STRUCTURAL CONCRETE SOFTWARE SYSTEM

ADAPT-PT/RC 20

Program Verification and Examples

For ADAPT-PT

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1 Overview

This verification manual is a companion to the general user manual of the program, namely:

- ADAPT-RC/PT 20 User Manual

The focus of this volume is two-fold. First it provides a detailed verification of practically all aspects of the program computations and code checks for operability in PT mode. Verifications made for general frame analyses apply to both RC and PT modes of operability. Where post-tensioning is involved, the validation applies to PT mode. Second, by way of detailed longhand calculations, it shows you the way to independently perform design calculations for post-tensioned building structures.

The material presented in this manual covers the design of one-way slabs, column-supported two-way slabs, and flanged beams. The volume concludes with a series of specific verifications, such as balanced loading and hyperstatic (secondary) moments.

Beyond its specific application as a supplement to ADAPT-PTRC computer program, this volume serves as a suitable educational material for those interested in the design of post-tensioned and reinforced concrete building structures. For those building design codes not addressed specifically within this document, contact adaptsupport@risa.com to receive specific implementation technical notes.

2 One-Way Slab Verification

The slab selected represents the deck of a one-way slab and beam construction, typical of parking structures. The design values obtained using ADAPT-PT/RC are verified through longhand calculations.

2.1 Given Values

The cross-sectional geometry of the slab and the supporting beams are given in **Fig. 2.1-1**. Other design parameters and particulars of the structure are specified in the following.

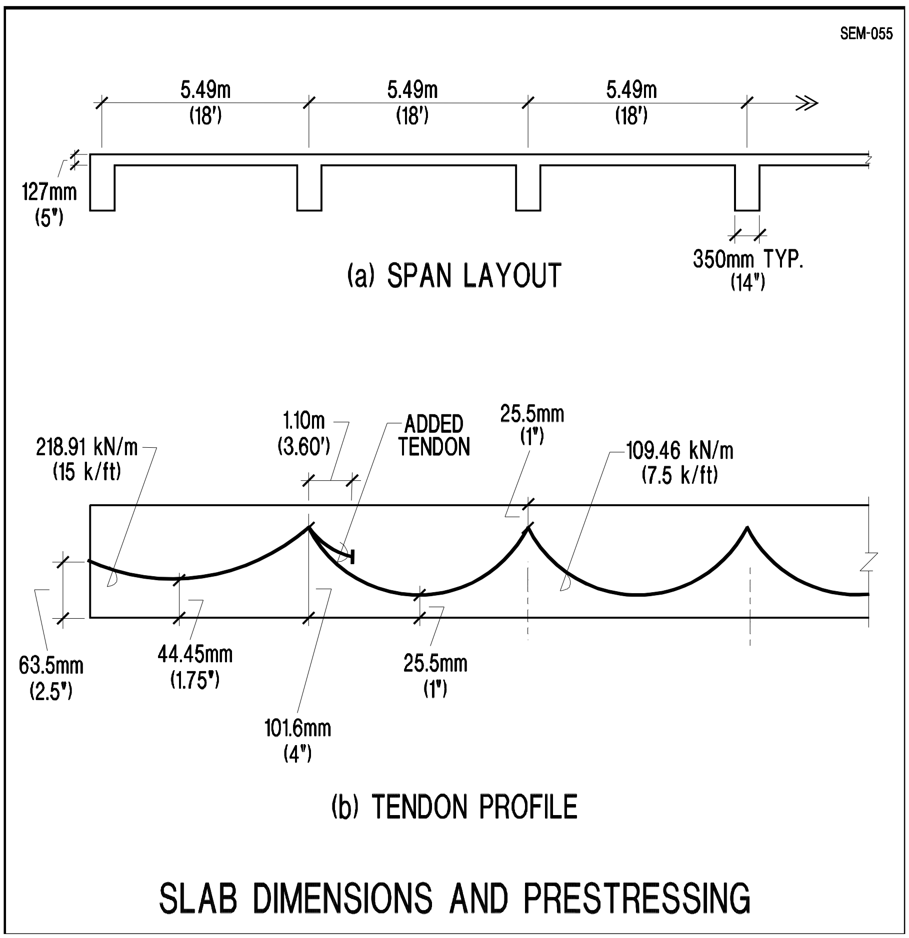


Figure 2.1-1

2.1.1 Structural System

The structural system is one-way slab construction supported on transverse beams.

2.1.2 Design Code

The design is based on ACI 318-14.

2.1.3 Material Properties

(i) Concrete

Compressive cylinder strength, f'_c	= 4000 psi (27.58 MPa)
Weight	= 150 pcf (2403 kg/m^3)
Modulus of elasticity	= 3605 ksi (24856 MPa)
Age of concrete at stressing	= 3 days
Compressive strength at stressing, f'_{ci}	= 3000 psi (20.68 MPa)

(ii) Post-Tensioning

Material:	
Low relaxation, seven wire strand	
Strand diameter	= ½ in (13 mm)
Strand area	=0.153 in^2 (99 mm^2)
Modulus of elasticity	= 28000 ksi (193054 MPa)
Ultimate strength of strand, fpu	= 270 ksi (1861.60MPa)
Average effective stress (fse)	= 175 ksi (1206.59 MPa)
System:	
System:	= unbonded
Stressing:	
Ratio of jacking stress to strand's ultimate strength	= 0.8
Anchor set	= 0.25 in (6.35 mm)
Coefficient of angular friction, μ	= 0.07 /radian
Coefficient of wobble friction, K	= 0.0014 rad/ft (0.0046 rad/m)
Stress on day 3	
Minimum concrete cylinder strength at stressing	= 3000 psi (20.68 MPa)

(iii) Nonprestressed Reinforcement

Yield stress f_y = 60 ksi (413.69 MPa)
Modulus of elasticity = 29000 ksi (199,949 MPa)

(iv) Design Loading

Dead Load	
Selfweight	= based on volume

Allowance for curbs, lighting,
Drainage, etc. = 5 psf (0.24 kN/m^2)
Total = 5 psf + self weight

Live Load = 50 psf (2.39 kN/m^2)
(Live load is conservatively not reduced.)

2.1.4 Load Cases and Combinations

(i) Strength Load Combinations

The strength requirement for each member is established using the following factored load combinations:

Primary load combination:
1.2*DL + 1.6*LL + 1*HYP

Other load combination:
1.4*DL + 1*HYP

Where "HYP" is the secondary (hyperstatic) moments, shears and reactions due to post-tensioning.

(ii) Serviceability Load Combinations

Final stresses:
The design is selected to be carried out according to the "Transitional" (T) state of stress of the code. That is to say, the maximum hypothetical tensile stresses will be allowed to exceed 6 $\sqrt{f'_c}$ but be retained less than 12 $\sqrt{f'_c}$ A hypothetical tensile stress equal to 9 * $\sqrt{f'_c}$ is set as design target.

Tensile stress (top and bottom) = 9$\sqrt{f'_c}$ = 569.21 psi (3.92 MPa)

Compressive stress
For sustained load condition = 0.45f'_c = 1800 psi (12.41 MPa)
For total load condition = 0.60 * f'_c = 2400 psi (16.55 MPa)
Load combinations for serviceability check:

Total load condition
1*DL + 1*LL + 1*PT

Sustained load condition
1*DL + 0.3*LL + 1*PT

The factors for neither of the above load combinations are spelled out in the code. Their selection is based on common practice.

Initial stresses (transfer):
Maximum tension = 3 $\sqrt{f'_{ci}}$
Maximum compression = 0.60 * f'_{ci}

Load combinations for stress check at transfer of prestressing:
U = 1.00 DL + 1.15* PT

2.1.5 Deflections

Having maintained the hypothetical tensile stresses within the limits stated in the preceding, the deflections would be calculated assuming gross cross-sectional properties. Long-term deflections are estimated using a creep coefficient of 2.

For the floor slabs the maximum deflections are maintained below the following value with the understanding that the floor structure is not attached to nonstructural elements likely to be damaged by large deflections of the floor:

Slabs:
Live load deflection $\leq$ span/360

2.1.6 Cover

(i) Nonprestressed Reinforcement

Cover to top bars = 1 in (25 mm)
Cover to bottom bars = 1 in (25 mm)

(ii) Prestressed Reinforcement

Top cover
All spans = 0.75 in (19 mm)

Bottom cover
Interior spans = 0.75 in (19 mm)
Exterior spans = 1.50 in (38 mm)

2.1.7 Tendon Profile

In this example, the tendon profile selected is simple parabola. In the first and last spans, the profile is not symmetrical. As a result, the low point of the tendon will not be at midspan.

Interior spans = simple parabola with low point at center

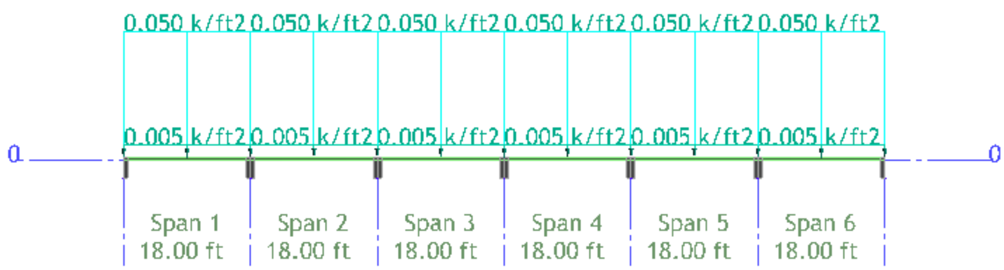
Exterior spans = simple parabola with low point at 0.366*L from the left support for first span and 0.634*L for last span from the left support

2.2 Computed Values

The computed values are obtained from ADAPT-PT/RC 20. The relevant parts of the tabular report are summarized below. Since the structure is symmetrical, only the part of the report that refers to the first half of the structure is reproduced below.

2.2.1 Computer Report for American Units

SIX SPAN ONE WAY SLAB



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ADAPT

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		Post-tensioning	
F'c for BEAMS/SLABS	4000.00 psi	SYSTEM	UNBONDED
Ec for BEAMS/SLABS	3605.00 ksi	Fpu	270.00 ksi
CREEP factor	2.00	Fse	175.00 ksi
CONCRETE WEIGHT	NORMAL	Strand area	0.153 in 2
UNIT WEIGHT	150.00 pcf	Min CGS from TOP	1.00 in
Tension stress limits / (f'c)1/2		Min CGS from BOT for interior spans	1.00 in
At Top	9.000	Min CGS from BOT for exterior spans	1.75 in
At Bottom	9.000	Min average precompression	125.00 psi
Compression stress limits / f'c		Max spacing / slab depth	8.00
At all locations	0.450	Analysis and design options	
Reinforcement		Structural system	ONE-WAY
Fy (Main bars)	60.00 ksi	Moment of Inertia over support is	NOT INCREASED
Fy (Shear reinforcement)	60.00 ksi	Moments reduced to face of support	YES
Minimum Cover at TOP	1.00 in	Moment Redistribution	NO
Minimum Cover at BOTTOM	1.00 in	DESIGN CODE SELECTED	ACI-318 (2014)

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		ft	in	in	in	in	in	in	in		
1	1	18.00	12.00	5.00					5.00	0.50	0.50
2	1	18.00	12.00	5.00					5.00	0.50	0.50
3	1	18.00	12.00	5.00					5.00	0.50	0.50
4	1	18.00	12.00	5.00					5.00	0.50	0.50
5	1	18.00	12.00	5.00					5.00	0.50	0.50
6	1	18.00	12.00	5.00					5.00	0.50	0.50

2.6 Transverse Beam Data

Joint	Depth	Width Before	Width After
	in	in	in
1	34.00	0.00	7.00
2	34.00	7.00	7.00
3	34.00	7.00	7.00
4	34.00	7.00	7.00
5	34.00	7.00	7.00
6	34.00	7.00	7.00
7	34.00	7.00	0.00

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	in	ft	in	in			ft	in	in		
1	14.0	0.0	0.0	0.0	100	(1)					
2	14.0	0.0	0.0	0.0	100	(1)					
3	14.0	0.0	0.0	0.0	100	(1)					
4	14.0	0.0	0.0	0.0	100	(1)					
5	14.0	0.0	0.0	0.0	100	(1)					
6	14.0	0.0	0.0	0.0	100	(1)					

7	14.0	0.0	0.0	0.0	100	(1)					

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			k/ft2	k/ft	k/ft	ft	ft	ft	k	k-ft
1	LL	U	0.050							
1	SDL	U	0.005							
2	LL	U	0.050							
2	SDL	U	0.005							
3	LL	U	0.050							
3	SDL	U	0.005							
4	LL	U	0.050							
4	SDL	U	0.005							
5	LL	U	0.050							
5	SDL	U	0.005							
6	LL	U	0.050							
6	SDL	U	0.005							

NOTE: SELFWEIGHT INCLUSION REQUIRED (SW= SELF WEIGHT Computed from geometry input and treated as dead loading. Unit selfweight W = 150.0 pcf

NOTE: LIVE LOADING is SKIPPED with a skip factor of 1.00

4 - CALCULATED SECTION PROPERTIES

4.2 Section Properties for Non-Uniform Spans

Span	Segment	Area	I	Yb	Yt
		in2	in4	in	in
1	1	408.00	0.39E+05	17.00	17.00
1	2	60.00	0.13E+03	2.50	2.50
1	3	408.00	0.39E+05	17.00	17.00
2	1	408.00	0.39E+05	17.00	17.00
2	2	60.00	0.13E+03	2.50	2.50
2	3	408.00	0.39E+05	17.00	17.00
3	1	408.00	0.39E+05	17.00	17.00
3	2	60.00	0.13E+03	2.50	2.50
3	3	408.00	0.39E+05	17.00	17.00

5 - MOMENTS, SHEARS AND REACTIONS

5.1 Span Moments and Shears (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right	Shear Left	Shear Right
		k-ft	k-ft	k-ft	k	k
1	SW	0.00	1.38	-2.42	-0.64	0.91
2	SW	-2.42	0.54	-1.68	-0.82	0.73
3	SW	-1.68	0.77	-1.96	-0.76	0.79
4	SW	-1.96	0.77	-1.68	-0.79	0.76
1	SDL	0.00	0.11	-0.19	-0.03	0.06
2	SDL	-0.19	0.04	-0.13	-0.05	0.04
3	SDL	-0.13	0.06	-0.15	-0.04	0.05
4	SDL	-0.15	0.06	-0.13	-0.05	0.04

5.2 Reactions and Column Moments (Excluding Live Load)

Joint	Load Case	Reaction	Moment Lower Column	Moment Upper Column
		k	k-ft	k-ft
1	SW	0.64	0.00	0.00
2	SW	1.72	0.00	0.00
3	SW	1.49	0.00	0.00
4	SW	1.58	0.00	0.00
1	SDL	0.03	0.00	0.00
2	SDL	0.10	0.00	0.00
3	SDL	0.09	0.00	0.00
4	SDL	0.09	0.00	0.00

5.3 Span Moments and Shears (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min	Shear Left	Shear Right
	k-ft	k-ft	k-ft	k-ft	k-ft	k-ft	k	k
1	0.00	0.00	1.56	-0.47	-2.11	-0.58	-0.40	0.57
2	-2.11	-0.58	1.23	-0.79	-1.94	-0.25	-0.55	0.53
3	-1.94	-0.25	1.32	-0.70	-2.09	-0.47	-0.53	0.55
4	-2.09	-0.47	1.32	-0.70	-1.94	-0.25	-0.55	0.53

5.4 Reactions and Column Moments (Live Load)

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	k	k	k-ft	k-ft	k-ft	k-ft
1	0.40	-0.05	0.00	0.00	0.00	0.00
2	1.11	0.41	0.00	0.00	0.00	0.00
3	1.06	0.30	0.00	0.00	0.00	0.00
4	1.10	0.37	0.00	0.00	0.00	0.00

6 - MOMENTS REDUCED TO FACE OF SUPPORT

6.1 Reduced Moments at Face of Support (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right
		k-ft	k-ft	k-ft
1	SW	0.30	1.38	-1.96
2	SW	-2.02	0.54	-1.32
3	SW	-1.31	0.77	-1.57
4	SW	-1.57	0.77	-1.31
1	SDL	0.02	0.11	-0.16
2	SDL	-0.16	0.04	-0.11
3	SDL	-0.11	0.06	-0.13
4	SDL	-0.13	0.06	-0.11

6.2 Reduced Moments at Face of Support (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min
	k-ft	k-ft	k-ft	k-ft	k-ft	k-ft
1	-0.03	0.22	1.56	-0.47	-1.79	-0.56
2	-1.80	-0.37	1.23	-0.79	-1.64	-0.21
3	-1.64	-0.06	1.32	-0.70	-1.77	-0.26
4	-1.77	-0.26	1.32	-0.70	-1.64	-0.06

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile
Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
1	1	0.000	0.366	0.000	---
2	1	0.000	0.500	0.000	---
3	1	0.000	0.500	0.000	---
4	1	0.000	0.500	0.000	---
5	1	0.000	0.500	0.000	---
6	1	0.000	0.634	0.000	---

7.2 Selected Post-Tensioning Forces and Tendon Drape
Tendon A

Span	Force	CGS Left	CGS C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	k	in	in	in	in	psi	k/-	
1	15.000	2.50	---	1.75	4.00	250.00	0.043	47
2	7.500	4.00	---	1.00	4.00	125.00	0.046	51
3	7.500	4.00	---	1.00	4.00	125.00	0.046	51
4	7.500	4.00	---	1.00	4.00	125.00	0.046	51
5	7.500	4.00	---	1.00	4.00	125.00	0.046	51
6	15.000	4.00	---	1.75	2.50	250.00	0.043	47

Approximate weight of strand: 56.2 LB

7.4 Required Minimum Post-Tensioning Forces

	Based on Stress Conditions			Based on Minimum P/A		
Type	Left	Center	Right	Left	Center	Right
	k	k	k	k	k	k
1	0.00	5.13	9.68	7.50	7.50	7.50
2	9.97	0.00	3.16	7.50	7.50	7.50
3	3.04	0.00	5.73	7.50	7.50	7.50
4	5.72	0.00	3.04	7.50	7.50	7.50

7.5 Service Stresses (tension shown positive)
Envelope of Service 1

Span	Left Top Max-T	Left Top Max-C	Left Bot Max-T	Left Bot Max-C	Center Top Max-T	Center Top Max-C	Cetner Bot Max-T	Cetner Bot Max-C	Right Top Max-T	Right Top Max-C	Right Bot Max-T	Right Bot Max-C
	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi
1	-----	-302.88	-----	-215.41	-----	-494.19	-----	-151.61	65.38	-23.10	-----	-565.38
2	71.47	-31.74	-----	-571.47	-----	-153.33	-----	-242.48	64.36	-38.83	-----	-314.36
3	56.02	-57.37	-----	-306.02	-----	-275.17	25.17	-120.63	190.44	-----	-----	-440.44
4	189.84	-----	-----	-439.84	-----	-275.17	25.17	-120.63	56.62	-56.76	-----	-306.62

Envelope of Service 2

Span	Left Top Max-T	Left Top Max-C	Left Bot Max-T	Left Bot Max-C	Center Top Max-T	Center Top Max-C	Cetner Bot Max-T	Cetner Bot Max-C	Right Top Max-T	Right Top Max-C	Right Bot Max-T	Right Bot Max-C
	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi
1	-----	-340.47	-----	-220.50	-----	-755.89	255.89	-230.13	366.38	-----	-----	-866.38
2	374.71	-----	-----	-874.71	125.49	-360.52	110.52	-375.49	339.60	-4.38	-----	-589.60
3	330.70	-47.25	-----	-580.70	-----	-497.30	247.30	-238.70	488.08	-----	-----	-738.08
4	487.48	-----	-----	-737.48	-----	-497.30	247.30	-238.70	331.30	-46.65	-----	-581.30

7.6 Post-Tensioning Balance Moments, Shears and Reactions
Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right
	k-ft	k-ft	k-ft	k	k

1	-0.17	-0.94	1.34	0.01	0.01
2	1.38	-0.84	1.13	-0.04	-0.04
3	1.15	-0.61	0.91	0.01	0.01
4	0.91	-0.61	1.15	-0.01	-0.01

Reactions and Column Moments

Joint	Reaction	Moment Lower Column	Moment Upper Column
	k	k-ft	k-ft
1	-0.015	0.000	0.000
2	0.054	0.000	0.000
3	-0.054	0.000	0.000
4	0.028	0.000	0.000

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	k-ft	k-ft	k-ft	k-ft	k-ft	k-ft
1	0.33	0.73	4.15	0.91	-5.66	-3.22
2	-5.74	-3.29	2.77	-0.47	-3.91	-1.57
3	-3.87	-1.35	3.45	0.21	-4.65	-2.15
4	-4.65	-2.15	3.46	0.22	-3.86	-1.34

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	k	k	k-ft	k-ft	k-ft	k-ft
1	1.43	0.71	0.00	0.00	0.00	0.00
2	4.03	2.61	0.00	0.00	0.00	0.00
3	3.53	2.15	0.00	0.00	0.00	0.00
4	3.80	2.37	0.00	0.00	0.00	0.00

8.3 Secondary Moments

Span	Left	Midspan	Right
	k-ft	k-ft	k-ft
1	-0.01	-0.13	-0.26
2	-0.24	0.09	0.43
3	0.44	0.33	0.22
4	0.22	0.34	0.45

Note: Moments are reported at face of support

10 - MILD STEEL - NO REDISTRIBUTION

10.1 Required Rebar

10.1.1 Total Strip Required Rebar

Span	Location	From	To	As Required	Ultimate	Minimum
		ft	ft	in2	in2	in2
1	TOP	0.00	2.70	0.12	0.00	0.12
1	TOP	9.90	11.70	0.12	0.00	0.12
1	TOP	15.30	18.00	0.12	0.09	0.12
2	TOP	0.00	2.70	0.12	0.11	0.12

2	TOP	4.50	11.70	0.12	0.05	0.12
2	TOP	15.30	18.00	0.12	0.11	0.12
3	TOP	0.00	2.70	0.12	0.11	0.12
3	TOP	6.30	11.70	0.12	0.00	0.12
3	TOP	15.30	18.00	0.16	0.16	0.12
4	TOP	0.00	2.70	0.16	0.16	0.12
4	TOP	6.30	11.70	0.12	0.00	0.12
4	TOP	15.30	18.00	0.12	0.11	0.12
1	BOT	4.50	11.70	0.12	0.05	0.12
2	BOT	6.30	11.70	0.12	0.03	0.12
3	BOT	4.50	12.60	0.12	0.07	0.12
4	BOT	5.40	13.50	0.12	0.07	0.12

