<td>12.5</td>
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<tr>
<td>Vu(kips)</td>
<td>341.04</td>
<td>84.56</td>
<td>77.84</td>
<td>71.09</td>
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<td>Mu(KF)</td>
<td>-139.81</td>
<td>-118.54</td>
<td>85.07</td>
<td>271.44</td>
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<tr>
<td>dp(in)</td>
<td>16.2</td>
<td>16.1</td>
<td>20.28</td>
<td>24.43</td>
<td>26.92</td>
<td>27.75</td>
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<td>Vc(kips)</td>
<td>850.115</td>
<td>815.498</td>
<td>850.115</td>
<td>482.161</td>
<td>345.336</td>
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<td>VcMIN(K)</td>
<td>145.718</td>
<td>145.718</td>
<td>145.718</td>
<td>148.329</td>
<td>163.447</td>
<td>168.486</td>
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<tr>
<td>VcMAX(K)</td>
<td>364.294</td>
<td>364.294</td>
<td>364.294</td>
<td>370.821</td>
<td>408.617</td>
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<td>STIRRUPS</td>
<td>REQ'D</td>
<td>N/R</td>
<td>N/R</td>
<td>N/R</td>
<td>N/R</td>
<td>N/R</td>
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<tr>
<td>BAR SIZE</td>
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<td>4</td>
<td>4</td>
<td>4</td>
<td>60ksi</td>
</tr>
<tr>
<td>BAR AREA</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>MIN SPCG</td>
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<td>22.5</td>
<td>22.5</td>
<td>22.5</td>
<td>22.5</td>
<td>22.5</td>
</tr>
<tr>
<td>REQ'D SPCG(in)</td>
<td>15.6</td>
<td>22.5</td>
<td>22.5</td>
<td>22.5</td>
<td>22.5</td>
<td>22.5</td>
</tr>
<tr>
<td>AvMIN(in2)</td>
<td>0.0356</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>STIRRUP TYPE</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Vs(kips)</td>
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<tr>
<td>PhiVn(K)</td>
<td>341.035</td>
<td>331.41</td>
<td>331.41</td>
<td>337.348</td>
<td>317.943</td>
<td>246.255</td>
</tr>
</tbody>
</table>
CHECK: MAX Phi Mn FOR OVERREINFORCED SECTION CALCULATED ON SHT. #B OF DESIGN EXAMPLE; TYP. BM. 12" x 90° /-M5 @ FACE OF INT. SUPPORT.

\[ w + w_p > \text{MAX ALLOWABLE} \]

\[ +M_n \cdot \text{MAX} = (-.90 \times (4000/1000) \times 18 \times (21.04)^2 \times ((.76 \times .25) - (0.8 \times .25))) \]

\[ = -1025.95 \text{ KF} \]

\[ 12 \]