12 - SHEAR REINFORCEMENT

12.1 Shear Calculation Envelope

SPAN 1

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	ft	in	k	kft		in2	in
0.03	0.58	4.00	-1.09	0.74	0.12	0.00	0.00
0.05	0.90	4.00	-1.03	1.08	0.15	0.00	0.00
0.10	1.80	4.00	-0.91	1.95	0.20	0.00	0.00
0.15	2.70	4.00	-0.74	2.69	0.16	0.00	0.00
0.20	3.60	4.00	-0.61	3.30	0.13	0.00	0.00
0.25	4.50	4.00	-0.45	3.78	0.10	0.00	0.00
0.30	5.40	4.00	-0.32	4.13	0.07	0.00	0.00
0.35	6.30	4.00	-0.15	4.34	0.03	0.00	0.00
0.40	7.20	4.00	0.11	4.42	0.03	0.00	0.00
0.45	8.10	4.00	0.23	4.38	0.05	0.00	0.00
0.50	9.00	4.00	0.37	4.19	0.08	0.00	0.00
0.55	9.90	4.00	0.51	3.88	0.11	0.00	0.00
0.60	10.80	4.00	0.67	3.44	0.15	0.00	0.00
0.65	11.70	4.00	0.79	2.86	0.17	0.00	0.00
0.70	12.60	4.00	0.96	2.15	0.21	0.00	0.00
0.75	13.50	4.00	1.09	1.31	0.20	0.00	0.00
0.80	14.40	4.00	0.62	-1.75	0.14	0.00	0.00
0.85	15.30	4.00	0.69	-2.43	0.15	0.00	0.00
0.90	16.20	4.00	1.53	-1.99	0.23	0.00	0.00
0.95	17.10	4.00	1.67	-3.36	0.32	0.00	0.00
0.97	17.42	4.00	1.73	-3.73	0.34	0.00	0.00

SPAN 2

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	ft	in	k	kft		in2	in
0.03	0.58	4.00	-1.60	-3.48	0.33	0.00	0.00
0.05	0.90	4.00	-1.55	-3.06	0.31	0.00	0.00
0.10	1.80	4.00	-1.41	-1.97	0.24	0.00	0.00
0.15	2.70	4.00	-1.25	-1.01	0.16	0.00	0.00
0.20	3.60	4.00	-0.61	-1.02	0.13	0.00	0.00
0.25	4.50	4.00	-0.46	-1.84	0.10	0.00	0.00
0.30	5.40	4.00	-0.84	1.32	0.14	0.00	0.00
0.35	6.30	4.00	-0.68	1.89	0.15	0.00	0.00
0.40	7.20	4.00	-0.54	2.32	0.12	0.00	0.00
0.45	8.10	4.00	-0.40	2.63	0.09	0.00	0.00
0.50	9.00	4.00	-0.25	2.80	0.05	0.00	0.00
0.55	9.90	4.00	0.18	2.84	0.04	0.00	0.00
0.60	10.80	4.00	0.33	2.75	0.07	0.00	0.00
0.65	11.70	4.00	0.46	2.53	0.10	0.00	0.00

0.70	12.60	4.00	0.60	2.18	0.13	0.00	0.00
0.75	13.50	4.00	0.75	1.69	0.17	0.00	0.00
0.80	14.40	4.00	0.90	1.08	0.14	0.00	0.00
0.85	15.30	4.00	1.04	0.38	0.09	0.00	0.00
0.90	16.20	4.00	1.19	-0.39	0.10	0.00	0.00
0.95	17.10	4.00	1.34	-1.29	0.15	0.00	0.00
0.97	17.42	4.00	1.38	-1.63	0.18	0.00	0.00

SPAN 3

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	ft	in	k	kft		in2	in
0.03	0.58	4.00	-1.46	-1.36	0.15	0.00	0.00
0.05	0.90	4.00	-0.73	-1.31	0.14	0.00	0.00
0.10	1.80	4.00	-0.53	-2.24	0.12	0.00	0.00
0.15	2.70	4.00	-1.12	0.75	0.12	0.00	0.00
0.20	3.60	4.00	-0.97	1.43	0.18	0.00	0.00
0.25	4.50	4.00	-0.83	2.03	0.18	0.00	0.00
0.30	5.40	4.00	-0.68	2.59	0.15	0.00	0.00
0.35	6.30	4.00	-0.53	3.01	0.12	0.00	0.00
0.40	7.20	4.00	-0.39	3.30	0.09	0.00	0.00
0.45	8.10	4.00	-0.25	3.46	0.05	0.00	0.00
0.50	9.00	4.00	0.19	3.49	0.04	0.00	0.00
0.55	9.90	4.00	0.35	3.38	0.08	0.00	0.00
0.60	10.80	4.00	0.48	3.14	0.11	0.00	0.00
0.65	11.70	4.00	0.62	2.78	0.14	0.00	0.00
0.70	12.60	4.00	0.77	2.28	0.17	0.00	0.00
0.75	13.50	4.00	0.92	1.64	0.18	0.00	0.00
0.80	14.40	4.00	1.06	0.88	0.12	0.00	0.00
0.85	15.30	4.00	0.54	-1.74	0.12	0.00	0.00
0.90	16.20	4.00	0.72	-1.22	0.14	0.00	0.00
0.95	17.10	4.00	1.50	-1.87	0.21	0.00	0.00
0.97	17.42	4.00	1.55	-2.26	0.23	0.00	0.00

Note: "Vu" is related to the load combination which produces the maximum "Ratio"
Note: Sections with **** have exceeded the maximum allowable shear stress.

14 - DEFLECTIONS

14.1 Maximum Span Deflections

Span	SW	SW+PT	SW+PT+ SDL	SW+PT+SDL +Creep	LL	X	Total
	in	in	in	in	in	in	in
1	0.15	0.06	0.07	0.22(966)	0.12(1823)	0.00(****)	0.34(631)
2	0.02	-0.05	-0.05	-0.15(1466)	0.02(14139)	0.00(****)	-0.14(1516)
3	0.06	0.01	0.02	0.05(4011)	0.04(4983)	0.00(****)	0.10(2254)
4	0.06	0.01	0.02	0.05(4022)	0.04(4982)	0.00(****)	0.10(2256)

Legend (2.1):

Span C = Cantilever
Form 1 = Rectangular, 2 = T or Inverted L, 3 = I, 4 = Extended T or L section
Rh Elevation of top surface
TF Top flange
MF Middle flange
BF Bottom flange

Legend (2.7):

The Column Boundary Condition (CBC):
Fixed at both 1
Hinged at near end, fixed at far end 2

Fixed at near end, hinged at far end 3
Fixed at near end, roller with rotational fixity at far end 4
LC Lower Column
UC Upper Column

Legend (3.1):
Class: SW: Selfweight, LL: Live Load, SDL: Superimposed Dead Load, X: Other Loading
Type: U: Uniform, P: Partial Uniform, L: Line Load, M: Applied Moment
C: Concentrated Load, R: Triangle, V: Variable, T: Trapezoidal

Legend (4.1, 4.2):
Yb: distance from centroid to bottom fiber
Yt: distance from centroid to top fiber
I: gross moment of inertia

Legend (7.1):
Type
1 = reversed parabola
2 = simple parabola with straight portion over support
3 = harped tendon
4 = straight tendon
5 = extended reversed parabola

Legend (7.2):
CGS C1: CGS of left middle point of tendon for type 5 profile
CGS C2: CGS of right middle point of tendon for type 5 profile or middle point of other types

Legend (10.1, 11.1):
From: Beginning of rebar measured from left support of the span
To: End of rebar measured from left support of the span
As Required: Envelope of minimum and ultimate rebar
Ultimate: Required rebar for ultimate load combinations
Minimum: Required minimum rebar

Legend (12):
d: Effective depth of section for shear rebar calculation
Vu: Ultimate shear
Ratio: ratio of ultimate to allowable shear stress
Req.: Required shear reinforcement per unit length
Spacing: Spacing between shear rebar

2.2.2 Computer Report for SI Units

ADAPT

Your Partner in Concrete Design

SIX SPAN ONE WAY SLAB

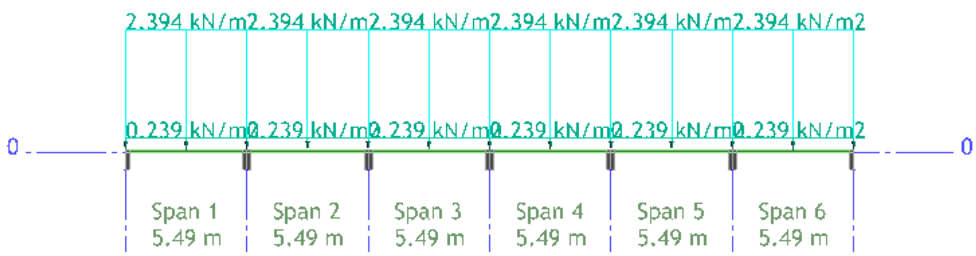


TABLE OF CONTENT:

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		Post-tensioning	
F'c for BEAMS/SLABS	28.00 N/mm 2	SYSTEM	UNBONDED
Ec for BEAMS/SLABS	24870.00 N/mm 2	Fpu	1862.00 N/mm 2
CREEP factor	2.00	Fse	1206.60 N/mm 2
CONCRETE WEIGHT	NORMAL	Strand area	98.709 mm 2
UNIT WEIGHT	2403.00 Kg/m 3	Min CGS from TOP	25.40 mm
Tension stress limits / (f'c)1/2		Min CGS from BOT for interior spans	25.40 mm
At Top	0.750	Min CGS from BOT for exterior spans	44.45 mm
At Bottom	0.750	Min average precompression	0.86 N/mm 2
Compression stress limits / f'c		Max spacing / slab depth	8.00
At all locations	0.450	Analysis and design options	
Reinforcement		Structural system	ONE-WAY
Fy (Main bars)	413.69 N/mm 2	Moment of Inertia over support is	NOT INCREASED
Fy (Shear reinforcement)	413.69 N/mm 2	Moments reduced to face of support	YES
Minimum Cover at TOP	25.40 mm	Moment Redistribution	NO
Minimum Cover at BOTTOM	25.40 mm	DESIGN CODE SELECTED	ACI-318 (2014)

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		m	mm	mm	mm	mm	mm	mm	mm		
1	1	5.49	305	127					127	0.50	0.50
2	1	5.49	305	127					127	0.50	0.50
3	1	5.49	305	127					127	0.50	0.50
4	1	5.49	305	127					127	0.50	0.50
5	1	5.49	305	127					127	0.50	0.50
6	1	5.49	305	127					127	0.50	0.50

2.6 Transverse Beam Data

Joint	Depth	Width Before	Width After
	mm	mm	mm
1	864	0	178
2	864	178	178
3	864	178	178
4	864	178	178
5	864	178	178
6	864	178	178
7	864	178	0

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	mm	m	mm	mm			m	mm	mm		
1	356.0	0.0	0.0	0.0	100	(1)					
2	356.0	0.0	0.0	0.0	100	(1)					
3	356.0	0.0	0.0	0.0	100	(1)					
4	356.0	0.0	0.0	0.0	100	(1)					
5	356.0	0.0	0.0	0.0	100	(1)					
6	356.0	0.0	0.0	0.0	100	(1)					

7	356.0	0.0	0.0	0.0	100	(1)					

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			kN/m2	kN/m	kN/m	m	m	m	kN	kN-m
1	LL	U	2.394							
1	SDL	U	0.239							
2	LL	U	2.394							
2	SDL	U	0.239							
3	LL	U	2.394							
3	SDL	U	0.239							
4	LL	U	2.394							
4	SDL	U	0.239							
5	LL	U	2.394							
5	SDL	U	0.239							
6	LL	U	2.394							
6	SDL	U	0.239							

NOTE: SELFWEIGHT INCLUSION REQUIRED (SW= SELF WEIGHT Computed from geometry input and treated as dead loading. Unit selfweight W = 2403.0 Kg/m^3

NOTE: LIVE LOADING is SKIPPED with a skip factor of 1.00

4 - CALCULATED SECTION PROPERTIES

4.2 Section Properties for Non-Uniform Spans

Span	Segment	Area	I	Yb	Yt
		mm2	mm4	mm	mm
1	1	263520.00	0.16E+11	432.00	432.00
1	2	38735.00	0.52E+08	63.50	63.50
1	3	263520.00	0.16E+11	432.00	432.00
2	1	263520.00	0.16E+11	432.00	432.00
2	2	38735.00	0.52E+08	63.50	63.50
2	3	263520.00	0.16E+11	432.00	432.00
3	1	263520.00	0.16E+11	432.00	432.00
3	2	38735.00	0.52E+08	63.50	63.50
3	3	263520.00	0.16E+11	432.00	432.00

5 - MOMENTS, SHEARS AND REACTIONS

5.1 Span Moments and Shears (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right	Shear Left	Shear Right
		kN-m	kN-m	kN-m	kN	kN
1	SW	0.00	1.88	-3.28	-2.85	4.05
2	SW	-3.28	0.74	-2.28	-3.63	3.26
3	SW	-2.28	1.05	-2.66	-3.38	3.52
4	SW	-2.66	1.05	-2.28	-3.52	3.38
1	SDL	0.00	0.15	-0.25	-0.15	0.25
2	SDL	-0.25	0.06	-0.18	-0.21	0.19
3	SDL	-0.18	0.08	-0.20	-0.19	0.21
4	SDL	-0.20	0.08	-0.18	-0.21	0.19

5.2 Reactions and Column Moments (Excluding Live Load)

Joint	Load Case	Reaction	Moment	Moment

			Lower Column	Upper Column
		kN	kN-m	kN-m
1	SW	2.85	0.00	0.00
2	SW	7.68	0.00	0.00
3	SW	6.64	0.00	0.00
4	SW	7.03	0.00	0.00
1	SDL	0.15	0.00	0.00
2	SDL	0.46	0.00	0.00
3	SDL	0.38	0.00	0.00
4	SDL	0.41	0.00	0.00
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00
4	XL	0.00	0.00	0.00

5.3 Span Moments and Shears (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN	kN
1	0.00	0.00	2.11	-0.63	-2.87	-0.79	-1.77	2.53
2	-2.87	-0.79	1.67	-1.07	-2.63	-0.35	-2.43	2.34
3	-2.63	-0.35	1.79	-0.95	-2.83	-0.64	-2.37	2.46
4	-2.83	-0.64	1.79	-0.95	-2.63	-0.35	-2.46	2.37

5.4 Reactions and Column Moments (Live Load)

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	1.77	-0.23	0.00	0.00	0.00	0.00
2	4.95	1.81	0.00	0.00	0.00	0.00
3	4.70	1.36	0.00	0.00	0.00	0.00
4	4.91	1.66	0.00	0.00	0.00	0.00

6 - MOMENTS REDUCED TO FACE OF SUPPORT

6.1 Reduced Moments at Face of Support (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right
		kN-m	kN-m	kN-m
1	SW	0.41	1.88	-2.66
2	SW	-2.73	0.74	-1.79
3	SW	-1.77	1.05	-2.13
4	SW	-2.13	1.05	-1.77
1	SDL	0.03	0.15	-0.21
2	SDL	-0.22	0.06	-0.14
3	SDL	-0.14	0.08	-0.17
4	SDL	-0.17	0.08	-0.14

6.2 Reduced Moments at Face of Support (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	-0.04	0.30	2.11	-0.63	-2.43	-0.76
2	-2.45	-0.50	1.67	-1.07	-2.22	-0.28
3	-2.22	-0.08	1.79	-0.95	-2.40	-0.36
4	-2.40	-0.36	1.79	-0.95	-2.22	-0.08

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile

Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
1	1	0.000	0.366	0.000	---
2	1	0.000	0.500	0.000	---
3	1	0.000	0.500	0.000	---
4	1	0.000	0.500	0.000	---
5	1	0.000	0.500	0.000	---
6	1	0.000	0.634	0.000	---

7.2 Selected Post-Tensioning Forces and Tendon Drape

Tendon A

Span	Force	CGS Left	CGS C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	kN	mm	mm	mm	mm	MPa	kN/-	
1	66.730	64.00	---	44.00	102.00	1.72	0.648	49
2	33.360	102.00	---	25.00	102.00	0.86	0.683	51
3	33.360	102.00	---	25.00	102.00	0.86	0.683	51
4	33.360	102.00	---	25.00	102.00	0.86	0.683	51
5	33.360	102.00	---	25.00	102.00	0.86	0.683	51
6	66.730	102.00	---	44.00	64.00	1.72	0.648	49

Approximate weight of strand: 25.5 Kg

7.4 Required Minimum Post-Tensioning Forces

	Based on Stress Conditions			Based on Minimum P/A		
Type	Left	Center	Right	Left	Center	Right
	kN	kN	kN	kN	kN	kN
1	0.00	21.76	41.91	33.31	33.31	33.31
2	43.18	0.00	13.44	33.31	33.31	33.31
3	12.90	0.00	24.69	33.31	33.31	33.31
4	24.63	0.00	12.93	33.31	33.31	33.31

7.5 Service Stresses (tension shown positive)

Envelope of Service 1

Span	Left Top Max-T	Left Top Max-C	Left Bot Max-T	Left Bot Max-C	Center Top Max-T	Center Top Max-C	Cetner Bot Max-T	Cetner Bot Max-C	Right Top Max-T	Right Top Max-C	Right Bot Max-T	Right Bot Max-C
	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
1	-----	-2.12	-----	-1.46	-----	-3.38	-----	-1.07	0.41	-0.20	-----	-3.86
2	0.45	-0.26	-----	-3.90	-----	-1.05	-----	-1.68	0.43	-0.28	-----	-2.15
3	0.37	-0.41	-----	-2.09	-----	-1.89	0.17	-0.84	1.29	-----	-----	-3.02
4	1.29	-----	-----	-3.01	-----	-1.89	0.17	-0.84	0.38	-0.41	-----	-2.10

Envelope of Service 2

Span	Left Top Max-T	Left Top Max-C	Left Bot Max-T	Left Bot Max-C	Center Top Max-T	Center Top Max-C	Cetner Bot Max-T	Cetner Bot Max-C	Right Top Max-T	Right Top Max-C	Right Bot Max-T	Right Bot Max-C
	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
1	-----	-2.38	-----	-1.49	-----	-5.18	1.74	-1.61	2.49	-----	-----	-5.94
2	2.54	-----	-----	-5.99	0.87	-2.48	0.76	-2.59	2.33	-0.05	-----	-4.05
3	2.26	-0.34	-----	-3.99	-----	-3.42	1.70	-1.65	3.35	-----	-----	-5.07
4	3.34	-----	-----	-5.06	-----	-3.42	1.70	-1.65	2.27	-0.34	-----	-3.99

7.6 Post-Tensioning Balance Moments, Shears and Reactions

Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right

	kN-m	kN-m	kN-m	kN	kN
1	-0.20	-1.30	1.85	0.06	0.06
2	1.90	-1.14	1.55	-0.18	-0.18
3	1.57	-0.83	1.25	0.06	0.06
4	1.26	-0.83	1.57	-0.06	-0.06

Reactions and Column Moments

Joint	Reaction	Moment Lower Column	Moment Upper Column
	kN	kN-m	kN-m
1	-0.063	0.000	0.000
2	0.238	0.000	0.000
3	-0.238	0.000	0.000
4	0.123	0.000	0.000

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	0.44	1.00	5.64	1.24	-7.67	-4.35
2	-7.77	-4.45	3.77	-0.63	-5.30	-2.13
3	-5.24	-1.83	4.69	0.29	-6.30	-2.91
4	-6.30	-2.91	4.70	0.30	-5.23	-1.81

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	6.38	3.17	0.00	0.00	0.00	0.00
2	17.93	11.63	0.00	0.00	0.00	0.00
3	15.72	9.60	0.00	0.00	0.00	0.00
4	16.91	10.55	0.00	0.00	0.00	0.00

8.3 Secondary Moments

Span	Left	Midspan	Right
	kN-m	kN-m	kN-m
1	-0.01	-0.17	-0.34
2	-0.32	0.13	0.58
3	0.60	0.46	0.31
4	0.31	0.46	0.62

Note: Moments are reported at face of support

10 - MILD STEEL - NO REDISTRIBUTION

10.1 Required Rebar

10.1.1 Total Strip Required Rebar

Span	Location	From	To	As Required	Ultimate	Minimum
		m	m	mm2	mm2	mm2
1	TOP	0.00	0.82	77.47	0.00	77.47
1	TOP	3.02	3.57	77.47	0.00	77.47

1	TOP	4.66	5.49	77.47	58.21	77.47
2	TOP	0.00	3.57	77.47	67.81	77.47
2	TOP	4.66	5.49	77.47	70.72	77.47
3	TOP	0.00	0.82	77.47	66.96	77.47
3	TOP	1.92	3.57	77.47	0.00	77.47
3	TOP	4.66	5.49	103.00	103.00	77.47
4	TOP	0.00	0.82	103.00	103.00	77.47
4	TOP	1.92	3.57	77.47	0.00	77.47
4	TOP	4.66	5.49	77.47	66.96	77.47
1	BOT	1.37	3.57	77.47	30.11	77.47
2	BOT	1.92	3.57	77.47	19.51	77.47
3	BOT	1.65	3.84	77.47	46.65	77.47
4	BOT	1.65	4.12	77.47	46.65	77.47

12 - SHEAR REINFORCEMENT

12.1 Shear Calculation Envelope

SPAN 1

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.03	0.18	101.60	-4.83	1.01	0.12	0.00	0.00
0.05	0.27	101.60	-4.60	1.47	0.15	0.00	0.00
0.10	0.55	101.60	-3.96	2.65	0.19	0.00	0.00
0.15	0.82	101.60	-3.30	3.66	0.16	0.00	0.00
0.20	1.10	101.60	-2.66	4.48	0.13	0.00	0.00
0.25	1.37	101.60	-2.01	5.13	0.10	0.00	0.00
0.30	1.65	101.60	-1.37	5.60	0.07	0.00	0.00
0.35	1.92	101.60	-0.72	5.89	0.04	0.00	0.00
0.40	2.19	101.60	0.56	6.01	0.03	0.00	0.00
0.45	2.47	101.60	1.03	5.94	0.05	0.00	0.00
0.50	2.74	101.60	1.67	5.70	0.08	0.00	0.00
0.55	3.02	101.60	2.32	5.27	0.11	0.00	0.00
0.60	3.29	101.60	2.96	4.67	0.14	0.00	0.00
0.65	3.57	101.60	3.60	3.89	0.18	0.00	0.00
0.70	3.84	101.60	4.25	2.93	0.21	0.00	0.00
0.75	4.12	101.60	4.89	1.79	0.20	0.00	0.00
0.80	4.39	101.60	2.78	-2.37	0.14	0.00	0.00
0.85	4.66	101.60	3.11	-3.29	0.15	0.00	0.00
0.90	4.94	101.60	6.84	-2.70	0.23	0.00	0.00
0.95	5.21	101.60	7.48	-4.55	0.32	0.00	0.00
0.97	5.31	101.60	7.70	-5.05	0.34	0.00	0.00

SPAN 2

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.03	0.18	101.60	-7.13	-4.71	0.33	0.00	0.00
0.05	0.27	101.60	-6.90	-4.15	0.31	0.00	0.00
0.10	0.55	101.60	-6.26	-2.66	0.24	0.00	0.00
0.15	0.82	101.60	-5.62	-1.36	0.16	0.00	0.00
0.20	1.10	101.60	-2.73	-1.37	0.13	0.00	0.00
0.25	1.37	101.60	-2.35	-0.67	0.10	0.00	0.00
0.30	1.65	101.60	-3.66	1.80	0.14	0.00	0.00
0.35	1.92	101.60	-3.01	2.57	0.15	0.00	0.00
0.40	2.19	101.60	-2.37	3.16	0.12	0.00	0.00
0.45	2.47	101.60	-1.72	3.57	0.08	0.00	0.00
0.50	2.74	102.00	-1.08	3.81	0.05	0.00	0.00
0.55	3.02	101.60	0.78	3.86	0.04	0.00	0.00
0.60	3.29	101.60	1.42	3.74	0.07	0.00	0.00

0.65	3.57	101.60	2.07	3.44	0.10	0.00	0.00
0.70	3.84	101.60	2.71	2.96	0.13	0.00	0.00
0.75	4.12	101.60	3.36	2.30	0.16	0.00	0.00
0.80	4.39	101.60	4.00	1.46	0.14	0.00	0.00
0.85	4.66	101.60	4.64	0.52	0.09	0.00	0.00
0.90	4.94	101.60	5.29	-0.52	0.10	0.00	0.00
0.95	5.21	101.60	5.93	-1.74	0.15	0.00	0.00
0.97	5.31	101.60	6.15	-2.21	0.18	0.00	0.00

SPAN 3

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.03	0.18	101.60	-6.46	-1.84	0.15	0.00	0.00
0.05	0.27	101.60	-3.24	-1.78	0.14	0.00	0.00
0.10	0.55	101.60	-2.39	-3.04	0.12	0.00	0.00
0.15	0.82	101.60	-4.93	1.02	0.12	0.00	0.00
0.20	1.10	101.60	-4.28	1.94	0.17	0.00	0.00
0.25	1.37	101.60	-3.64	2.76	0.18	0.00	0.00
0.30	1.65	101.60	-3.00	3.52	0.15	0.00	0.00
0.35	1.92	101.60	-2.35	4.09	0.12	0.00	0.00
0.40	2.19	101.60	-1.71	4.48	0.08	0.00	0.00
0.45	2.47	101.60	-1.06	4.70	0.05	0.00	0.00
0.50	2.74	102.00	0.88	4.73	0.04	0.00	0.00
0.55	3.02	101.60	1.52	4.59	0.07	0.00	0.00
0.60	3.29	101.60	2.16	4.27	0.11	0.00	0.00
0.65	3.57	101.60	2.81	3.77	0.14	0.00	0.00
0.70	3.84	101.60	3.45	3.10	0.17	0.00	0.00
0.75	4.12	101.60	4.10	2.24	0.18	0.00	0.00
0.80	4.39	101.60	4.74	1.20	0.12	0.00	0.00
0.85	4.66	101.60	2.42	-2.36	0.12	0.00	0.00
0.90	4.94	101.60	3.20	-1.65	0.14	0.00	0.00
0.95	5.21	101.60	6.69	-2.52	0.21	0.00	0.00
0.97	5.31	101.60	6.91	-3.06	0.23	0.00	0.00

Note: "Vu" is related to the load combination which produces the maximum "Ratio"
Note: Sections with **** have exceeded the maximum allowable shear stress.

14 - DEFLECTIONS

14.1 Maximum Span Deflections

Span	SW	SW+PT	SW+PT+ SDL	SW+PT+SDL +Creep	LL	X	Total
	mm	mm	mm	mm	mm	mm	mm
1	3.9	1.6	1.9	5.6(987)	3.0(1825)	0.0(****)	8.6(640)
2	0.6	-1.3	-1.2	-3.7(1470)	0.4(14158)	0.0(****)	-3.6(1521)
3	1.4	0.3	0.4	1.3(4082)	1.1(4986)	0.0(****)	2.4(2278)
4	1.4	0.3	0.4	1.3(4092)	1.1(4985)	0.0(****)	2.4(2280)
5	0.6	-1.3	-1.2	-3.7(1469)	0.4(14162)	0.0(****)	-3.6(1520)
6	3.9	1.6	1.9	5.6(987)	3.0(1825)	0.0(****)	8.6(640)

2.3 Verification

2.3.1 Verification of Report for American Units

The ADAPT-PT report is presented in numbered data blocks. Each data block data area provided in table. For example, looking at the report, it is observed that data block 2.1 third column is the *span lengths*. In notation form, this is referred to as (B2.1, C3).

2.3.1.1 Geometry of Slab (Data Block 2)

Data block 2.1, 2.6 and 2.7 identify the geometry of the slab, transverse beam and column supports.

2.3.1.2 Loading (Data Block 3)

Data block 3.1 lists the details of the loading read from input by the program.

2.3.1.3 Calculated Section Properties (Data Block 4)

Data block 4 reflects the calculated section properties of all the spans. Section properties at mid span:

Area, A = 5* 12
= 60 in^2 (38.71e3 mm^2) (ADAPT-PT 60, B4.2, C3)

Moment of inertia, I = $(b * h^3)/ 12$
= $(12 * 5^3)/12$
= 125 in^4 (52.03e6 mm^4) (ADAPT-PT 0.13e3,B4.2, C4)

Distance from bottom fiber to centroid, Yb = h/2
= 2.5 in (64 mm) (ADAPT-PT 2.5, B4.2, C5)

Distance from top fiber to centroid, Yt = h/2
= 2.5 in (64 mm) (ADAPT-PT 2.5,B4.2, C6)

2.3.1.4 Material Properties (Data Block 1)

Concrete, post tensioning strand and mild reinforcement material properties are given in data block 1.

2.3.1.5 Dead and Live Load Moments (Data Block 5)

Data block 5 lists the centerline elastic moments and reactions due to dead load and live load. Centerline moments for the first and second spans are listed in **Table 2.3-1**.

TABLE 2.3-1 DEAD AND LIVE LOAD MOMENTS

Span	Left	Midspan	Right	Reference Number
First span				
Self weight, k-ft (kNm)	0 (0)	1.38 (1.87)	-2.42 (-3.28)	B5.1, C3-5
Dead load, k-ft (kNm)	0 (0)	0.11 (0.15)	-0.19 (-0.26)	B5.1, C3-5
Live load, k-ft (kNm)	0 (0)	1.56 (2.12)	-2.11 (-2.86)	B5.3, C2-7
Second span				
Self weight, k-ft (kNm)	-2.42 (-3.28)	0.54 (0.73)	-1.68 (-2.28)	B5.1, C3-5
Dead load, k-ft (kNm)	-0.19 (-0.26)	0.04 (0.05)	-0.13 (-0.18)	B5.1, C2-4
Live load, k-ft (kNm)	-2.11 (-2.86)	1.23 (1.67)	-1.94 (-2.63)	B5.3, C2-7

2.3.1.6 Reactions

ADAPT-PT calculates the reactions from the evaluated support moments and span loading. ADAPT-PT's results are shown in data block 5.1, columns 6 and 7 (B5.1, C6-7) for DL and data block 5.3, columns 8 and 9(B 5.3, C8-9) for LL. The sum of the shears is tabulated as support reactions in data block 5.2, column 3 (B 5.2, C3) and data block 5.4 columns 2 and 3 for DL and LL respectively. The reactions due to dead load sum up to 9.81k.

The sum of the reactions can be verified by adding up the total dead load on the structure as follows:

Number of spans	=6	
Length of each span	=18 ft (5.49 m)	
Width of transverse beam	=14 in. = 1.17 ft (0.36 m)	(B2.6, C2-3)

Load intensity on transvers beam = 0.425 + 0.005
= 0.43 k/ft (6.28 kN/m)

Load intensity on slab = 0.063 + 0.005
= 0.068 k/ft (0.99 kN/m)

Total Loading = (1.17 *0 .43 +(18 –1.17) *0.068)*6
= 9.88 k (43.95 kN) (ADAPT-PT 9.81, OK)

2.3.1.7 Reduction of Moments to the Face-of-Support (Data Block 6)

ADAPT-PT calculates the face-of-support moments from the equations of statics.

For verification consider the reduction of self-weight moment at first interior support for span one:

Reduced moment = M + Wa2/8 -Va/2

M = centerline moment	= 2.42 k-ft (-3.28 kN-m)	(B5, C5)
V = centerline shear	= 0.91 k (4.05 kN)	(B5,C6)
W = applied load	= 0.425 k/ft (6.20 kN/m)	
A = support width	=14 in. = 1.17 ft (0.36 m)	(B2.6, C3-4)

Reduced moment $= -2.42 - 0.425*1.17^2/8 + 0.91 * 1.17/2$
= -1.96 k-ft (-2.66 kNm) (ADAPT-PT -1.96, B6.1, C5)

2.3.1.8 Tendon Profiles and Forces (Data Block 7.1 and 7.2)

Data block 7.1 and 7.2 report the tendon profiles and forces. Here reversed parabola (type 1) is selected as tendon shape. In an actual case the user has the option to select the profile from the library of ADAPT-PT tendon profiles.

Data block 7.1 is the description of reversed parabola. In data block 7.1 the zeros under column 3 and 5 indicate that the parabola used for the central part of the span extends to the support centerlines. In this case, column 6 has no significance. In building construction, the low points of the tendon shapes are generally placed at midspan. But in this example, for first and last spans, the low points are selected such as to provide a uniform upward force over the entire span. Due to the different tendon heights at the left and right supports, the low points will not fall at midspan. The distance of low point of the first span from the left support is calculated as follows:(Refer to **Fig. 2.3-1**).

a	= 2.5 -1.75
	= 0.75 in. (19mm)
b	= 4-1.75
	= 2.25 in. (57mm)
L	= 18 ft (5.49 m)
C	= 18 * { [√(0.75/ 2.25)]/[1+ √(0.75/ 2.25)] }
	=6.59 ft (2.01 m)
X2/L	= 6.59/18
	= 0.366 (ADAPT-PT B7.1,C-4)

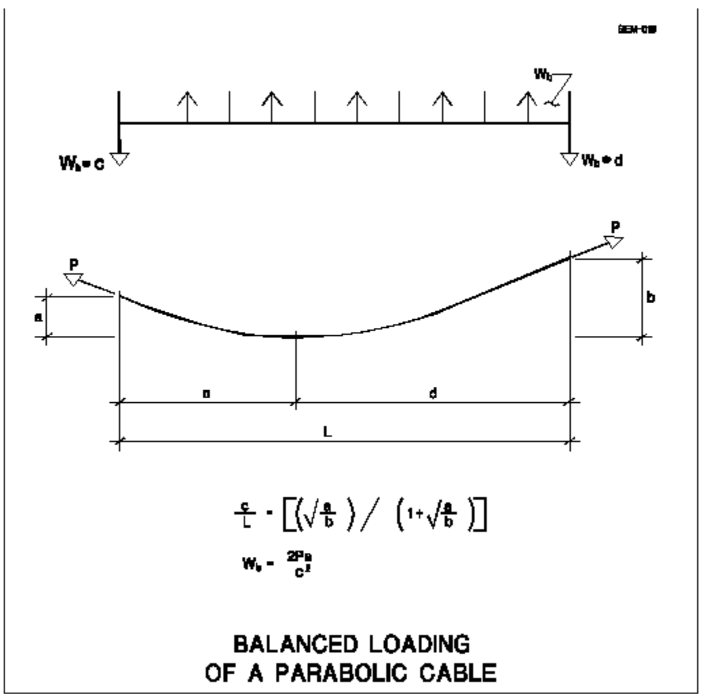


Figure 2.3-1

Data Block 7.2, columns 3-6 (B 7.2, C 3-6) list the tendon heights at control points.

Data Block 7.2, column 2 reports the selection of tendon forces. Observe that the forces selected (B 7.2, C2) are duly larger than those required (B 7.4, C 2-7). This ensures that the extreme fiber tensile stresses will be

equal or less than the maximum allowable values specified by the user as part of input (B1).
Data Block 7.2, column 8 (C8) gives the calculated values of balanced loading. The verification is as follows:

Span 1:

Provided PT force, T = 15 k/ft (66.72 kN/m) (B7.2, C2)

a = 2.5-1.75
= 0.75 in. (19mm)

b = 4-1.75
= 2.25 in. (57mm)

L = 18 ft (5.49 m)

c = 18 * { [√(0.75/ 2.25)]/[1+ √(0.75/ 2.25)]
= 6.59 ft (2.01 m)

w_b / tendon = (2 * T *a / L^2)
= 2 * 15 * (0.75/12)/ 6.59^2
= 0.043 klf (0.63 kN/m) (ADAPT-PT 0.043,B 7.2, C8)

% DL balanced:

DL = selfweight + weight of transverse beam + SDL
= 0.063 *(18-(14/12)) +0 .425 * (7/12) * 2 + 0.005 * 18
= 1.65 k (7.32 kN)

w_b = 0.043* 18 = 0.77 k (3.43 kN)

% DL balanced = (0.77/ 1.65)*100
= 47 (ADAPT-PT 47, B 7.2, C9)

Span 2:

Provided PT force = 7 k/ft (31.14 kN/m) (B7.2, C2)

a = 4-1.0
= 3 in. (76mm)

w_b / tendon = 8* P*a/ L^2
(Since the profile is symmetrical, i.e., a = b = 3 in)
= 8 * 7.5 * (3/12)/ 18^2
= 0.046 klf (0.67 kN/m) (ADAPT-PT 0.046,B 7.2, C8)
= (0.046*18/ 1.65)*100
= 50 (ADAPT-PT 51, B 7.2, C9)

A detailed list of the balanced loading generated for the entire structure is given in the detailed tabular report under Data Block 22, Post-Tensioning Balanced Loading.

2.3.1.9 Post-Tensioning Balanced Moments (Data Block 7.6)

Balanced moments due to post-tensioning are obtained by applying the balanced loading to the structure. The outcome is summarized in **Table 2.3-3.**

TABLE 2.3-3 BALANCED (POST-TENSIONING) MOMENTS

Span	Post-Tensioning Moment k-ft (kNm)			Reference Number
	Left*	Midspan	Right*	
First Span	-0.17 (-0.23)	-0.94 (-1.27)	1.34 (1.82)	B7.6, C2-4
Second Span	1.38 (1.87)	-0.84 (-1.14)	1.13 (1.53)	B7.6, C2-4

* Face of support

The support shears due to post-tensioning are listed in B7.6, C 5-6. In the case of a prestressed slab or beam it is only the secondary shears, which are resisted by the supports. The secondary reactions, which are the sum of secondary shears, are normally much smaller than the values calculated as reactions of upward forces.

The support reactions are reported in 7.6 lower data block, C2.

Forces created by prestressing at the supports of a member are, by definition, the secondary reactions. The secondary reactions must be in self-equilibrium. The sum of reactions due to post-tensioning given by ADAPT-PT is zero (B 7.6, C2). Refer to **Fig. 2.3-2** for details of Reactions.

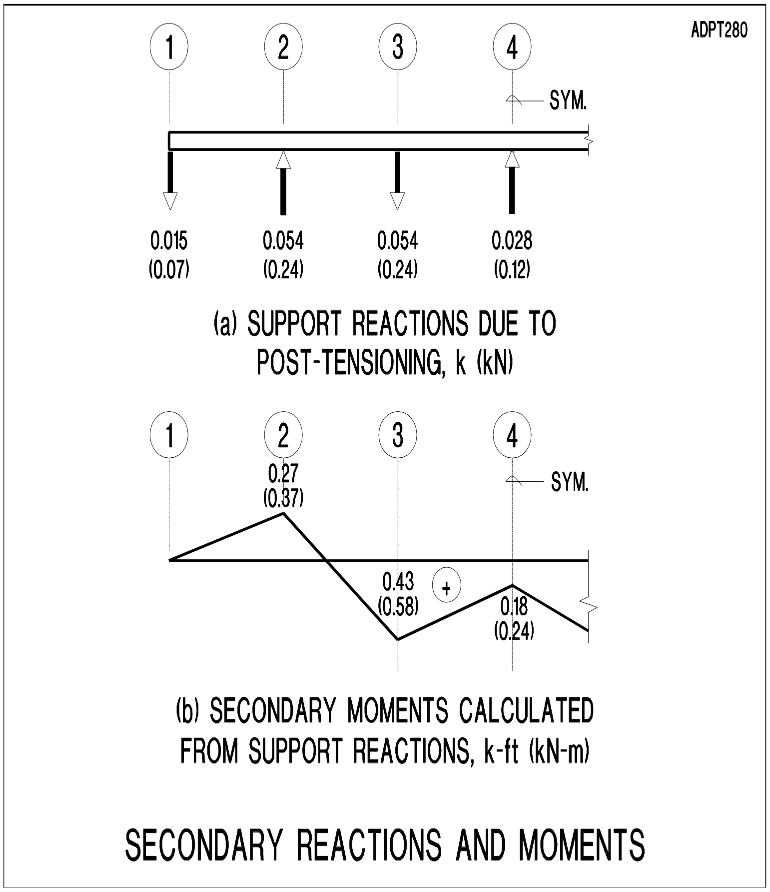


Figure 2.3-2

2.3.1.10 Stress Check for Serviceability (Data Block 7.5)

Data block 7.5 lists the service stresses at top and bottom for supports and mid span. ADAPT- PT's calculation is as follows:

Data block 7.5 lists the service stresses at top and bottom for supports and mid span. This has two data blocks with service stresses, Envelope of Service 1, and Envelope of Service 2. Envelope of Service 1 is the envelope of service stresses from the Sustained Load Combinations. Similarly, Envelope of Service 2 is the envelope of service stresses from the Total Load combinations. This section provides the calculation for Envelope of Service 2.

Consider the Midspan of Span 1:

Stresses:

$\sigma = (M_D+M_L+M_{PT})/S + (P/A)$

$S = I/Y_c$

Where M_D, M_L, M_{PT} are the moments across the entire tributary of the design strip. S is the section modulus; A is the area; I is the moment of inertia of the section; and Y_c is the distance of the centroid of the section to farthest tension fiber of the section.

Stress limits:
Top Tension = 9*√4000 = 569 psi (3.92 MPa) (B1)

Bottom Tension Compression (for service) = 9*√4000
= 569 psi (3.92 MPa)
= 0.45 * 4000
= -1800 psi (-12.41 MPa)

A	= 60 in^2 (38.71e3 mm^2)	(B4.2, C3)
I	= 125 in^4 (52.03e6 mm^4)	(B4.2, C4)
Y_b	= 2.5 in (64 mm)	(B4.2, C5)
Y_t	= 2.5 in (64 mm)	(B4.2, C6)

S_{bottom}=S_{top} = 125/ 2.5
=50 in^3 (8.19e5 in^3)

P	= 15 k/- (66.72 kN/m)	(B7.2, C2)
M_D	= 1.49 k-ft (2.02 kNm)	(B6.1, C4)
M_L	= 1.56 k-ft (2.12 kNm)	(B6.2, C4)
M_{PT}	= -0.94 k-ft (-1.27 kNm)	(B7.6, C3)
M_D+M_L+M_{PT}	= 1.49 + 1.56 –0.94	
	= 2.11 k-ft (2.86 kNm)	

P/A = -15*1000/ 60
= -250 psi (-1.72 MPa)

Top fiber:
σ = (-2.11*12000)/50- (250)
= -756.40 psi (-5.22 MPa) (ADAPT-PT -755.89, B7.5)
< -1800 psi (-12.41 MPa)

Bottom fiber:
σ = (2.11*12000)/50- (250)
= 256.40 psi (1.77 MPa) (ADAPT-PT 255.89, B7.5)
< 569 psi (3.92 MPa)

Calculations for all other points are carried out in the same way and printed in ADAPT-PT, Block 7.5. Stress calculations at 1/20 th points are printed in a file called STRESS. DAT. This file is stored in the subdirectory, where the data is executed. Also, in the data block 27 of the detailed tabular report.

2.3.1.11 Required Post-Tensioning (Data Block 7.4)

Consider the required post-tensioning at the right support of span one; given by ADAPT-PT as 9.68 kips (B 7.4, C 4).

The verification is carried out by demonstrating that the "required minimum post-tensioning force" suggested by ADAPT-PT, if used, leads to the maximum allowable tensile stress specified by the user. In this example the maximum allowable stress in tension is: 9√f'c.

Stress due to dead and live moments:

M = -(1.96+0.16+1.79)
= -3.91 k-ft (-5.30 kNm) (ADAPT-PT B6.1-6.2)

M/S = 3.91 *12000/ 50
= 938.40 psi (6.47 MPa)

Stress due to balanced moment is obtained by prorating the moment due to the selected force (15 k) by the force suggested by ADAPT-PT (9.68 k).

M/S = (9.68/15)*1.34 *12000/ 50 = 207.54 psi (1.43 MPa)

Stress due to direct compression:
P/A = 9.68 * 1000/ 60 = 161.33 psi (1.11MPa)

Total tensile stress:
938.40 – 207.54 – 161.33 = 569.53 psi (3.93MPa)

Allowable stress:
9√f'c = 9 *√4000 = 569.21 psi (3.92 MPa) (OK)

It is shown that the calculated required post-tensioning corresponds to the maximum permissible tensile stress as specified by the user in data block 1.

2.3.1.12 Secondary Moments (Data Block 8.3)

The secondary moments for the first two spans from the data block 8.3 are summarized in the **Table 2.3-4**. The moments are reduced to the face-of support. To obtain the centerline moments, you have to select "No" for reduce to face-of- support option in the "Design Settings" input screen.

TABLE 2.3-4: HYPERSTATIC (SECONDARY MOMENTS) OF SPANS 1 AND 2

2.3.1.12.1.1.1 Span	Secondary Moment, k-ft (kNm)			Reference Number
	Left	Midspan	Right	
First Span	-0.01 (-0.01)	-0.13 (-0.18)	-0.26 (-0.35)	B8.3, C2-4
Second Span	-0.24 (-0.33)	0.09 (0.12)	0.43 (0.58)	B8.3, C2-4

Secondary moments are computed by ADAPT-PT using the direct definition of secondary actions. Secondary moments are moments induced in the structure as a consequence of restraining effects of its supports to free displacement of the structure due to prestressing. The restraining effects appear as support reactions caused by post-tensioning. Hence, secondary moments may be calculated as moments in the structural member due to post-tensioning reactions. ADAPT-PT calculates the post-tensioning reactions and lists them in data block 7.6 under *reactions* and *column moments.*

The post-tensioning reactions are shown in **Fig. 2.3-2**. A secondary moment diagram constructed from these reactions is also shown in **Fig. 2.3-2**. The centerline secondary moments at supports are:

Support 2 = -0.015*18
= -0.27 k-ft (0.37 kNm) (ADAPT-PT 0.26, MSECSF.DAT)
Support 3 = -0.015*36+0.054*18
= 0.43 k-ft (0.58 kNm) (ADAPT-PT 0.45, MSECSF.DAT)
Support 4 = -0.015*54+0.054*36-0.054*18
= 0.17 k-ft (0.23 kNm) (ADAPT-PT 0.21, MSECSF.DAT)

Note that the secondary moments given in ADAPT-PT are reduced to the face-of-support if dead and live moments are also reduced. You can refer the file MSECSF.DAT that is generated and stored in the subdirectory, where you executed your data for a detailed list of centerline secondary moments and shears.

Secondary moments are also given by the following relationship. This relationship, however, is not used in ADAPT-PT and is not recommended, since it does not include an equilibrium check to detect errors in computation.

$M_{sec} = M_{bal}$ - F*e

The following is the verification of ADAPT-PT's values for the first span midspan using the above algorithm:

M_{bal}	= 0.94 k-ft	(B7.6, C3)
F	= 15k	
e	= (5/2)-1.85	
	= 0.65 in.	
M_{sec}	= -0.94 – 15*-0.65/12	
	= -0.13 k-ft (-0.17 kNm)	

From the **Fig. 2.3-2** M_{sec} at first in-span = (0+0.26)/2 = -0.13 k-ft.
(ADAPT-PT -0.13 k-ft)

2.3.1.13 Factored Moments (Design Moments) (Data Block 8.1)

Consider the verification of the moment at left of second support:

1.2 M_d	= 1.2 * -2.12	
	= -2.54 k-ft (-3.45 kNm)	
1.6 M_l	= 1.6 * -1.79	
	= -2.86 k-ft (3.88 kNm)	
1.0 M_{sec}	= 1.0 * -0.26	
	= -0.26 k-ft (-0.35 kNm)	
Mu	= 1.2 Md + 1.6 Ml + 1.0 Msec	
	= -5.66 k-ft (-7.67 kNm)	(ADAPT-PT –5.66, B8.1, C6)

2.3.1.14 Nonprestressed Reinforcement (Mild Reinforcement) (Data Block 10)

ADAPT-PT computes the mild reinforcement required for each criterion and selects the largest.

Consider the mid span of first span for verification:

(i) Minimum Steel

Per ACI 318-14, Section 7.6.2.3, the minimum bonded reinforcement is:

$A_s = 0.004*A_{tens}$

Where A_{tens} is the area of the section between the tension fiber and the section centroid. The minimum rebar is required for members reinforced with unbonded tendons. The added rebar is to reduce the in-service crack width and enhance the ductility of the member in ultimate strength condition.

Per foot of slab width,

A_s = 0.004*2.5*12
= 0.12in^2(77.42 mm^2) (ADAPT-PT 0.12, B10.1.1, C5)

(ii) Ultimate Strength Requirement

Design moments:

The design moments are obtained from two load combinations:

$M_{u1} = 1.2 *M_D+1.6* M_L+1.0*M_{Hyp}$
$M_{u1} = 1.4 *M_D+1.0*M_{Hyp}$

The second combination governs when the values from dead load are eight times or more of those of live loading. This is a rare condition.

M_{u1} = 1.2 *1.49+1.6* 1.56 + 1.0*-0.13
= 4.15 k-ft (5.63 kNm) (ADAPT-PT 4.15, B8.1, C4)

b (width) = 12 in. (305 mm)

h (height) = 5 in. (127 mm)
Rebar Cover = 1.00 in. (25 mm) (B1)
Bottom bar dia. = 0.75 in. (19 mm) (#6 bar)

d_r = d_t = 5 - (1.00 + 0.75/2)
= 3.63 in. (83 mm)
PT = 15 k (66.72 kN) (B7.2, C2)
d_p = 5-1.85 =3.15 in (80 mm) (PTCGS.DAT)
f_{se} = 175 ksi (1206.59 MPa) (B1)
Span = 18 ft (5.49 m)
Rebar area = 0.04 in2 (45 mm^2) (B 10.1.1, C6, & B 29, C4)
f_y = 60 ksi (413.69 MPa)

Calculate design stress in tendon (f_{ps}):

Span to depth ratio = 18*12/5 = 43.2 > 35

Hence, use ACI Equation (18-5):

f_{ps}	$= f_{se} + 10000 + (f'_c/300*\rho_p)$	

where,

f'_c	= 4000 psi (27.59 MPa)	(B1)
ρ_p	= ratio of prestressed reinforcement	
	= Aps/b*dp	
A_{ps}	= 15/175	
	= 0.086 in.^{2} (55 mm^2)	
ρ_p	= 0.086/(12*3.15)	
	= 0.0023	
f_{ps}	= 175000 + 10000 + (4000/300*0.0023)	
	= 190797 psi (1315.51 MPa)	
f_{ps}	= 190.797 < (175 + 30)	
	= 205 ksi	(OK)
Tension (T)	= PT + rebar	
	= 0.086*190.797 + 0.04*60	
	= 16.41 + 2.4	
	= 18.81 k (83.67 kN)	
a	= Depth of compression zone	
	$= T/0.85*b*f'_c)$	
	= 18.81/(0.85*12*4) = 0.46 in. (12 mm)	
c	= a/0.85	
	= 0.54 in. (14 mm)	
c/d_t	= 0.54/3.25 = 0.17 < 0.375, hence ϕ = 0.9	
ϕM_n	= 0.9*[16.41(3.15-0.46/2) + 2.4*(3.63-0.46/2)]/12	
	= 4.21 k ft (5.70 kNm)	
		(ADAPT-PT 4.15, B8.1, C4 OK)

Therefore, reinforcement required for the ultimate strength is less than the minimum required steel (B10.1.1, C7). No supplemental rebar is required. Provide minimum steel (B10.1.1, C5).

2.3.1.15 Shear Design (Data Block 12)

Check one-way shear:

Distribution of design shear is summarized in the following **Table 2.3-5**. The design shear (Vu) is computed from the results of the standard frame analysis or performed for the loading condition D, L and PT. For this example design shear is calculated from ADAPT-PT B5 & B7.6.

$V_u = 1.2* V_D + 1.6* V_L + 1.0 * V_{Hyp}$

TABLE 2.3-5 DESIGN SHEAR AT SUPPORTS

Design Shear (Vu)						
Span	**1**	**2**	**3**	**4**	**5**	**6**
Left **k (kN)**	-1.43 (-6.36)	-1.96 (-8.72)	-1.80 (-8.00)	-1.90 (-8.45)	-1.73 (-7.70)	-2.08 (-9.25)
Right **k (kN)**	2.09 (9.30)	1.73 (7.70)	1.90 (8.45)	1.80 (8.00)	1.95 (8.67)	1.43 (6.36)

$V_u \leq \phi V_c$

$\phi V_c = 0.75 * 2*\sqrt{f'_c} * b_w*d$

From the **Table 2.3-5**, maximum V_u is 2.09 k(9.30 kN) at the first interior support.

$\phi V_c = 0.75 * 2*\sqrt{4000} * 12*3.63$
$= 4.13$ k (18.37 kN)

2.05 k (9.12 kN) < 4.13 k (18.37 kN) (OK)
No shear reinforcement is required. (ADAPT-PT B12)

2.3.2 Verification of SI Report

The SI version is verified by way of comparing its output with the American version. **Table 2.3-6** lists the first span critical values of the one-way slab for both the American and the SI system of units. Good agreement between the two versions is observed.

TABLE 2.3-6 COMPARISON BETWEEN THE METRIC AND AMERICAN OUTPUTS OF ADAPT-PT FOR PTI ONE-WAY SLAB EXAMPLE (PTI01M)

	SI output		American output	Reference number
	[kN,m]	[k,ft]	[k,ft]	
DL Moment Span	2.03	1.50	1.49	B5.1, C4
DL Moment Support	-3.53	-2.60	-2.61	B5.1, C5
DL Moment Reduced	-2.87	-2.12	-2.12	B6.1, C5
LL Moment Span	2.11	1.56	1.56	B5.3, C4
LL Moment Support	-2.87	-2.12	-2.11	B5.3, C6
LL Moment Reduced	-2.43	-1.79	-1.79	B6.2, C6
Required PT Span	21.76	4.89	5.13	B7.4, C3
Required PT Support	41.91	9.42	9.68	B7.4, C4
Stress Bottom at Center	1.74	252.36	255.89	B7.5, C8,Env-2
Stress Top at Center	-5.18	-751.31	-755.89	B7.5, C7, Env-2
Secondary Moment Span	-0.17	-0.13	-0.13	B8.3, C3
Rebar - Bottom	77.47	0.12	0.12	B10.1.1, C5
Rebar - Top	77.47	0.12	0.12	B10.1.1, C5
Deflection DL+PT+CR (Long-term)	5.6	0.22	0.22	B14.1, C5

3 Two-Way Slab Verification

The column-supported slab selected has the same geometry, material property and loading as the design example in the PTI's publication "Design Of Post-Tensioned Slabs With Unbonded Tendons" [3rd edition, 2004]. The following defines the entire parameters of the structural floor system, necessary to analyze and design the entire floor structure. However, as in the PTI example the design provided in the following considers a typical design strip in the transverse direction.

3.1 Given Values

Loading and other details are given in the following pages.

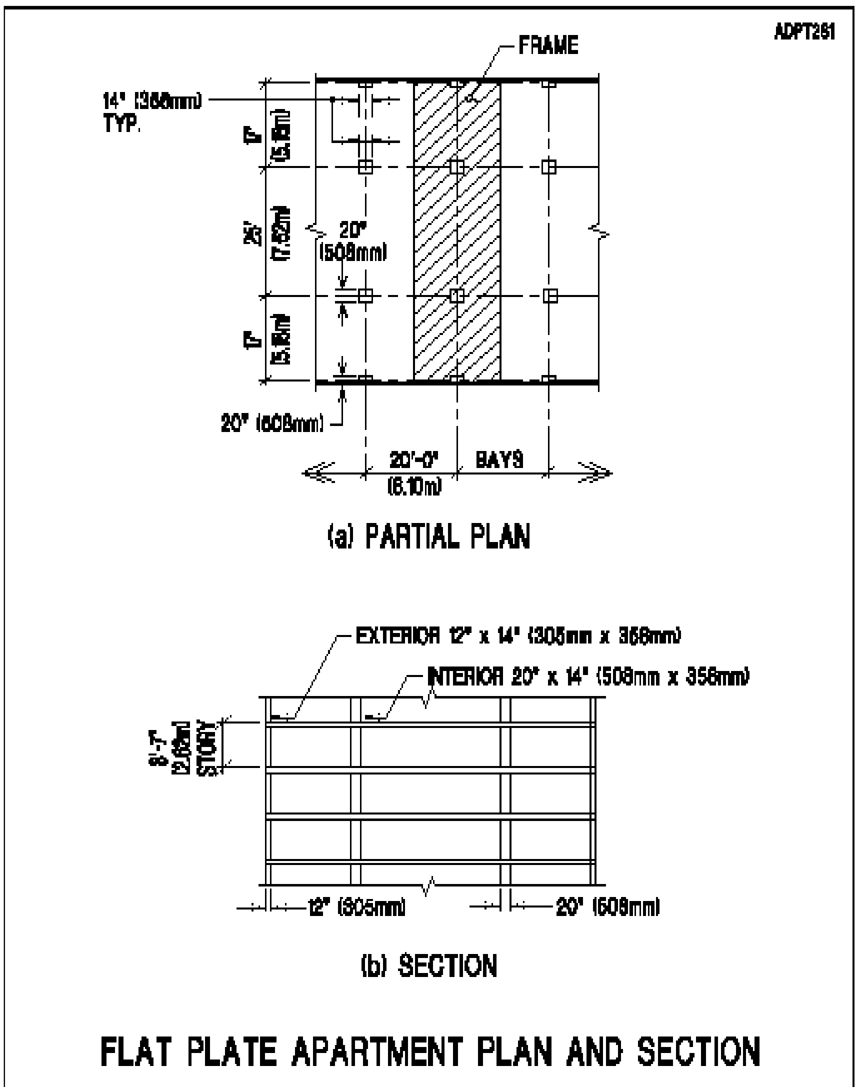


Figure 3.1-1

3.1.1 Structural System

The structural system consists of three-span two-way slab.

3.1.2 Design Code

The design is based on ACI 318-14.

3.1.3 Material Properties

(i) Concrete

Compressive cylinder strength, f'_c	= 4000 psi (27.58 MPa)
Weight	= 150 pcf (2403 kg/m^3)
Modulus of elasticity	= 3605 ksi (24856 MPa)
Age of concrete at stressing	= 3 days

(ii) Post-Tensioning

Material:

Low relaxation, seven wire strand	
Strand diameter	= ½ in (13 mm)
Strand area	= 0.153 in2 (99 mm^2)
Modulus of elasticity	= 28000 ksi (193054 MPa)
Ultimate strength of strand, f_{pu}	= 270 ksi (1861.60MPa)
Average effective stress (f_{se})	= 175 ksi (1206.59 MPa)

System:

System unbonded

Stressing:

Ratio of jacking stress to strand's ultimate strength	= 0.8
Anchor set	= 0.25 in (6.35 mm)
Coefficient of angular friction, μ	= 0.07 /radian
Coefficient of wobble friction, K	= 0.0014 rad/ft
	= (0.0046 rad/m)
Stress on day 3	
Minimum concrete cylinder strength at stressing f'_{ci}	= 3000 psi (20.68 MPa)

(iii) Nonprestressed Reinforcement

Yield stress f_y = 60 ksi (413.69 MPa)
Modulus of elasticity = 29000 ksi (199,949 MPa)

(iv) Design Loading

Dead load = 0.096 k/ft (1.40 kN/m)
Live load = 0.034 k/ft (0.50 kN/m)
(Live load is conservatively not reduced.)

3.1.4 Load Cases and Combinations

(i) Strength Load Combinations

The strength requirement for each member is established using the following factored load combinations:

Primary load combination
1.2*DL + 1.6*LL + 1*HYP

Other load combination
1.4*DL + 1*HYP

Where "HYP" is the secondary (hyperstatic) moments, shears, and reactions due to post-tensioning.

(ii) Serviceability Load Combinations

Final stresses:

The design is selected to be carried out according to the "Uncracked" (U) state of stress of the code. That is to say, the maximum hypothetical tensile stresses shall not exceed 6 $\sqrt{f'_c}$ but be retained less than 12 $\sqrt{f'_c}$ A hypothetical tensile stress equal to 9 * $\sqrt{f'_c}$ is set as design target.

Tensile stress (top and bottom) = 6 * $\sqrt{f'_c}$ = 379.47 psi (2.62 MPa)

Compressive stress
For sustained load condition = 0.45 * f'_c = 1800 psi (12.41 MPa)
For total load condition = 0.60 * f'_c = 2400 psi (16.55 MPa)

Load combinations for serviceability check:

Total load condition

1*DL + 1*LL + 1*PT

Sustained load condition
1*DL + 0.3*LL + 1*PT

The factors for neither of the above load combinations are spelled out in the code. Their selection is based on common practice.

Initial stresses (transfer):

Maximum tension = 3 $\sqrt{f'_{ci}}$

Maximum compression = 0.60 * f'_{ci}

Load combinations for stress check at transfer of prestressing:

U = 1.00 DL + 1.15* PT

3.1.5 Deflections

Having maintained the hypothetical tensile stresses within the limits stated in the preceding, the deflections would be calculated assuming gross cross-sectional properties. Long-term deflections are estimated using a creep coefficient of 2.

For the floor slabs the maximum deflections are maintained below the following value with the understanding that the floor structure is not attached to nonstructural elements likely to be damaged by large deflections of the floor:

Slabs:

Live load deflection $\leq$ span/360

3.1.6 Cover

(i) Nonprestressed Reinforcement

Cover to top bars = 1 in (25 mm)
Cover to bottom bars = 1 in (25 mm)

(ii) Prestressed Reinforcement

Top cover = 1.25 in (32 mm) for all spans
Bottom cover
Interior spans = 1.25 in (32 mm)
Exterior spans = 1.75 in (44 mm)

3.1.7 Tendon Profile

Interior spans = reversed parabola with low point at center

Exterior spans = reversed parabola with low point at 0.490*L from the left support for first span and 0.510*L for last span from the left support

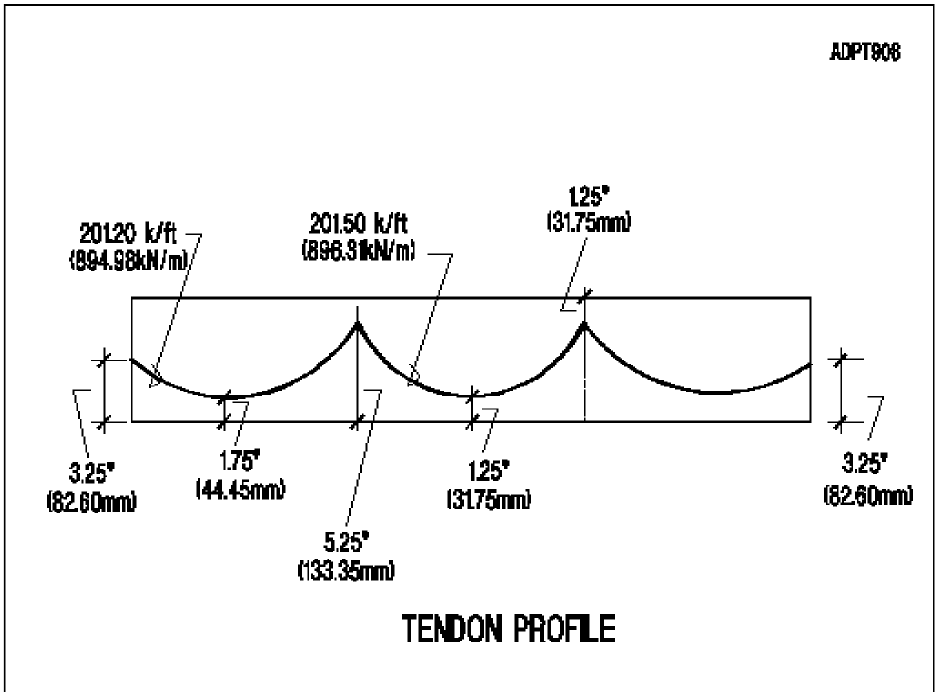


Figure 3.1-2

3.2 Computed Values

The computed values are obtained from ADAPT-PT. The relevant parts of the tabular report are summarized below.

3.2.1 Computer Report for American Units

ADAPT
Your Partner in Concrete Design

TWO-WAY FLAT SLAB VERIFICATION

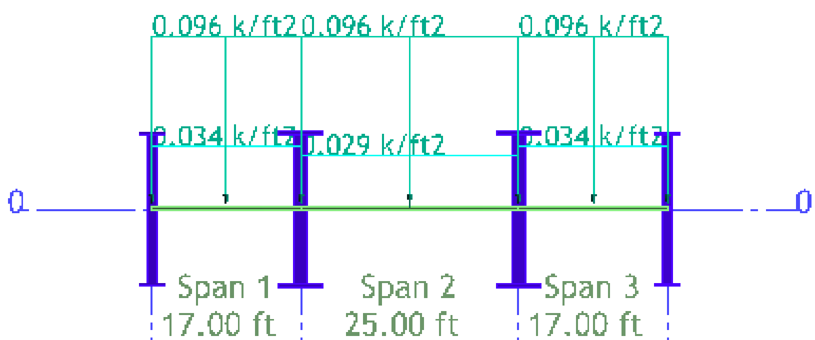


TABLE OF CONTENT:

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		Minimum Cover at BOTTOM	1.00 in
F'c for BEAMS/SLABS	4000.00 psi	Post-tensioning	
For COLUMNS/WALLS	4000.00 psi	SYSTEM	UNBONDED
Ec for BEAMS/SLABS	3605.00 ksi	Fpu	270.00 ksi
For COLUMNS/WALLS	3605.00 ksi	Fse	175.00 ksi
CREEP factor	2.00	Strand area	0.153 in 2
CONCRETE WEIGHT	NORMAL	Min CGS from TOP	1.25 in
Tension stress limits / (f'c)1/2		Min CGS from BOT for interior spans	1.25 in
At Top	6.000	Min CGS from BOT for exterior spans	1.75 in
At Bottom	6.000	Min average precompression	125.00 psi
Compression stress limits / f'c		Max spacing / slab depth	8.00
At all locations	0.450	Analysis and design options	
Reinforcement		Structural system - Equiv Frame	TWO-WAY
Fy (Main bars)	60.00 ksi	Moments reduced to face of support	YES
Fy (Shear reinforcement)	60.00 ksi	Moment Redistribution	NO
Minimum Cover at TOP	1.00 in	DESIGN CODE SELECTED	ACI-318 (2014)

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		ft	in	in	in	in	in	in	in		
1	1	17.00	12.00	6.50					6.50	10.00	10.00
2	1	25.00	12.00	6.50					6.50	10.00	10.00
3	1	17.00	12.00	6.50					6.50	10.00	10.00

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	in	ft	in	in			ft	in	in		
1	12.0	8.6	14.0	12.0	100	(1)	8.6	14.0	12.0	100	(1)
2	20.0	8.6	14.0	20.0	100	(1)	8.6	14.0	20.0	100	(1)
3	20.0	8.6	14.0	20.0	100	(1)	8.6	14.0	20.0	100	(1)
4	12.0	8.6	14.0	12.0	100	(1)	8.6	14.0	12.0	100	(1)

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			k/ft2	k/ft	k/ft	ft	ft	ft	k	k-ft
1	LL	U	0.034							
1	SDL	U	0.096							
2	LL	U	0.029							
2	SDL	U	0.096							
3	LL	U	0.034							
3	SDL	U	0.096							

NOTE: LIVE LOADING is SKIPPED with a skip factor of 1.00

4 - CALCULATED SECTION PROPERTIES

4.1 Section Properties of Uniform Spans and Cantilevers

Span	Area	I	Yb	Yt
	in2	in4	in	in
1	1560.00	0.55E+04	3.25	3.25
2	1560.00	0.55E+04	3.25	3.25
3	1560.00	0.55E+04	3.25	3.25

5 - MOMENTS, SHEARS AND REACTIONS

5.1 Span Moments and Shears (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right	Shear Left	Shear Right
		k-ft	k-ft	k-ft	k	k
1	SW	0.00	0.00	0.00	0.00	0.00
2	SW	0.00	0.00	0.00	0.00	0.00
3	SW	0.00	0.00	0.00	0.00	0.00
1	SDL	-11.33	25.46	-76.47	-12.49	20.15
2	SDL	-94.13	55.87	-94.13	-24.00	24.00
3	SDL	-76.47	25.46	-11.33	-20.15	12.49
1	XL	0.00	0.00	0.00	0.00	0.00
2	XL	0.00	0.00	0.00	0.00	0.00
3	XL	0.00	0.00	0.00	0.00	0.00

5.2 Reactions and Column Moments (Excluding Live Load)

Joint	Load Case	Reaction	Moment Lower Column	Moment Upper Column
		k	k-ft	k-ft
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
4	SW	0.00	0.00	0.00
1	SDL	12.49	-5.82	-5.50
2	SDL	44.15	-9.08	-8.58
3	SDL	44.15	9.08	8.58
4	SDL	12.49	5.82	5.50
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00
4	XL	0.00	0.00	0.00

5.3 Span Moments and Shears (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min	Shear Left	Shear Right
	k-ft	k-ft	k-ft	k-ft	k-ft	k-ft	k	k
1	-6.43	2.06	14.45	-4.63	-26.11	-10.35	-5.35	7.07
2	-31.14	-3.42	19.79	-3.42	-31.14	-3.42	-7.56	7.56
3	-26.11	-10.35	14.45	-4.63	-6.43	2.06	-7.07	5.35

5.4 Reactions and Column Moments (Live Load)

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	k	k	k-ft	k-ft	k-ft	k-ft
1	5.35	-0.79	1.06	-3.31	1.00	-3.13
2	14.63	6.21	5.34	-7.29	5.04	-6.89
3	14.63	6.21	7.29	-5.34	6.89	-5.04
4	5.35	-0.79	3.31	-1.06	3.13	-1.00

6 - MOMENTS REDUCED TO FACE OF SUPPORT

6.1 Reduced Moments at Face of Support (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right
		k-ft	k-ft	k-ft
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
1	SDL	-5.32	25.46	-60.34
2	SDL	-74.79	55.88	-74.79
3	SDL	-60.34	25.46	-5.32
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00

6.2 Reduced Moments at Face of Support (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min
	k-ft	k-ft	k-ft	k-ft	k-ft	k-ft
1	-3.84	1.67	14.45	-4.63	-20.45	-8.86
2	-25.04	-3.42	19.79	-3.42	-25.04	-3.42
3	-20.45	-8.86	14.45	-4.63	-3.84	1.67

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile
Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
1	1	0.000	0.490	0.000	---
2	1	0.000	0.500	0.000	---
3	1	0.000	0.510	0.000	---

7.2 Selected Post-Tensioning Forces and Tendon Drape
Tendon A

Span	Force	CGS Left	CGS C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	k	in	in	in	in	psi	k/-	
1	201.200	3.25	---	1.75	5.25	128.97	1.152	60
2	201.500	5.25	---	1.25	5.25	129.17	0.860	45
3	201.200	5.25	---	1.75	3.25	128.97	1.152	60

Approximate weight of strand: 247.1 LB

7.4 Required Minimum Post-Tensioning Forces

	Based on Stress Conditions			Based on Minimum P/A		
Type	Left	Center	Right	Left	Center	Right
	k	k	k	k	k	k
1	0.00	0.00	112.07	195.00	195.00	195.00
2	174.53	108.32	174.55	195.00	195.00	195.00
3	112.04	0.00	0.00	195.00	195.00	195.00

7.5 Service Stresses (tension shown positive)
Envelope of Service 1

Span	Left Top Max-T	Left Top Max-C	Left Bot Max-T	Left Bot Max-C	Center Top Max-T	Center Top Max-C	Cetner Bot Max-T	Cetner Bot Max-C	Right Top Max-T	Right Top Max-C	Right Bot Max-T	Right Bot Max-C
	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi

1	-----	-123.32	-----	-146.37	-----	-215.81	-----	-82.79	122.85	-----	-----	-381.18
2	204.11	-----	-----	-462.44	-----	-403.69	145.35	-----	204.14	-----	-----	-462.47
3	122.77	-----	-----	-381.11	-----	-215.78	-----	-82.82	-----	-123.25	-----	-146.44

Envelope of Service 2

Span	Left Top Max-T	Left Top Max-C	Left Bot Max-T	Left Bot Max-C	Center Top Max-T	Center Top Max-C	Cetner Bot Max-T	Cetner Bot Max-C	Right Top Max-T	Right Top Max-C	Right Bot Max-T	Right Bot Max-C
	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi
1	-----	-131.63	-----	-165.48	-----	-287.63	29.68	-105.83	224.49	-----	-----	-482.83
2	328.57	-----	-----	-586.91	-----	-502.06	243.73	-----	328.60	-----	-----	-586.94
3	224.42	-----	-----	-482.75	-----	-287.60	29.65	-105.86	-----	-131.56	-----	-165.55

7.6 Post-Tensioning Balance Moments, Shears and Reactions
Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right
	k-ft	k-ft	k-ft	k	k
1	4.03	-17.57	30.98	-0.08	-0.08
2	35.37	-23.15	35.37	0.00	0.00
3	30.99	-17.57	4.01	0.08	0.08

Reactions and Column Moments

Joint	Reaction	Moment Lower Column	Moment Upper Column
	k	k-ft	k-ft
1	0.076	3.553	3.359
2	-0.076	1.141	1.078
3	-0.077	-1.141	-1.078
4	0.077	-3.556	-3.361

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	k-ft	k-ft	k-ft	k-ft	k-ft	k-ft
1	-5.59	3.24	61.23	30.70	-96.99	-78.44
2	-119.39	-84.79	109.15	72.02	-119.38	-84.78
3	-96.97	-78.43	61.24	30.70	-5.58	3.24

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	k	k	k-ft	k-ft	k-ft	k-ft
1	23.62	13.80	-1.74	-8.73	-1.64	-8.25
2	76.31	62.84	-1.21	-21.42	-1.15	-20.25
3	76.31	62.84	21.42	1.21	20.25	1.15
4	23.62	13.80	8.72	1.73	8.25	1.64

8.3 Secondary Moments

Span	Left	Midspan	Right
	k-ft	k-ft	k-ft
1	6.95	7.56	8.14
2	10.43	10.43	10.44
3	8.16	7.57	6.95

ADAPT

Note: Moments are reported at face of support

10 - MILD STEEL - NO REDISTRIBUTION

10.1 Required Rebar

10.1.1 Total Strip Required Rebar

Span	Location	From	To	As Required	Ultimate	Minimum
		ft	ft	in2	in2	in2
1	TOP	0.00	2.55	1.17	0.00	1.17
1	TOP	14.45	17.00	1.23	0.58	1.23
2	TOP	0.00	3.75	1.95	1.95	1.23
2	TOP	21.25	25.00	1.95	1.95	1.23
3	TOP	0.00	2.55	1.23	0.58	1.23
3	TOP	14.45	17.00	1.17	0.00	1.17
2	BOT	8.75	16.25	2.07	1.16	2.07

10.2 Provided Rebar

10.2.1 Total Strip Provided Rebar

Span	ID	Location	From	Quantity	Size	Length	Area
			ft			ft	in2
1	1	TOP	0.00	4	5	3.50	1.24
1	2	TOP	13.60	4	5	8.50	1.24
2	3	TOP	20.00	4	5	8.50	1.24
3	4	TOP	13.60	4	5	3.50	1.24
1	5	TOP	16.00	3	5	4.50	0.93
2	6	TOP	21.50	3	5	4.50	0.93
2	7	BOT	6.50	4	5	12.00	1.24
2	8	BOT	7.75	3	5	9.50	0.93

10.2.2 Total Strip Steel Disposition

Span	ID	Location	From	Quantity	Size	Length
			ft			ft
1	1	TOP	0.00	4	5	3.50
1	2	TOP	13.60	4	5	3.40
1	5	TOP	16.00	3	5	1.00
2	2	TOP	0.00	4	5	5.10
2	3	TOP	20.00	4	5	5.00
2	5	TOP	0.00	3	5	3.50
2	6	TOP	21.50	3	5	3.50
3	3	TOP	0.00	4	5	3.50
3	4	TOP	13.60	4	5	3.50
3	6	TOP	0.00	3	5	1.00
2	7	BOT	6.50	4	5	12.00
2	8	BOT	7.75	3	5	9.50

13 - PUNCHING SHEAR REINFORCEMENT

13.1 Critical Section Geometry

Column	Layer	Cond.	a	d	b1	b2
			in	in	in	in
1	1	2	2.44	4.88	14.44	18.88

2	1	1	2.44	4.88	24.88	18.88
3	1	1	2.44	4.88	24.88	18.88
4	1	2	2.44	4.88	14.44	18.88

13.2 Critical Section Stresses

Label	Layer	Cond.	Factored shear	Factored moment	Stress due to shear	Stress due to moment	Total stress	Allowable stress	Stress ratio
			k	k-ft	ksi	ksi	ksi	ksi	
1	1	2	-23.62	+16.98	0.10	0.031	0.132	0.190	0.697
2	1	1	-76.31	+27.02	0.18	0.042	0.221	0.195	1.133
3	1	1	-76.31	-27.02	0.18	0.042	0.221	0.195	1.133
4	1	2	-23.62	-16.97	0.10	0.031	0.132	0.190	0.697

13.3 Punching Shear Reinforcement
Reinforcement option: Stirrups
Bar Size: 5

Col.	Dist	N_Legs	Dist	N_Legs	Dist	N_Legs	Dist	N_Legs	Dist	N_Legs
	in		in		in		in		in	
1										
2	2.4	9	4.9	11	7.3	13	9.8	15	12.2	17
3	2.4	9	4.9	11	7.3	13	9.8	15	12.2	17
4										

Dist. = Distance measured from the face of support
Note: Columns with --- have not been checked for punching shear.
Note: Columns with *** have exceeded the maximum allowable shear stress.

14 - DEFLECTIONS

14.1 Maximum Span Deflections

Span	SW	SW+PT	SW+PT+SDL	SW+PT+SDL+Creep	LL	X	Total
	in	in	in	in	in	in	in
1	0.00	-0.03	0.01	0.04(4582)	0.02(10852)	0.00(****)	0.06(3251)
2	0.00	-0.08	0.13	0.38(780)	0.06(5029)	0.00(****)	0.44(675)
3	0.00	-0.03	0.01	0.04(4585)	0.02(10855)	0.00(****)	0.06(3252)

30 - PUNCHING SHEAR REINFORCEMENT

Reinforcement option: Stirrup
Bar Size: 5
Column - 1

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		in	in	in	in	k	k-ft	ksi	ksi		in2		in
1	2	2.44	4.88	14.44	18.88	-23.62	16.98	0.132	0.190	0.70	0.00	0	0.00

Dist. = Distance between the legs

Column - 2

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		in	in	in	in	k	k-ft	ksi	ksi		in2		in
1	1	2.44	4.88	24.88	18.88	-76.31	27.02	0.221	0.195	1.13	0.60	9	9.75
2	1	4.88	4.88	29.75	23.75	-76.31	27.02	0.174	0.187	0.93	0.46	11	9.75
3	1	7.31	4.88	34.63	28.63	-76.31	27.02	0.144	0.173	0.83	0.34	13	9.75
4	1	9.75	4.88	39.50	33.50	-76.31	27.02	0.122	0.164	0.75	0.22	15	9.75
5	1	12.19	4.88	44.37	38.38	-76.31	27.02	0.106	0.156	0.68	0.10	17	9.75
6	1	14.63	4.88	49.25	43.25	-76.31	27.02	0.094	0.150	0.63	0.00	0	0.00

Dist. = Distance between the legs

Column - 3

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		in	in	in	in	k	k-ft	ksi	ksi		in2		in
1	1	2.44	4.88	24.88	18.88	-76.31	-27.02	0.221	0.195	1.13	0.60	9	9.75
2	1	4.88	4.88	29.75	23.75	-76.31	-27.02	0.174	0.187	0.93	0.46	11	9.75
3	1	7.31	4.88	34.63	28.63	-76.31	-27.02	0.144	0.173	0.83	0.34	13	9.75
4	1	9.75	4.88	39.50	33.50	-76.31	-27.02	0.122	0.164	0.75	0.22	15	9.75
5	1	12.19	4.88	44.37	38.38	-76.31	-27.02	0.106	0.156	0.68	0.10	17	9.75
6	1	14.63	4.88	49.25	43.25	-76.31	-27.02	0.094	0.150	0.63	0.00	0	0.00

Dist. = Distance between the legs

Column - 4

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		in	in	in	in	k	k-ft	ksi	ksi		in2		in
1	2	2.44	4.88	14.44	18.88	-23.62	-16.97	0.132	0.190	0.70	0.00	0	0.00

Dist. = Distance between the legs

Note: Columns with --- have not been checked for punching shear.
Note: Columns with *** have exceeded the maximum allowable shear stress.
Note: For the layers with As = 0.00, more reinforcement is provided to satisfy provision 13.3.7.4 of canadian-04 design code.

Legend (2.1):
Span C = Cantilever
Form 1 = Rectangular, 2 = T or Inverted L, 3 = I, 4 = Extended T or L section
Rh Elevation of top surface
TF Top flange
MF Middle flange
BF Bottom flange

Legend (2.7):
The Column Boundary Condition (CBC):
Fixed at both 1
Hinged at near end, fixed at far end 2
Fixed at near end, hinged at far end 3
Fixed at near end, roller with rotational fixity at far end 4
LC Lower Column
UC Upper Column

Legend (3.1):
Class: SW: Selfweight, LL: Live Load, SDL: Superimposed Dead Load, X: Other Loading
Type: U: Uniform, P: Partial Uniform, L: Line Load, M: Applied Moment
C: Concentrated Load, R: Triangle, V: Variable, T: Trapezoidal

Legend (4.1, 4.2):
Yb: distance from centroid to bottom fiber
Yt: distance from centroid to top fiber
I: gross moment of inertia

Legend (7.1):
Type
1 = reversed parabola
2 = simple parabola with straight portion over support
3 = harped tendon
4 = straight tendon
5 = extended reversed parabola

Legend (7.2):

CGS C1: CGS of left middle point of tendon for type 5 profile
CGS C2: CGS of right middle point of tendon for type 5 profile or middle point of other types

Legend (10.1, 11.1):
From: Beginning of rebar measured from left support of the span
To: End of rebar measured from left support of the span
As Required: Envelope of minimum and ultimate rebar
Ultimate: Required rebar for ultimate load combinations
Minimum: Required minimum rebar

Legend (10.2, 11_2):
ID: ID number of the bar as shown on graph
From: Beginning of rebar measured from left support of the span
Quantity: Number of bars
Size: Bar number
Length: Total length of the bar
Area: Area of reinforcement

Legend (13):

Cond.	: 1 = Interior, 2 = End, 3 = Corner, 4 = Edge
a	: The distance between the layer and face of column or drop cap(*)
d	: Effective depth
b1	: length of section parallel to span line
b2	: length of section normal to span line
Vu	: Factored shear
Mu	: Factored moment
Stress	: Maximum stress
Allow	: Allowable stress
Ratio	: Ratio of calculated to allowable stress
As	: Required area of reinforcement
Nlegs	: Number of legs for stirrup

Legend (30):

Cond.	: 1 = Interior, 2 = End, 3 = Corner, 4 = Edge
a	: The distance between the layer and face of column or drop cap(*)
d	: Effective depth
b1	: length of section parallel to span line
b2	: length of section normal to span line
Vu	: Factored shear
Mu	: Factored moment
Stress	: Maximum stress
Allow	: Allowable stress
Ratio	: Ratio of calculated to allowable stress
As	: Required area of reinforcement
Nlegs	: Number of legs for stirrup

EQUIVALENT FRAME CONSTANTS

DATA BLOCK 290

K_c Lower Column	K_c Upper Column	K_t	K_{ec}	S
.82852E+02	.78322E+02	.64997E+02	.46318E+02	.10701E+01
.38357E+03	.36260E+03	.13077E+03	.11127E+03	.57367E+00
.38357E+03	.36260E+03	.13077E+03	.11127E+03	.57367E+00
.82852E+02	.78322E+02	.64997E+02	.46318E+02	.10701E+01

F3 F4 F6 F8

STIFFNESS COEFFICIENTS

DATA BLOCK 310

Span	K11	K12	K21	K22
1	.10770E+03	.53848E+02	.53848E+02	.10770E+03
2	.73233E+02	.36617E+02	.36617E+02	.73233E+02
3	.10770E+03	.53848E+02	.53848E+02	.10770E+03

F10 F11

TABLE 3.2.1-1

EXCERPT FROM FILE CS.DAT

FOR TWO-WAY APARTMENT EXAMPLE PTI-2WAY

3.2.2 Computer Report for SI Units

ADAPT

Your Partner in Concrete Design

TWO-WAY FLAT SLAB VERIFICATION

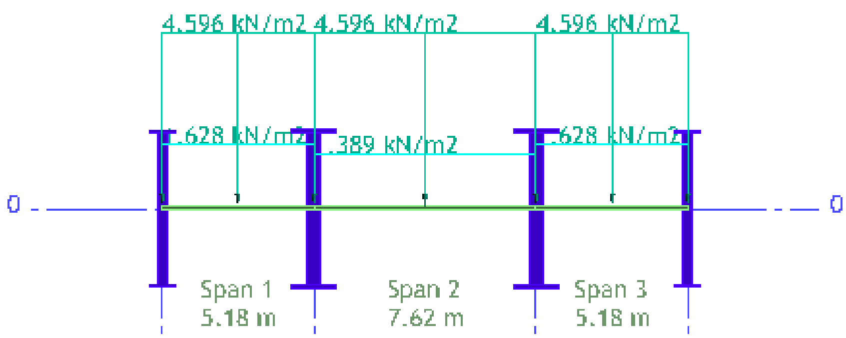


TABLE OF CONTENT:

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		Minimum Cover at BOTTOM	25.40 mm
F'c for BEAMS/SLABS	28.00 N/mm 2	Post-tensioning	
For COLUMNS/WALLS	28.00 N/mm 2	SYSTEM	UNBONDED
Ec for BEAMS/SLABS	24870.00 N/mm 2	Fpu	1862.00 N/mm 2
For COLUMNS/WALLS	24870.00 N/mm 2	Fse	1206.60 N/mm 2
CREEP factor	2.00	Strand area	98.709 mm 2
CONCRETE WEIGHT	NORMAL	Min CGS from TOP	31.75 mm
Tension stress limits / (f'c)1/2		Min CGS from BOT for interior spans	31.75 mm
At Top	0.500	Min CGS from BOT for exterior spans	44.45 mm
At Bottom	0.500	Min average precompression	0.86 N/mm 2
Compression stress limits / f'c		Max spacing / slab depth	8.00
At all locations	0.450	Analysis and design options	
Reinforcement		Structural system - Equiv Frame	TWO-WAY
Fy (Main bars)	413.69 N/mm 2	Moments reduced to face of support	YES
Fy (Shear reinforcement)	413.69 N/mm 2	Moment Redistribution	NO
Minimum Cover at TOP	25.40 mm	DESIGN CODE SELECTED	ACI-318 (2014)

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		m	mm	mm	mm	mm	mm	mm	mm		
1	1	5.18	304	165					165	10.00	10.00
2	1	7.62	304	165					165	10.00	10.00
3	1	5.18	304	165					165	10.00	10.00

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	mm	m	mm	mm			m	mm	mm		
1	304.0	2.6	355.0	304.0	100	(1)	2.6	355.0	304.0	100	(1)
2	508.0	2.6	355.0	508.0	100	(1)	2.6	355.0	508.0	100	(1)
3	508.0	2.6	355.0	508.0	100	(1)	2.6	355.0	508.0	100	(1)
4	304.0	2.6	355.0	304.0	100	(1)	2.6	355.0	304.0	100	(1)

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			kN/m2	kN/m	kN/m	m	m	m	kN	kN-m
1	LL	U	1.628							
1	SDL	U	4.596							
2	LL	U	1.389							
2	SDL	U	4.596							
3	LL	U	1.628							
3	SDL	U	4.596							

NOTE: LIVE LOADING is SKIPPED with a skip factor of 1.00

4 - CALCULATED SECTION PROPERTIES

4.1 Section Properties of Uniform Spans and Cantilevers

Span	Area	I	Yb	Yt
	mm2	mm4	mm	mm
1	1003200.00	0.23E+10	82.50	82.50
2	1003200.00	0.23E+10	82.50	82.50
3	1003200.00	0.23E+10	82.50	82.50

5 - MOMENTS, SHEARS AND REACTIONS

5.1 Span Moments and Shears (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right	Shear Left	Shear Right
		kN-m	kN-m	kN-m	kN	kN
1	SW	0.00	0.00	0.00	0.00	0.00
2	SW	0.00	0.00	0.00	0.00	0.00
3	SW	0.00	0.00	0.00	0.00	0.00
1	SDL	-15.33	34.45	-103.36	-55.41	89.39
2	SDL	-127.29	75.53	-127.29	-106.47	106.46
3	SDL	-103.36	34.46	-15.33	-89.39	55.41
1	XL	0.00	0.00	0.00	0.00	0.00
2	XL	0.00	0.00	0.00	0.00	0.00
3	XL	0.00	0.00	0.00	0.00	0.00

5.2 Reactions and Column Moments (Excluding Live Load)

Joint	Load Case	Reaction	Moment Lower Column	Moment Upper Column
		kN	kN-m	kN-m
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
4	SW	0.00	0.00	0.00
1	SDL	55.41	-7.88	-7.45
2	SDL	195.86	-12.30	-11.63
3	SDL	195.85	12.30	11.63
4	SDL	55.41	7.88	7.45
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00
4	XL	0.00	0.00	0.00

5.3 Span Moments and Shears (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN	kN
1	-8.69	2.79	19.53	-6.25	-35.30	-13.97	-23.72	31.36
2	-42.13	-4.61	26.76	-4.61	-42.12	-4.61	-33.56	33.56
3	-35.30	-13.97	19.53	-6.25	-8.69	2.79	-31.36	23.72

5.4 Reactions and Column Moments (Live Load)

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	23.72	-3.49	1.43	-4.47	1.35	-4.23
2	64.93	27.58	7.24	-9.89	6.84	-9.35
3	64.93	27.58	9.89	-7.24	9.35	-6.84

4	23.72	-3.49	4.47	-1.43	4.23	-1.35

6 - MOMENTS REDUCED TO FACE OF SUPPORT

6.1 Reduced Moments at Face of Support (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right
		kN-m	kN-m	kN-m
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
1	SDL	-7.23	34.45	-81.56
2	SDL	-101.20	75.53	-101.10
3	SDL	-81.55	34.46	-7.23
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00

6.2 Reduced Moments at Face of Support (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	-5.20	2.26	19.53	-6.25	-27.65	-12.00
2	-33.87	-4.61	26.76	-4.61	-33.87	-4.61
3	-27.65	-12.00	19.53	-6.25	-5.20	2.26

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile
Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
1	1	0.000	0.490	0.000	---
2	1	0.000	0.500	0.000	---
3	1	0.000	0.510	0.000	---

7.2 Selected Post-Tensioning Forces and Tendon Drape
Tendon A

Span	Force	CGS Left	CGS C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	kN	mm	mm	mm	mm	MPa	kN/-	
1	894.980	83.00	---	44.00	133.00	0.89	16.938	61
2	896.310	133.00	---	32.00	133.00	0.89	12.473	45
3	894.980	133.00	---	44.00	83.00	0.89	16.938	61

Approximate weight of strand: 112.2 Kg

7.4 Required Minimum Post-Tensioning Forces

	Based on Stress Conditions			Based on Minimum P/A		
Type	Left	Center	Right	Left	Center	Right
	kN	kN	kN	kN	kN	kN
1	0.00	0.00	487.15	862.75	862.75	862.75
2	768.66	471.17	767.69	862.75	862.75	862.75
3	486.83	0.00	0.00	862.75	862.75	862.75

7.5 Service Stresses (tension shown positive)
Envelope of Service 1

Span	Left Top	Left Top	Left Bot	Left Bot	Center Top	Center Top	Cetner Bot	Cetner Bot	Right Top	Right Top	Right Bot	Right Bot

	Max-T	Max-C	Max-T	Max-C	Max-T	Max-C	Max-T	Max-C	Max-T	Max-C	Max-T	Max-C
	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
1	-----	-0.87	-----	-1.00	-----	-1.48	-----	-0.58	0.84	-----	-----	-2.63
2	1.41	-----	-----	-3.20	-----	-2.80	1.01	-----	1.41	-----	-----	-3.20
3	0.84	-----	-----	-2.63	-----	-1.48	-----	-0.58	-----	-0.87	-----	-1.00

Envelope of Service 2

Span	Left Top Max-T	Left Top Max-C	Left Bot Max-T	Left Bot Max-C	Center Top Max-T	Center Top Max-C	Cetner Bot Max-T	Cetner Bot Max-C	Right Top Max-T	Right Top Max-C	Right Bot Max-T	Right Bot Max-C
	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
1	-----	-0.92	-----	-1.13	-----	-1.98	0.19	-0.74	1.54	-----	-----	-3.33
2	2.27	-----	-----	-4.06	-----	-3.47	1.69	-----	2.27	-----	-----	-4.06
3	1.54	-----	-----	-3.33	-----	-1.98	0.19	-0.74	-----	-0.93	-----	-1.13

7.6 Post-Tensioning Balance Moments, Shears and Reactions
Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN	kN
1	5.85	-24.06	41.99	-0.39	-0.39
2	47.74	-31.08	47.71	0.00	0.00
3	42.01	-24.06	5.91	0.38	0.38

Reactions and Column Moments

Joint	Reaction	Moment Lower Column	Moment Upper Column
	kN	kN-m	kN-m
1	0.387	4.830	4.566
2	-0.388	1.418	1.340
3	-0.376	-1.439	-1.360
4	0.377	-4.823	-4.559

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	-7.54	4.39	82.99	41.74	-130.81	-105.77
2	-161.47	-114.66	147.60	97.41	-161.37	-114.56
3	-130.86	-105.82	82.96	41.71	-7.56	4.38

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	104.83	61.30	-2.33	-11.78	-2.21	-11.13
2	338.58	278.82	-1.76	-29.17	-1.67	-27.58
3	338.59	278.83	29.15	1.74	27.56	1.65
4	104.82	61.29	11.78	2.34	11.14	2.21

8.3 Secondary Moments

Span	Left	Midspan	Right
	kN-m	kN-m	kN-m

1	9.45	10.40	11.30
2	14.16	14.15	14.14
3	11.24	10.36	9.44

Note: Moments are reported at face of support

10 - MILD STEEL - NO REDISTRIBUTION

10.1 Required Rebar

10.1.1 Total Strip Required Rebar

Span	Location	From	To	As Required	Ultimate	Minimum
		m	m	mm2	mm2	mm2
1	TOP	0.00	0.78	752.40	0.00	752.40
1	TOP	4.41	5.18	792.10	332.40	792.10
2	TOP	0.00	1.14	1250.00	1250.00	792.10
2	TOP	6.48	7.62	1250.00	1250.00	792.10
3	TOP	0.00	0.78	792.10	332.40	792.10
3	TOP	4.41	5.18	752.40	0.00	752.40
2	BOT	2.67	4.95	1338.00	763.20	1338.00

13 - PUNCHING SHEAR REINFORCEMENT

13.1 Critical Section Geometry

Column	Layer	Cond.	a	d	b1	b2
			mm	mm	mm	mm
1	1	2	61.80	123.60	365.80	478.60
2	1	1	61.80	123.60	631.60	478.60
3	1	1	61.80	123.60	631.60	478.60
4	1	2	61.80	123.60	365.80	478.60

13.2 Critical Section Stresses

Label	Layer	Cond.	Factored shear	Factored moment	Stress due to shear	Stress due to moment	Total stress	Allowable stress	Stress ratio
			kN	kN-m	MPa	MPa	MPa	MPa	
1	1	2	-104.83	+22.91	0.70	0.212	0.913	1.318	0.693
2	1	1	-338.53	+36.84	1.23	0.294	1.527	1.354	1.128
3	1	1	-338.52	-36.80	1.23	0.293	1.527	1.354	1.128
4	1	2	-104.83	-22.93	0.70	0.212	0.913	1.318	0.693

13.3 Punching Shear Reinforcement

Reinforcement option: Shear Studs
Stud diameter: 16
Number of rails per side: 2

Col.	Dist	Dist	Dist	Dist	Dist	Dist	Dist	Dist	Dist	Dist
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
1										
2	61.8	123.6	185.4	247.2	309.0					
3	61.8	123.6	185.4	247.2	309.0					
4										

Dist. = Distance measured from the face of support
Note: Columns with --- have not been checked for punching shear.
Note: Columns with *** have exceeded the maximum allowable shear stress.

14 - DEFLECTIONS

14.1 Maximum Span Deflections

Span	SW	SW+PT	SW+PT+ SDL	SW+PT+SDL +Creep	LL	X	Total
	mm	mm	mm	mm	mm	mm	mm
1	0.0	-0.9	0.4	1.1(4685)	0.5(10834)	0.0(****)	1.6(3301)
2	0.0	-2.0	3.3	9.8(776)	1.5(5022)	0.0(****)	11.3(672)
3	0.0	-0.9	0.4	1.1(4680)	0.5(10833)	0.0(****)	1.6(3298)

30 - PUNCHING SHEAR REINFORCEMENT

Reinforcement option: Stud
Stud diameter: 16
Number of rails per side: 2

Column - 1

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NStuds	Dist.
		mm	mm	mm	mm	kN	kN-m	MPa	MPa		mm2		mm
1	2	61.80	123.60	365.80	478.60	-104.83	22.91	0.913	1.318	0.69	0.00	0	0.00

Dist. = Distance between shear studs between layers

Column - 2

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NStuds	Dist.
		mm	mm	mm	mm	kN	kN-m	MPa	MPa		mm2		mm
1	1	61.80	123.60	631.60	478.60	-338.53	36.84	1.527	1.354	1.13	384.00	1	61.80
2	1	123.60	123.60	755.20	602.20	-338.53	36.84	1.205	1.295	0.93	295.30	1	61.80
3	1	185.40	123.60	878.80	725.80	-338.53	36.84	0.994	1.203	0.83	214.00	1	61.80
4	1	247.20	123.60	1002.40	849.40	-338.53	36.84	0.845	1.135	0.74	137.10	1	61.80
5	1	309.00	123.60	1126.00	973.00	-338.53	36.84	0.734	1.083	0.68	63.01	1	61.80
6	1	370.80	123.60	1249.60	1096.60	-338.53	36.84	0.649	1.042	0.62	0.00	0	0.00

Dist. = Distance between shear studs between layers

Column - 3

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NStuds	Dist.
		mm	mm	mm	mm	kN	kN-m	MPa	MPa		mm2		mm
1	1	61.80	123.60	631.60	478.60	-338.52	-36.80	1.527	1.354	1.13	383.90	1	61.80
2	1	123.60	123.60	755.20	602.20	-338.52	-36.80	1.205	1.295	0.93	295.20	1	61.80
3	1	185.40	123.60	878.80	725.80	-338.52	-36.80	0.993	1.203	0.83	213.90	1	61.80
4	1	247.20	123.60	1002.40	849.40	-338.52	-36.80	0.844	1.135	0.74	137.00	1	61.80
5	1	309.00	123.60	1126.00	973.00	-338.52	-36.80	0.734	1.083	0.68	62.93	1	61.80
6	1	370.80	123.60	1249.60	1096.60	-338.52	-36.80	0.649	1.042	0.62	0.00	0	0.00

Dist. = Distance between shear studs between layers

Column - 4

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NStuds	Dist.
		mm	mm	mm	mm	kN	kN-m	MPa	MPa		mm2		mm
1	2	61.80	123.60	365.80	478.60	-104.83	-22.93	0.913	1.318	0.69	0.00	0	0.00

Dist. = Distance between shear studs between layers
Note: Columns with --- have not been checked for punching shear.
Note: Columns with *** have exceeded the maximum allowable shear stress.
Note: For the layers with As = 0.00, more reinforcement is provided to satisfy provision 13.3.7.4 of canadian-04 design code.

3.3 Verification

3.3.1 Verification of Report for American Units

The ADAPT-PT report is presented in numbered data blocks. Each data block data are provided in table. For example, looking at the report, it is observed that data block 2.1 third column is the *length of the span*. In notation form, this is referred to as (B2.1, C3).

3.3.1.1 Geometry of Slab (Data Block 2)

Data block 2.1, 2.3 and 2.7 identify the geometry of the slab, transverse beam and column supports.

3.3.1.2 Loading (Data Block 3.1)

Data block 3.1 lists the loading details.

3.3.1.3 Calculated Section Properties (Data Block 4)

Data block 4 reflects the calculated section properties of all the spans.

Section properties at mid span:

Area, A = 6.5* 20* 12
= 1560 in^2 (10.06e5 mm^2) (ADAPT 1560, B4.1, C2)
Moment of inertia, I = $(b*h^3)/12$
= $(240*6.5^3)/12$
= 0.55E+04in^4 (22.86e8 mm^4)
(ADAPT 0.55E+04,B4.1, C3)

Distance from bottom fiber to
centroid, Y_b = 3.25 in (83 mm) (ADAPT 3.25, B4.1, C4)

Distance from top fiber to
centroid, Y_t = 3.25 in (83 mm) (ADAPT 3.25,B4.1, C5)

3.3.1.4 Material Properties (Data Block 1)

Concrete, post-tensioning strand and mild reinforcement material properties are given in data block 1.

3.3.1.5 Tendon Profile, Force and Balanced Loading (Data Block 7)

The tendon geometry and forces are summarized in data blocks 7.1 and 7.2 in ADAPT-PT report.

3.3.1.6 Structural System Line (Centerline) Moments

ADAPT-PT has the option to use the Equivalent Frame Method, as described in ACI-318 (2014), and used in this example. The centerline moments are determined using modified column stiffness. This accounts for the biaxial response of the slab that is not explicitly represented in the strip model.

3.3.1.7 Column Stiffness Kc (Reference Numbers F3, F4, See Table 3.2.1-1)

Consider the columns at second support:

Dimensions = 14 x 20
I_{co} = 14*203/12 = 9333 in^4 (3.88e9 mm^4)
Length = 103 in (2616 mm)

For upper column:

L = floor to floor distance
K_c = $(4EI_{co}/L)$ = 4*1*9333/103 = 362.5 (F4, **Table 3.2.1-1**)

For lower column:

L' = clear height = 103 – (6.5/2) = 99.75 in. (2534 mm)

I = I_{co}*[L*(1 + 3*(L/L'))/4*L']
= 9333*[103*(1 + 3*(103/99.75))/4*99.75]
= 9873 in^4 (4.11e9 mm^4)

K_c = 4EI/L’
= 4*1*9873/103 = 384 (F3, **Table 3.2.1-1**)

Torsional stiffness K_t:

C = (1   0.63*x/y)*(x^3*y/3)
= (1   0.63*6.5/20)*(6.5^3*20/3) = 1456
L2 = tributary of frame = 20*12 = 240 in. (6096 mm)
c2 = 14 in., or 1.17 ft (0.36 m)

each side K_t = (9*C*E)/[L2*$(1-c_2/L_2)^3$]
= (9*1456*1)/[240*(1   1.17/20)3] = 65.42

Total K_t = 2 * 65.42 = 131 (F6, **Table 3.2.1-1**)

Equivalent column stiffness:

$1/K_{ec}$ = $(1/K_t + 1/K_c)$

K_{ec} = 1/[1/131+ 1/(384+ 363)] = 111 (F8, **Table 3.2.1-1**)

	ADAPT	Reference Number
Second column:		
Lower column stiffness K_c	384	F3*
Upper column stiffness K_c	363	F4
Torsional stiffness K_t	131	F6
Equivalent column stiffness K_{ec}	111	F8
Interior slab:		
Slab stiffness K_s	75	F10
Carry over	0.51	F11/F10

* Reference numbers preceded by "F" refer to report from ADAPT-PT's data files which are generated with the solution.

Consider the interior slab:

ADAPT employs the formulation given in ACI-318(2014) to arrive at the stiffness and carry over factors. Refer to ADAPT manual chapter on theory for additional details. The stiffness coefficients for the three spans are marked as K11 through K22 in **Table 3.2.1-1**. For the second span the carry over factor is:

Carry over = 36.62/73.23 = 0.50 (F11/F10, **Table 3.2.1-1**)

3.3.1.8 Dead and Live Load Moments (Data Block 5)

Data block 5 list the centerline elastic moments and reactions due to dead load and live load. Centerline moments for the interior span are listed in the following table:

Span	Left	Midspan	Right	Reference Number
Second Span				
Dead load **k-ft (kNm)**	-94.13 (-127.62)	55.87 (75.75)	-94.13 (-127.62)	B5.1, C3-5
Live load **k-ft (kNm)**	-31.14 (-42.22)	19.79 (26.83)	-31.14 (-42.22)	B5.3, C2-7
Post tensioning **k-ft (kNm)**	44.02 (59.68)	-23.15 (-31.39)	44.02 (59.68)	

* The value of post-tensioning is read from a data file in ADAPT-PTcomputer run (PTBMSF.DAT) which is not reproduced here.

3.3.1.9 Reduction of Moments to the Face-of-Support

ADAPT-PT calculates the face-of-support moments from the equations of statics.

For the purposes of clarification and verification of results consider the dead load moment at right of the second support:

Centerline moment/bay= -94.13 k ft (-127.62 kNm) (B5, C3)

Shear V = 24.00 k (106.76 kN) (B5, C5)

Support width c = 20/12 = 1.67 ft (B2.2, C2)

Loading w = 0.096 k/ft^2 (4.60 kN/m^2) (B3.1, C4)

Moment at face-of-support:

M = 94.13 + 24*1.67/2 - 0.5*(0.096*20)*(1.67/2)
= 74.89 k ft (-101.54 kNm) (B6.1, C3 M = 74.79 OK)

Moments at the face-of-support and at midspan for the interior span are listed in the following table for comparison.

	ADAPT	Reference Number
Right face of second support		
Dead and live moments, k-ft (kNm)	-(74.79+25.04)/20 = -4.99 (-6.77)	(B 6.1,6.2,C2)
Post tensioning moment	35.37/20 = 1.77 (2.40)	(B 7.6, C2)
Net moments	-3.22 (-4.37)	
Midspan moment		
Dead and live moments	(55.88+19.79)/20 = 3.78 (5.12)	(B 6.1,6.2, C4)
Post-tensioning moment	-23.15/20 = -1.16 (-1.57)	(B7.6, C3)
Net moments	2.62 (3.55)	
Sum of + and - moments	5.84 (7.92)	

Regarding the sum of positive and negative moments for the interior span (ADAPT 5.84 k-ft) observe that these should be equal to the static moment of the clear span (M_o). This is reiterated in ACI-318(2014) in Equation 8.10.3.2, where the sum of moments is expressed by Equation 13-3 reproduced below:

$$M_o = W_u * L_2 * L_n^2/8$$

where,

W_u = 0.096 +0.029 –0.860/20
= 0.082 k/ft² (3.93 kN/m²)
L_2 = 1 ft (as moments computed are per foot)
L_n = 25   20/12 = 23.33 ft (7.11 m)

hence,

M_o = 0.082*1*23.332/8
= 5.58 k-ft/ft (7.57 kNm/m)   (ADAPT 5.84 OK)

3.3.1.10 Stresses (Data Block 7.5)

Data block 7.5 lists the service stresses at top and bottom for supports and mid span. The post-tensioning is determined, such as to keep the stresses below allowable values.

Total Load Combination:

Stress Limits for allowable values:

Top Tension	= 6*√4000	
	= 380 psi (2.62 MPa)	(ADAPT B1)
Bottom Tension	= 6*√4000	
	= 380 psi (2.62 MPa)	

Compression (for service)	= 0.45 * 4000
	= -1800 psi (-12.41 MPa)

Consider the right face of second support:

Stresses:

$\sigma = (M_D+M_L+M_{PT})/S + (P/A)$
$S = I/Y_c$

Where M_D,M_L,M_{PT} are the moments across the entire tributary of the design strip. S is the section modulus; A is the area; I is the moment of inertia of the section; and Y_c is the distance of the centroid of the section to farthest tension fiber of the section.

A	= 1560 in^2 (1.01e6 mm^2)	(ADAPT B4.1, C2)
I	= 0.55E+04 in^4 (2.29e9 mm^4)	(ADAPT B4.1, C3)
Y_b	= 3.25 in (83 mm)	(ADAPT B4.1, C4)
Y_t	= 3.25 in (83 mm)	(ADAPT B4.1, C5)

$S_{bottom} = S_{top}$ = (0.55E+04)/ 3.25
=1690.15 in^3 (2.77e7 mm^3)

P	= 201.5 k (896.31kN)	(ADAPT B7.2, C2)
M_D	= -74.79 k-ft (-101.40 kNm)	(ADAPT B6.1, C3)
M_L	= -25.04 k-ft (-33.95 kNm)	(ADAPT B6.2, C2)
M_{PT}	= 35.37 k-ft (47.94 kNm)	(ADAPT B7.6, C2)

$M_D+M_L+M_{PT}$ = -74.79 + -25.04 + 35.37

	= -64.46 k-ft (-87.41 kN)
P/A	= -201.5*1000/ 1560
	= -129.17 psi (-0.89 MPa)

Top fiber:

σ	= (64.46*12000)/1690.15- (129.17)
	= 328.57 psi (2.27 MPa) < 380 psi (2.62MPa)
	(ADAPT 328.57, B7.5-Envelope of Service 2, C2, OK)

Bottom fiber:

σ	= (-64.46*12000)/1690.15- (129.17)
	= -586.91 psi (-4.05 MPa) <-1800 psi (-12.41 MPa)
	(ADAPT –586.91, B7.5-Envelope of Service 2, C5, OK)

Calculations for all other points are carried out in the same way and printed in ADAPT-PT Block 7.5. Stresses for sustained load combinations are reported in the table under "Envelope of Service 1" of the Block 7.5. Stress calculations at 1/20 th points are reported in STRESSES. DAT file in the subdirectory, where data was executed.

3.3.1.11 Secondary Moments (Data Block 8.3)

There are two ways for calculating the secondary moments. ADAPT-PT uses the direct method derived from the definition of secondary actions. The subject matter slab together with the secondary actions computed at the supports is shown in **Fig. 3.3-1.** The secondary actions, which represent the reactions at supports due to post-tensioning, are taken from data block 7.6 of ADAPT-PT output. The secondary moments in the slab are moments induced by the secondary actions at the supports.

The secondary shears and moments at the supports must be in self-equilibrium since the applied loading, namely the post-tensioning forces, form a self-equilibrating system.

Sum of secondary reactions:

0.076-0.076-0.077+0.077 = 0 k (zero, OK)

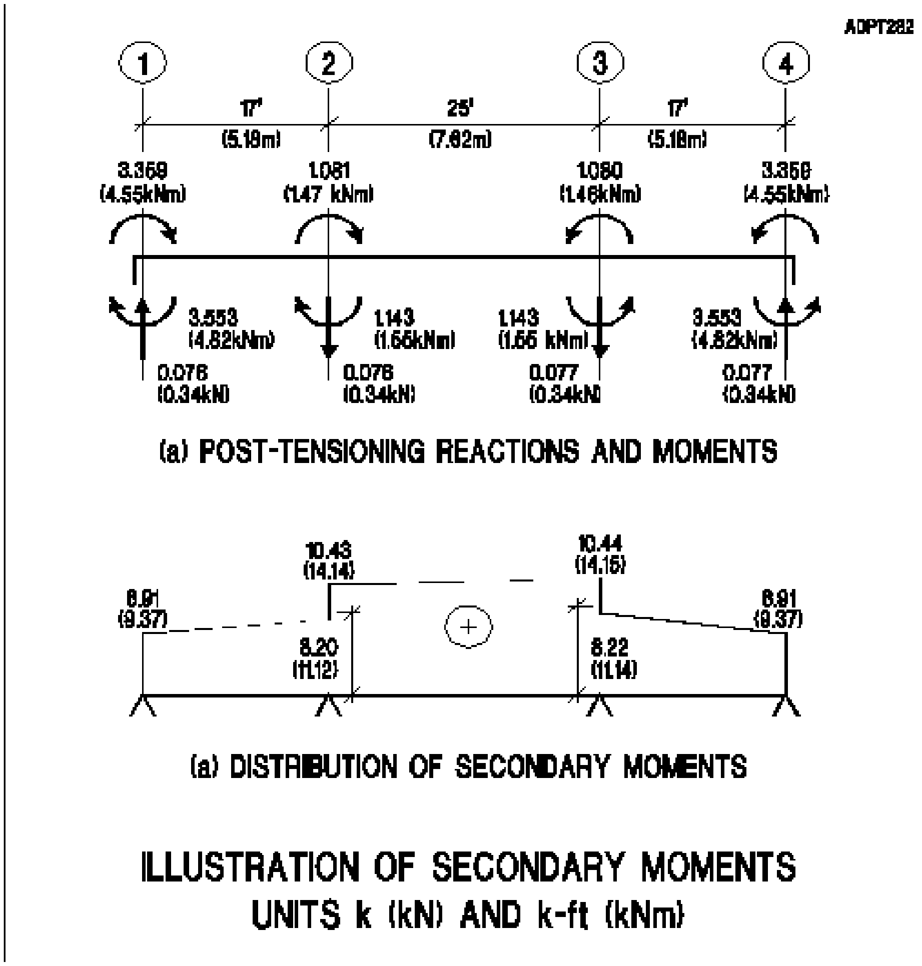


Figure 3.3-1

Check the validity of the solution for static equilibrium:

ΣVertical Forces = 0.076-0.076-0.077+0.077
= 0 OK

ΣMoments about Support #1 = 3.553+ 3.359 + 1.141 + 1.078 – 1.141 – 1.078 – 3.556 – 3.361 +0.076*17 +0.077* 42-0.077*59
= -0.022 k-ft (approx. = 0, OK) (B7.6)

CENTERLINE secondary moments at ends of spans

Left of span 1: M_{sec} = 3.553 + 3.359
= 6.912 k-ft (9.37 kNm)

Right of span 1: M_{sec} = 6.912+ 0.076*17
= 8.204 k-ft (11.12 kNm)

Left of span 2: M_{sec} = 8.204 + 1.078 + 1.141
= 10.42 k-ft (14.14 kNm)

(ADAPT 10.43, B8.3, C2, OK)

The remainder of secondary moments may be calculated in a similar manner. In order to minimize numerical inaccuracies, ADAPT-PT calculates the secondary moments of the right spans from the secondary actions of the right side.

MID-SPAN secondary moments

Because secondary moments vary linearly from support to support, the mid-span moment is the average of the support values. Hence, for the first span:

M_{sec} = 0.5*(6.912 + 8.204)
= 7.558 k-ft (10.25 kNm) (ADAPT 7.56, B8.3, C3 OK)

Secondary moments adjusted to face-of-supports

The reduction of secondary moments to the faces of supports is simply obtained from linear interpolation of the centerline values. The (V*a/3) approximation is not valid in this case. For moment at the left face of second support from **Fig. 3.3-2:**

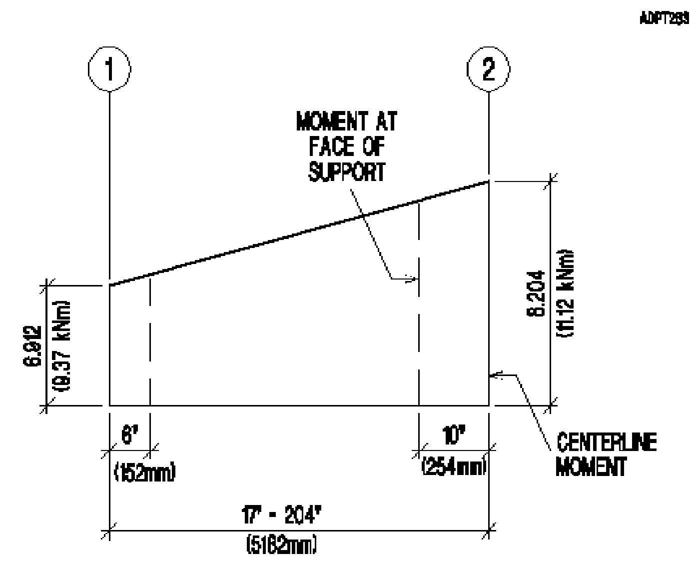
M_{sec} = 8.204-(10/204)*(8.204-6.912)
= 8.141 k-ft (11.04 kNm) (ADAPT 8.14, B8.3, C4 OK)

Secondary moments may also be calculated using the following alternative relationship. This relationship, however, is not used in ADAPT-PT and is not recommended, since it does not include an equilibrium check to detect errors in computation.

$M_{sec} = M_{bal}$-F*e

where,

M_{bal} = 44.01 k-ft (59.68 kNm) (from file PTBMSF.DAT)
F = 201.50 k (896.31kN) (B7.2,C2)
e (eccentricity) = 5.25 - 3.25
= 2.00 in. (51 mm)
M_{sec} = 44.01 – 201.50*2.00/12
= 10.43 k-ft(14.15 kNm),
which is the same as given in **Fig. 3.3-1**



SECONDARY MOMENTS FOR FIRST SPAN

Figure 3.3-2

It is emphasized that the values given in ADAPT-PT report (B7.6) are already reduced to the face of support.

3.3.1.12 Factored Moments (Design Moments) (Data Block 8.1)

The following demonstrates the calculation of the design moment at the right of second support:

M_u	$= 1.2\ M_d + 1.6\ M_l + 1.0^*\ M_{sec}$	
$1.2\ M_d$	$= 1.2^*(\ 74.79)$	
	$=\ 89.75$ k-ft (-121.68 kNm)	(B6.1, C3)
$1.6\ M_l$	$= 1.6^*(-25.04)$	
	$=\ 40.06$ k-ft (-54.31 kNm)	(B6.2, C2)
$1.0\ M_{sec}$	$= 1.0^*10.43$	
	$= 10.43$ k-ft (14.14 kNm)	(B8.3, C2)
M_u	$=\ 119.38$ k-ft (-161.86 kNm)	(ADAPT -119.39, B8.1, C2)

3.3.1.13 Nonprestressed (Mild) Reinforcement (Data Block 10)

In this section the mild reinforcement calculations of ADAPT-PT are verified for selected points along the slab for the condition of *no redistribution*. The following aspects of the nonprestressed reinforcement calculations are verified:

- Minimum rebar over the supports.
- Rebar to meet the ultimate strength requirements.
- Reinforcement for tensile block.

In the following calculations data describing the tendon profile was read off from the data block 21, Tendon Heights, detailed report. It is also available from ADAPT-PT data file called PTCGS.DAT. The file contains a detailed description of the tendon shape at various points along the span.

(i) Minimum Rebar at Supports

Consider the right face of second support. The minimum rebar is determined from the following expression:

A_{min} = 0.00075*h*L

where,

h	= slab thickness (6.5 in.)
L	= length of slab in direction of rebar
	= 0.5(17 + 25)*12
	= 252 in. (6401 mm) (For second column)
	= length of the in the transverse direction
	= 20*12 = 240 in (6096 mm)
L	= 252 in (6401 mm)

hence,

A_{min}	= 0.00075*6.5*252
	= 1.23 in.^{2} (792 mm^2) (ADAPT 1.23, B10.1.1, C7 OK)

(ii) Ultimate Strength Requirement

Consider the right face of second support:

M_u	= 119.39 k-ft (-161.86 kNm)	(B8.1,C2)
b (width)	= 20*12	
	= 240 in. (6096 mm)	
h (height)	= 6.5 in. (165 mm)	
Cover at top	= 1.00 in. (25 mm)	(B1)
Top bar dia.	= 0.625 in. (16 mm)	(#5 bar)
$d_r = d_t$	= 6.5-(1.00 + 0.625/2)	
	= 5.19 in. (132 mm)	(B9.3,C1)
PT	= 201.50 k (896.31kN)	(B9.3,C1)

d_p	= 4.75 in. (121 mm)	(PTCGS.DAT)
f_{se}	= 175 ksi (1206.59 MPa)	(B1, PTI 34)
Span	= 25 ft (7.62 m)	
Rebar area	= 1.95 in^2 (1258 mm^2)	(B10.1.1,C6)
f_y	= 60 ksi (413.69 MPa)	(B1)

Calculate design stress in tendon (f_{ps}):

Span-to-depth ratio = 25*12/6.5 = 46.1 > 35

hence, use ACI Equation (18-5):

$f_{ps} = f_{se} + 10000 + (f'_c/300*\rho_p)$

where,

f'_c	= 4000 psi (27.58 MPa) (B1)
ρ_p	= ratio of prestressed reinforcement
	= $A_{ps}/b*d_p$
A_{ps}	= 201.50/175
	= 1.15 in^2 (742 mm^2)
ρ_p	= 1.15/(240*4.75)
	= 0.00101
f_{ps}	= 175000+10000+(4000/300*0.00101)
	= 198201 psi (1366.56 MPa)
f_{ps}	= 198201 < (175 + 30)
	= 205 ksi (1413.43 MPa)(OK)
Tension (T)	= PT + rebar
	= 1.15*198+1.95*60
	= 227.93+117.0
	= 344.93 k (1534.32 kN)
a	= Depth of compression zone
	= T/0.85*b*f'c)
	= 344.93 /(0.85*240*4)
	= 0.42 in. (11 mm)
c	= 0.42/0.85
	= 0.49 in. (13 mm)
c/dt	= 0.49/5.19
	= 0.09 < 0.375, hence ϕ = 0.90
ϕMu	= 0.9*[227.93 (4.75-0.42/2)+117.0*(5.19-0.42/2)]/12
	= 121.31 k-ft (164.47 kNm) (B8.1,C2 OK)

(iii) Tensile Block Reinforcement

By requirements of ACI 318(2014), when the tensile stress in the span exceeds $2*(f'_c)^{1/2}$, the entire tensile force must be resisted by mild reinforcing at a stress of $f_y/2$.

Consider mid-point of interior span:

Tensile stress	= 243.73 psi (1.68 MPa)
	(B7.5, Env of Service-2 , C8)
$2*(f'_C)^{1/2}$ Compression	= 126 psi, hence rebar required
Stress Depth of tensile zone	= 502.06 psi (-3.46 MPa)
	= 6.5*[243.73/(243.73 + 502.06)]
	= 2.12 in. (54 mm)
Tension N_c	= 0.244*2.12*240/2
	= 62.07 k (276.10 kN)
	for the tributary
A_s	= 62.07/(0.5*60)
	= 2.07 in^2 (1335 mm^2)
	(ADAPT 2.07; B 10.1.1; C7)

3.3.1.14 Punching Shear Capacity (Data Block 13)

The punching shear calculations for the second column are verified. Note that the total shear and moments listed in data block 13.2 of ADAPT-PT output for shear check are factored as follows:

1.2D + 1.6L + Secondary effects

Additional details for the calculations of punching shear parameters are given in Section 5.9.

V_u = 76.31 kips (339.44 kN) (B13.2, C4)
M_u = 27.02 kip-ft (36.63 kNm) (B13.2, C5)

Section Properties:

c_1 = 20 in (508 mm)
c_2 = 14 in (356 mm)
h = 6.5 in (165 mm)
Dia .of bar = 0.625 in (#5 bar) (16mm)
Cover = 1.0 in (25 mm)

d_r = 6.5- 1.0- 0.625
=4.88 in (124 mm) (B13.1, C5)

c_1+ d = 20 + 4.88
= 24.88 in (632 mm) (B13.1, C6)

c_2 +d = 14 + 4.88
= 18.88 in (480 mm) (B13.1, C7)

A_c = 2d(c1 + c2 + 2d))
= 2*4.88 * (20+ 14+ 2*4.88)
= 427.10 in^2 (2.76e5 mm^2)

J_c = (c1+ d)*d3/6+ (c1 + d) 3*d/6 +d* (c2 + d)*(c1+ d) 2 /2
= 24.88*4.883/6 +24.883*4.88/6+4.88*18.88* 24.88 2 /2
= 41524 in^4 (1.73e10 mm^4)

γ_V = 1- {1/[1+ (2/3) * $((c_1 +d) / (c_2 +d))^{½}$]}
= 1- {1/[1+ (2/3) * $(24.88 / 18.88)^{½}$]}
= 0.433

Stress due to direct shear:

V_u / A_c = 76.31 / 427.10
= 0.179 ksi (1.23 MPa) (ADAPT 0.18, B13.2, C6 OK)

Stress due to bending:

M_{stress} = (γ_V * M_u * (c_1+ d))/ (2* J_c)
= (0.433 * 27.02 * 12 * 24.88)/ 2*41524
= 0.042 ksi (0.29 MPa) (ADAPT 0.042, B13.2, C7, OK)

Total Stress = Stress due to shear + stress due to bending
= 0.179 + 0.042
= 0.221 ksi (1.52 MPa) (ADAPT 0.221, B13.2, C8, OK)

Allowable stress (from ACI-318 equation 11.36):

$\phi v_c = \phi*[(\beta_p* \sqrt{f'_c} + 0.3 * f_{pc}) + V_p]$

where,

ϕ = 0.75
β_p is the smaller of 3.5 or ((α_s* d/ b_0)+ 1.5)
α_s = 40 for interior column
b_0 = Perimeter of the critical section
= 2 * (24.88 + 18.88)
= 87.52 in (2223 mm)
d = 4.88 in (124 mm)
β_p = ((α_s* d/ b_0)+ 1.5)

= ((40* 4.88 / 87.52)+ 1.5)
= 3.73 >3.50, ∴ use 3.50

f_{pc} = P/A
= 129.17 psi (0.89 MPa) (B7.2, C7)

$\phi\ v_c$ = 0.75 *(3.5* √4000 + 0.3 *129.17)
= 195.08 psi (1.35 MPa)

∴ Allowable Stress = 0.195 ksi (1.35 MPa) (ADAPT 0.195, B13.2, C9, OK)

Note that in the evaluation of allowable stresses, the term corresponding to the vertical component of tendon force (Vp) is conservatively disregarded.

Stress ratio:

Stress Ratio = Actual/Allowable
= 0.221/0.195
= 1.13 (ADAPT 1.13, B13.2, C10, OK)

∴ Punching shear stress exceeds the allowable stress. Provide shear reinforcement.

Check Maximum Shear stress:

$\phi v_n \leq \phi 8 \sqrt{f'_c}$

$\phi\ 6\sqrt{f'_c}$ = 0.75*8*√4000/1000 = 0.285 ksi > 0.221 ksi **OK**

Shear Reinforcement Design:

$$Av = \frac{(v_u - \varphi v_c) b_0 s}{\varphi\ f_y \sin\alpha}$$

ϕv_c = $\phi 2\sqrt{f'_c}$
= 0.75* 2√4000/1000
= 0.095 ksi

$$A_v = \frac{(0.221 - 0.095)87.52 \times 4.88/2}{0.75 \times 60} = 0.60\ in^2$$

(ADAPT 0.60, B30-Column 2, C12, OK)

Assume #5 stirrups, area of 1leg = 0.31 in^2
Number of legs, N_{legs} = 0.60 / 0.31 = 2
Distance between the legs = b_0 / N_{legs}

= 87.52/2 `

= 43.76 in > smax =2d = 9.76 in

∴ Distance between the legs = 9.76 in ≈ 9.75 in

(ADAPT 9.75, B30-Column 2, C14, OK)

∴ Number of legs, N_{legs} = 87.52 / 9.75

= 8.98 ≈ **9**

(ADAPT 9, B30-Column 2, C13, OK)

Since the stress exceeded at this location check the next critical location at d from the face of support.

3.3.1.15 Deflections (Data Block 14)

Herein the mid-span deflection of the central span is verified. Detailed deflection calculation is given in chapter 5-specific Verification of this volume. **Fig. 3.3-3** shows the bending moment diagram of the central span due to dead loading per foot of tributary. The values are from B5.1, C3-5. For example, the support moment is 94.13/20 = 4.71 k-ft. The static moment from ADAPT-PT is (94.13+55.87)/20 = 7.5 k-ft.

Check:

Static moment = $wL^2/8$

= 0.096*252/8

= 7.5 k ft (10.17 kNm) (OK)

Moment of inertia = 5500/20

= 275 in4 (1.14e8 mm4)

(B4, C3)

Concrete's modulus of elasticity = 3605 ksi (24856 MPa)

(Notes of B14)

Using the Moment-Area method of deflection calculation, the deflection at mid-span is given as the moment of the bending moment diagram between mid-span and the support taken about the support line and divided by E*I. Refer to the lower part of **Fig. 3.3-3**, where the applicable bending moment diagrams are shown separately for clarity.

Dead load deflection = [4.71*12*150*75 + 7.5*12*(150*2/3) * (150*5/8)]/(275*3605)

= 0.21 in. (5 mm)

(ADAPT 0.21, B14,C3&4 OK)

By proration, the live load and post-tensioning deflections can be verified as follows:

Live load deflection = (0.029/0.096)*0.21
= 0.06 in. (2 mm) (ADAPT 0.06, B14,C6)

Deflection due to dead load plus post-tensioning

Net loading = 0.096 – (0.860/20)
= 0.053 k/ft^2 (B7.2,C8)
= (0.053/0.096)*0.21
= 0.12 in. (3 mm) (ADAPT 0.13, B14,C4)

Note that the deflection due to post-tensioning is approximated in the verification. The distribution of balanced loading is not uniform and the proration employed in the verification on the basis of uniform distribution is not strictly accurate.

Creep factor = 2
Long-term deflection = [0.13*(1 + 2)+0.06]
= 0.45 in. (11 mm) (ADAPT 0.44, B14, C8)
Span/long term deflection = (25*12/0.45)
= 667 (B14,C8)

The slight differences between the hand calculated and ADAPT-PT computed ratios lies in the round off error in printed values of deflections.

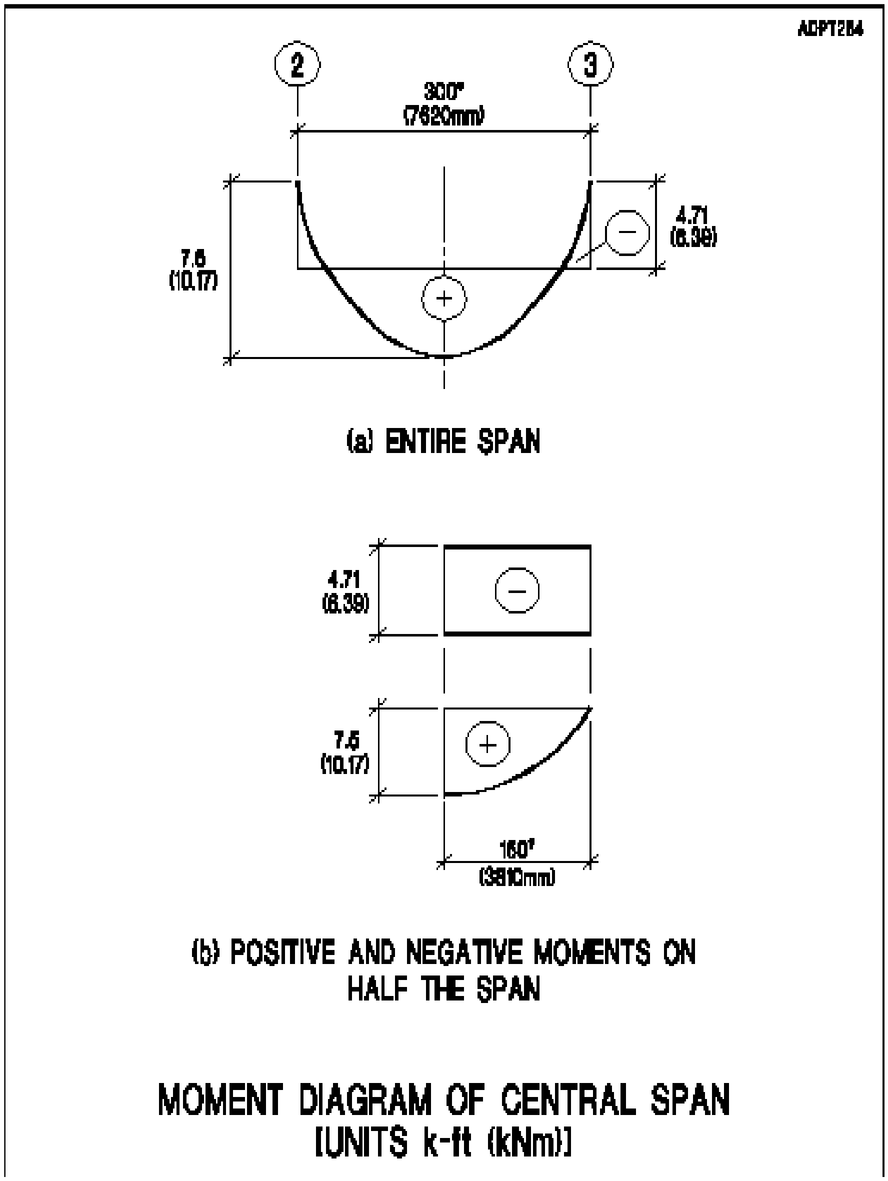


Figure 3.3-3

3.3.2 Verification of SI Report

The SI version is verified by way of comparing its output with the American version. **Table 3.3-1** lists the critical values of the two-way slab for both the American and the SI system of units. Good agreement between the two versions is observed.

TABLE 3.3-1 - COMPARISON BETWEEN THE METRIC AND AMERICAN OUTPUTS OF ADAPT FOR PTI TWO-WAY SLAB EXAMPLE (PTI02M)

	SI output [kN,m]	SI output [k,ft]	American output [k,ft]	Reference number
DL Moment Span	34.45	25.41	25.46	B5.1, C4
DL Moment Support	-103.36	-76.23	-76.47	B5.1, C5
DL Moment Reduced	-81.56	-60.16	-60.34	B6.1, C5
LL Moment Span	19.53	14.40	14.45	B5.3, C4
LL Moment Support	-35.30	-26.04	-26.11	B5.3, C6
LL Moment Reduced	-27.65	-20.39	-20.45	B6.2, C6
Required PT Span	471.17	105.92	108.32	B7.4, C3
Required PT Support	767.68	172.58	174.56	B7.4, C4
Stress Bottom at Center	1.69	245.12	243.73	B7.5-2, C8
Stress Top at Center	-3.47	-503.29	-502.06	B7.5-2, C7
Secondary Moments	10.40	7.67	7.56	B8.3, C3
Rebar - Bottom	1338	2.07	2.07	B10.1.1, C5
Rebar - Top	1163	1.80	1.88	B10.1.1, C5
Deflection LL	1.5	0.06	0.06	B14, C6
Punching Shear ratio	1.13	1.13	1.13	B13.2, C10

4 Cast-in-Place T-Beam Verification

This section covers the design example and verification of a two-span post-tensioned T-beam. The dimensions and design parameters selected are the same as the example in PTI's Design Manual (1985, 4th edition, page 326).

4.1 Given Values

The elevation and cross-sectional geometry of the beam are given in **Fig. 4.1-1**. The cross-sectional geometry of the beam shown refers to the stem and its effective width in bending. Other design parameters and particulars of the structure are specified in the following.

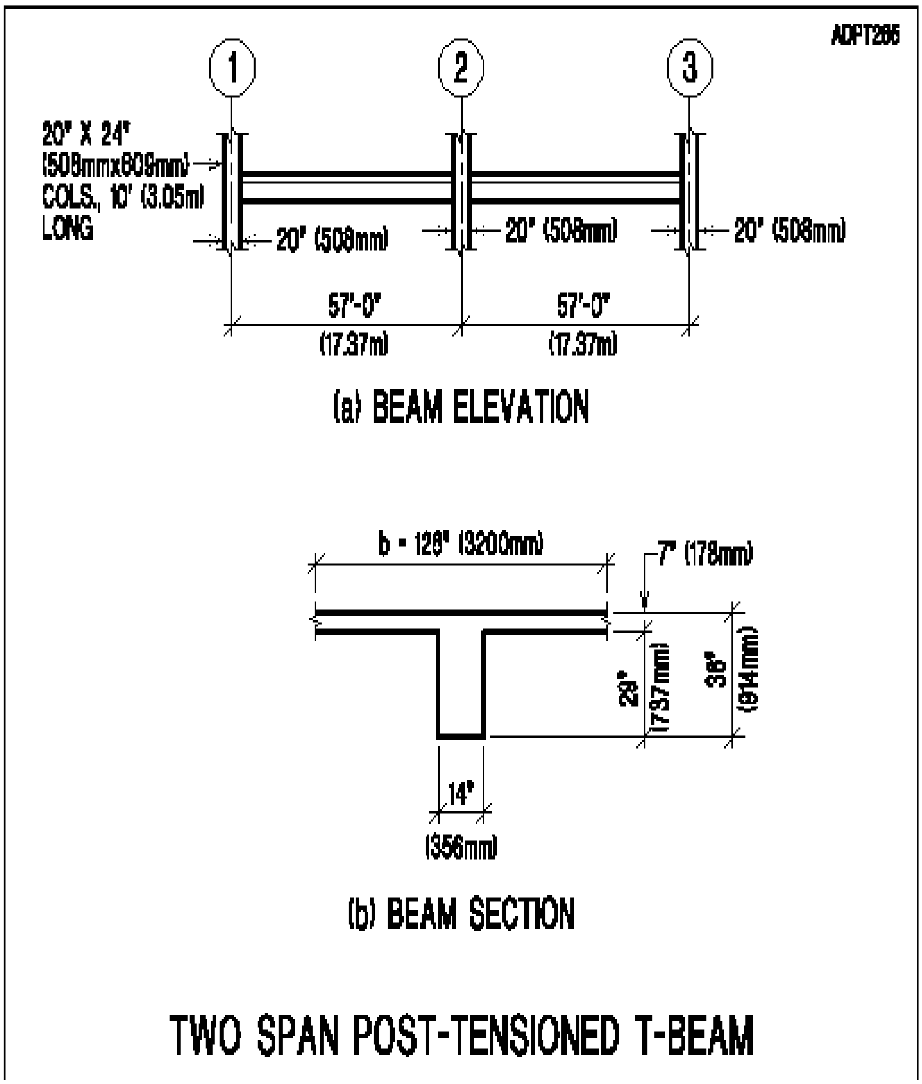


Figure 4.1-1

4.1.1 Structural System

The structural system consists of Two-span cast-in-place T-Beam supported by columns.

4.1.2 Design Code

The design is based on ACI 318-14.

4.1.3 Material Properties

(i) Concrete

Compressive cylinder strength, f'_c	= 5000 psi (34 MPa)
Weight	= 150 pcf (2403 kg/m^3)
Modulus of elasticity	= 4030 ksi (20.68 MPa)
Compressive cylinder strength at stressing, f'_c	= 3000 psi (20.68 MPa)

(ii) Post-Tensioning

Material:

Low relaxation, seven wire strand	
Strand diameter	= ½ in
Strand area	= 0.153 in^2 (99 mm^2)
Modulus of elaticity	= 28000 ksi (193054 MPa)
Ultimate strength of strand, f_{pu}	= 270 ksi (1862 MPa)
Average effective stress (f_{se})	= 175 ksi (1206 MPa)

System:

System	unbonded

Stressing:

Ratio of jacking stress to strand's ultimate strength	= 0.8
Anchor set	= 0.25 in (6.35 mm)
Coefficient of angular friction, μ	= 0.07 /radian
Coefficient of wobble friction, K	= 0.0014 rad/ft (0.0046 rad/m)
Stress on day 3	
Minimum concrete cylinder strength at stressing	= 1832 psi (12.63 MPa)

(iii) Nonprestressed Reinforcement

Yield stress fy = 60 ksi (413.69 MPa)
Modulus of elasticity = 29000 ksi (199,949 MPa)

(iv) Design Loading

Dead load = 2.777 k/ft (40.53 kN/m)
Live load = 0.807 k/ft (11.78 kN/m)

4.1.4 Load Cases and Combinations

(i) Strength Load Combinations

The strength requirement for each member is established using the following factored load combinations:

Primary load combination
1.2*DL + 1.6*LL + 1*HYP

Other load combination
1.4*DL + 1*HYP

Where "HYP" is the secondary (hyperstatic) moments, shears and reactions due to post-tensioning.

(ii) Serviceability Load Combinations

Final stresses:

The design is selected to be carried out according to the "Transitional" (T) state of stress of the code. That is to say, the maximum hypothetical tensile stresses will be allowed to exceed $6\sqrt{f'_c}$ but be retained less than $12\sqrt{f'_c}$ A hypothetical tensile stress equal to $9 * \sqrt{f'_c}$ is set as design target.

Tensile stress (top and bottom) = $9\sqrt{f'_c}$ = 569.21 psi (3.92 MPa)

Compressive stress

For sustained load condition = $0.45f'_c$
= 1800 psi (12.41 MPa)
For total load condition = $0.60 * f'_c$
= 2400 psi (16.55 MPa)

Load combinations for serviceability check:

Total load condition
1*DL + 1*LL + 1*PT

Sustained load condition
1*DL + 0.3*LL + 1*PT

The factors for neither of the above load combinations are spelled out in the code. Their selection is based on common practice.

Initial stresses (transfer):

Maximum tension = 3 $\sqrt{f'_{ci}}$
Maximum compression = 0.60 * f'_{ci}

Where $f'_{ci} = 0.75f'_c$ is the concrete cylinder strength at time of stressing.

Load Combinations for Stress Check at transfer of prestressing:

U = 1.00 DL + 1.15* PT

4.1.5 Deflections

Having maintained the hypothetical tensile stresses within the limits stated in the preceding, the deflections would be calculated assuming gross cross-sectional properties. Long-term deflections are estimated using a creep coefficient of 2.

For the floor slabs the maximum deflections are maintained below the following value with the understanding that the floor structure is not attached to nonstructural elements likely to be damaged by large deflections of the floor:

Slabs:

Live load deflection $\leq$ span/360

4.1.6 Cover

(i) Nonprestressed Reinforcement

Cover to top bars = 2 in (51 mm)
Cover to bottom bars = 2 in (51 mm)

(ii) Prestressed Reinforcement

Top cover = 4 in all spans (102 mm)
Bottom cover
Interior spans = 3 in (76 mm)
Exterior spans = 3 in (76 mm)

4.1.7 Tendon Profile

Reversed parabola with low point at center for both spans. Inflection points at 0.083L from central support.

4.2 Computed Values

The computed values are obtained from ADAPT-PT. The relevant parts of the tabular report are summarized below.

4.2.1 Computer Report for American Units

ADAPT

Your Partner in Concrete Design

Cast-in-Place T-Beam

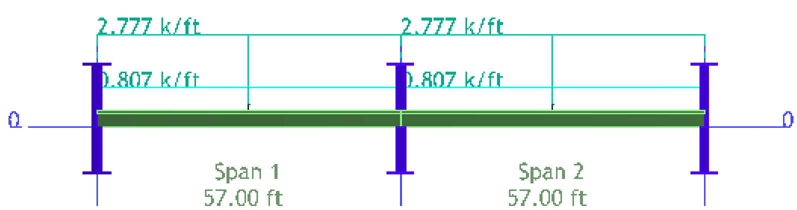


TABLE OF CONTENT:

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		Post-tensioning	
F'c for BEAMS/SLABS	5000.00 psi	SYSTEM	UNBONDED
For COLUMNS/WALLS	5000.00 psi	Fpu	270.00 ksi
Ec for BEAMS/SLABS	4030.50 ksi	Fse	175.00 ksi
For COLUMNS/WALLS	4030.50 ksi	Strand area	0.153 in 2
CREEP factor	2.00	Min CGS from TOP	4.00 in
CONCRETE WEIGHT	NORMAL	Min CGS from BOT for interior spans	3.00 in
Tension stress limits / (f'c)1/2		Min CGS from BOT for exterior spans	3.00 in
At Top	9.000	Min average precompression	125.00 psi
At Bottom	9.000	Max spacing / slab depth	8.00
Compression stress limits / f'c		Analysis and design options	
At all locations	0.450	Structural system	BEAM
Reinforcement		Moment of Inertia over support is	NOT INCREASED
Fy (Main bars)	60.00 ksi	Moments reduced to face of support	YES
Fy (Shear reinforcement)	60.00 ksi	Moment Redistribution	NO
Minimum Cover at TOP	2.00 in	Effective flange width consideration	NO
Minimum Cover at BOTTOM	2.00 in	DESIGN CODE SELECTED	ACI-318 (2014)

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		ft	in	in	in	in	in	in	in		
1	2	57.00	14.00	36.00	126.00	7.00			36.00	0.50	0.50
2	2	57.00	14.00	36.00	126.00	7.00			36.00	0.50	0.50

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	in	ft	in	in			ft	in	in		
1	20.0	10.0	24.0	20.0	100	(1)	10.0	24.0	20.0	100	(1)
2	20.0	10.0	24.0	20.0	100	(1)	10.0	24.0	20.0	100	(1)
3	20.0	10.0	24.0	20.0	100	(1)	10.0	24.0	20.0	100	(1)

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			k/ft2	k/ft	k/ft	ft	ft	ft	k	k-ft
1	LL	L		0.807		0.000	57.000			
1	SDL	L		2.777		0.000	57.000			
2	LL	L		0.807		0.000	57.000			
2	SDL	L		2.777		0.000	57.000			

4 - CALCULATED SECTION PROPERTIES

4.1 Section Properties of Uniform Spans and Cantilevers

Span	Area	I	Yb	Yt
	in2	in4	in	in

1	1288.00	0.12E+06	26.83	9.17
2	1288.00	0.12E+06	26.83	9.17

5 - MOMENTS, SHEARS AND REACTIONS

5.1 Span Moments and Shears (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right	Shear Left	Shear Right
		k-ft	k-ft	k-ft	k	k
1	SW	0.00	0.00	0.00	0.00	0.00
2	SW	0.00	0.00	0.00	0.00	0.00
1	SDL	-450.06	451.72	-902.12	-71.21	87.08
2	SDL	-902.10	451.72	-450.07	-87.07	71.21
1	XL	0.00	0.00	0.00	0.00	0.00
2	XL	0.00	0.00	0.00	0.00	0.00

5.2 Reactions and Column Moments (Excluding Live Load)

Joint	Load Case	Reaction	Moment Lower Column	Moment Upper Column
		k	k-ft	k-ft
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
1	SDL	71.21	-225.03	-225.03
2	SDL	174.15	0.01	0.01
3	SDL	71.21	225.03	225.03
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00

5.3 Span Moments and Shears (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min	Shear Left	Shear Right
	k-ft	k-ft	k-ft	k-ft	k-ft	k-ft	k	k
1	-130.79	-130.79	131.27	131.27	-262.16	-262.16	-20.69	25.30
2	-262.15	-262.15	131.27	131.27	-130.79	-130.79	-25.30	20.69

5.4 Reactions and Column Moments (Live Load)

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	k	k	k-ft	k-ft	k-ft	k-ft
1	20.69	20.69	-65.39	-65.39	-65.39	-65.39
2	50.61	50.61	0.00	0.00	0.00	0.00
3	20.69	20.69	65.40	65.40	65.40	65.40

6 - MOMENTS REDUCED TO FACE OF SUPPORT

6.1 Reduced Moments at Face of Support (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right
		k-ft	k-ft	k-ft
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
1	SDL	-391.67	451.75	-830.50
2	SDL	-830.50	451.75	-391.67

1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00

6.2 Reduced Moments at Face of Support (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min
	k-ft	k-ft	k-ft	k-ft	k-ft	k-ft
1	-113.83	-113.83	131.25	131.25	-241.33	-241.33
2	-241.33	-241.33	131.25	131.25	-113.83	-113.83

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile
Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
1	1	0.000	0.500	0.083	---
2	1	0.083	0.500	0.000	---

7.2 Selected Post-Tensioning Forces and Tendon Drape
Tendon A

Span	Force	CGS Left	CGS C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	k	in	in	in	in	psi	k/-	
1	338.500	26.83	---	3.00	32.00	262.81	1.835	66
2	338.500	32.00	---	3.00	26.83	262.81	1.835	66

Approximate weight of strand: 749.4 LB

7.4 Required Minimum Post-Tensioning Forces

	Based on Stress Conditions			Based on Minimum P/A		
Type	Left	Center	Right	Left	Center	Right
	k	k	k	k	k	k
1	0.00	274.60	149.02	161.00	161.00	161.00
2	148.91	274.44	0.00	161.00	161.00	161.00

7.5 Service Stresses (tension shown positive)

Envelope of Service 1

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	psi	psi	psi	psi	psi	psi
1	-117.16	-688.71	-415.85	184.70	64.87	-1221.02
2	64.34	-1219.46	-415.63	184.07	-117.16	-688.72

Envelope of Service 2

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	psi	psi	psi	psi	psi	psi
1	-45.34	-898.74	-498.67	426.90	217.14	-1666.29
2	216.61	-1664.73	-498.46	426.27	-45.33	-898.75

7.6 Post-Tensioning Balance Moments, Shears and Reactions
Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right
	k-ft	k-ft	k-ft	k	k
1	264.25	-321.33	539.33	-1.72	-1.72
2	539.92	-321.58	264.25	1.72	1.72

Reactions and Column Moments

Joint	Reaction	Moment	Moment

		Lower Column	Upper Column
	k	k-ft	k-ft
1	1.715	150.667	150.667
2	-3.439	-0.102	-0.102
3	1.723	-150.667	-150.667

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	k-ft	k-ft	k-ft	k-ft	k-ft	k-ft
1	-349.38	-245.58	1102.60	982.95	-984.40	-764.37
2	-984.65	-764.62	1102.52	982.87	-349.38	-245.58

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	k	k	k-ft	k-ft	k-ft	k-ft
1	120.27	101.41	-164.33	-223.96	-164.33	-223.96
2	286.58	240.44	-0.09	-0.09	-0.09	-0.09
3	120.28	101.42	223.96	164.33	223.96	164.33

8.3 Secondary Moments

Span	Left	Midspan	Right
	k-ft	k-ft	k-ft
1	302.75	350.50	398.33
2	398.08	350.42	302.75

Note: Moments are reported at face of support

10 - MILD STEEL - NO REDISTRIBUTION

10.1 Required Rebar

10.1.1 Total Strip Required Rebar

Span	Location	From	To	As Required	Ultimate	Minimum
		ft	ft	in2	in2	in2
1	TOP	0.00	8.55	3.65	0.00	3.65
1	TOP	48.46	56.99	3.65	1.55	3.65
2	TOP	0.00	8.55	3.65	1.55	3.65
2	TOP	48.46	56.99	3.65	0.00	3.65
1	BOT	19.95	37.04	1.50	0.19	1.50
2	BOT	19.95	37.04	1.50	0.19	1.50

10.2 Provided Rebar

10.2.1 Total Strip Provided Rebar

Span	ID	Location	From	Quantity	Size	Length	Area
			ft			ft	in2
1	1	TOP	0.00	9	6	11.50	3.96
1	2	TOP	45.60	9	6	23.00	3.96
2	3	TOP	45.60	9	6	11.50	3.96
1	4	BOT	16.10	4	6	24.00	1.76

2	5	BOT	17.10	4	6	24.00	1.76

10.2.2 Total Strip Steel Disposition

Span	ID	Location	From	Quantity	Size	Length
			ft			ft
1	1	TOP	0.00	9	6	11.50
1	2	TOP	45.60	9	6	11.40
2	2	TOP	0.00	9	6	11.60
2	3	TOP	45.60	9	6	11.50
1	4	BOT	16.10	4	6	24.00
2	5	BOT	17.10	4	6	24.00

12 - SHEAR REINFORCEMENT

12.1 Shear Calculation Envelope
SPAN 1

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	ft	in	k	kft		in2	in
0.01	0.83	28.80	-116.45	-352.90	1.09	0.09	23.62
0.05	2.85	28.80	-107.13	-125.14	1.00	0.07	23.62
0.10	5.70	28.80	-93.93	164.19	0.88	0.07	23.62
0.15	8.55	28.80	-80.78	415.65	0.94	0.07	23.62
0.20	11.40	28.80	-67.58	629.08	1.14	0.08	23.62
0.25	14.25	28.80	-54.41	804.72	1.21	0.09	23.62
0.30	17.10	29.19	-41.25	942.78	0.95	0.06	23.62
0.35	19.95	30.85	-28.06	1042.44	0.61	0.06	23.62
0.40	22.80	32.05	-14.89	1103.72	0.31	0.00	0.00
0.45	25.65	32.76	-1.71	1128.08	0.04	0.00	0.00
0.50	28.50	33.00	11.47	1113.32	0.23	0.00	0.00
0.55	31.35	32.65	24.64	1061.64	0.51	0.06	23.62
0.60	34.19	31.61	37.83	971.57	0.81	0.06	23.62
0.65	37.04	29.87	50.99	843.85	1.10	0.06	23.62
0.70	39.90	28.80	64.20	678.11	1.09	0.07	23.62
0.75	42.75	28.80	77.34	474.27	0.93	0.07	23.62
0.80	45.60	28.80	90.53	232.70	0.85	0.07	23.62
0.85	48.46	28.80	103.71	-46.87	0.97	0.07	23.62
0.90	51.31	28.80	116.90	-364.41	1.09	0.09	23.62
0.95	54.13	30.25	130.07	-719.82	1.16	0.16	23.62
0.99	56.17	31.49	139.38	-994.46	1.40	0.34	21.66

SPAN 2

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	ft	in	k	kft		in2	in
0.01	0.83	31.49	-139.40	-994.46	1.41	0.34	21.65
0.05	2.85	30.25	-130.07	-720.04	1.16	0.16	23.62
0.10	5.70	28.80	-116.90	-364.56	1.09	0.09	23.62
0.15	8.55	28.80	-103.71	-47.06	0.97	0.07	23.62
0.20	11.40	28.80	-90.55	232.48	0.85	0.07	23.62
0.25	14.25	28.80	-77.36	474.19	0.93	0.07	23.62
0.30	17.10	28.80	-64.18	677.96	1.09	0.07	23.62
0.35	19.95	29.87	-51.01	843.85	1.10	0.06	23.62
0.40	22.80	31.61	-37.83	971.57	0.81	0.06	23.62
0.45	25.65	32.65	-24.66	1061.64	0.51	0.06	23.62
0.50	28.50	33.00	-11.48	1113.32	0.23	0.00	0.00
0.55	31.35	32.76	1.70	1127.35	0.03	0.00	0.00
0.60	34.19	32.05	14.88	1103.72	0.31	0.00	0.00
0.65	37.04	30.85	28.06	1041.71	0.61	0.06	23.62
0.70	39.90	29.19	41.22	942.04	0.95	0.06	23.62

0.75	42.75	28.80	54.41	804.72	1.21	0.09	23.62
0.80	45.60	28.80	67.58	629.08	1.14	0.08	23.62
0.85	48.46	28.80	80.76	415.65	0.94	0.07	23.62
0.90	51.31	28.80	93.93	164.12	0.88	0.07	23.62
0.95	54.13	28.80	107.11	-125.29	1.00	0.07	23.62
0.99	56.17	28.80	116.43	-352.90	1.09	0.09	23.62

Note: "Vu" is related to the load combination which produces the maximum "Ratio"
Note: Sections with **** have exceeded the maximum allowable shear stress.

14 - DEFLECTIONS

14.1 Maximum Span Deflections

Span	SW	SW+PT	SW+PT+ SDL	SW+PT+SDL +Creep	LL	X	Total
	in	in	in	in	in	in	in
1	0.00	-0.22	0.12	0.35(1974)	0.11(6233)	0.00(****)	0.46(1499)
2	0.00	-0.22	0.12	0.35(1976)	0.11(6234)	0.00(****)	0.46(1500)

Legend (2.1):
Span C = Cantilever
Form 1 = Rectangular, 2 = T or Inverted L, 3 = I, 4 = Extended T or L section
Rh Elevation of top surface
TF Top flange
MF Middle flange
BF Bottom flange

Legend (2.7):
The Column Boundary Condition (CBC):
Fixed at both 1
Hinged at near end, fixed at far end 2
Fixed at near end, hinged at far end 3
Fixed at near end, roller with rotational fixity at far end 4
LC Lower Column
UC Upper Column

Legend (3.1):
Class: SW: Selfweight, LL: Live Load, SDL: Superimposed Dead Load, X: Other Loading
Type: U: Uniform, P: Partial Uniform, L: Line Load, M: Applied Moment
C: Concentrated Load, R: Triangle, V: Variable, T: Trapezoidal

Legend (4.1, 4.2):
Yb: distance from centroid to bottom fiber
Yt: distance from centroid to top fiber
I: gross moment of inertia

Legend (7.1):
Type
1 = reversed parabola
2 = simple parabola with straight portion over support
3 = harped tendon
4 = straight tendon
5 = extended reversed parabola

Legend (7.2):
CGS C1: CGS of left middle point of tendon for type 5 profile
CGS C2: CGS of right middle point of tendon for type 5 profile or middle point of other types

Legend (10.1, 11.1):
From: Beginning of rebar measured from left support of the span
To: End of rebar measured from left support of the span

As Required: Envelope of minimum and ultimate rebar
Ultimate: Required rebar for ultimate load combinations
Minimum: Required minimum rebar

Legend (10.2, 11_2):
ID: ID number of the bar as shown on graph
From: Beginning of rebar measured from left support of the span
Quantity: Number of bars
Size: Bar number
Length: Total length of the bar
Area: Area of reinforcement

Legend (12):
d: Effective depth of section for shear rebar calculation
Vu: Ultimate shear
Ratio: ratio of ultimate to allowable shear stress
Req.: Required shear reinforcement per unit length
Spacing: Spacing between shear rebar

4.2.2 Computer Report for SI Units

Cast-in-Place T-Beam

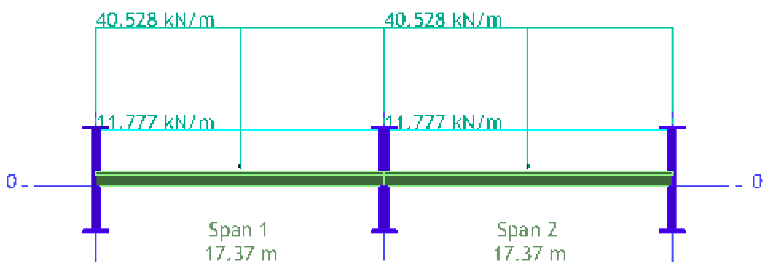


TABLE OF CONTENT:

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		Post-tensioning	
F'c for BEAMS/SLABS	34.00 N/mm 2	SYSTEM	UNBONDED
For COLUMNS/WALLS	34.00 N/mm 2	Fpu	1862.00 N/mm 2
Ec for BEAMS/SLABS	27405.00 N/mm 2	Fse	1206.00 N/mm 2
For COLUMNS/WALLS	27405.00 N/mm 2	Strand area	99.000 mm 2
CREEP factor	2.00	Min CGS from TOP	102.00 mm
CONCRETE WEIGHT	NORMAL	Min CGS from BOT for interior spans	76.00 mm
Tension stress limits / (f'c)1/2		Min CGS from BOT for exterior spans	76.00 mm
At Top	0.750	Min average precompression	0.86 N/mm 2
At Bottom	0.750	Max spacing / slab depth	8.00
Compression stress limits / f'c		Analysis and design options	
At all locations	0.450	Structural system	BEAM
Reinforcement		Moment of Inertia over support is	NOT INCREASED
Fy (Main bars)	413.69 N/mm 2	Moments reduced to face of support	YES
Fy (Shear reinforcement)	413.69 N/mm 2	Moment Redistribution	NO
Minimum Cover at TOP	51.00 mm	Effective flange width consideration	NO
Minimum Cover at BOTTOM	51.00 mm	DESIGN CODE SELECTED	ACI-318 (2014)

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		m	mm	mm	mm	mm	mm	mm	mm		
1	2	17.37	355	914	3200	177			914	0.50	0.50
2	2	17.37	355	914	3200	177			914	0.50	0.50

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	mm	m	mm	mm			m	mm	mm		
1	508.0	3.0	609.0	508.0	100	(1)	3.0	609.0	508.0	100	(1)
2	508.0	3.0	609.0	508.0	100	(1)	3.0	609.0	508.0	100	(1)
3	508.0	3.0	609.0	508.0	100	(1)	3.0	609.0	508.0	100	(1)

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			kN/m2	kN/m	kN/m	m	m	m	kN	kN-m
1	LL	L		11.777		0.000	17.374			
1	SDL	L		40.528		0.000	17.374			
2	LL	L		11.777		0.000	17.374			
2	SDL	L		40.528		0.000	17.374			

4 - CALCULATED SECTION PROPERTIES

4.1 Section Properties of Uniform Spans and Cantilevers

Span	Area	I	Yb	Yt
	mm2	mm4	mm	mm
1	828035.00	0.51E+11	681.10	232.90

2	828035.00	0.51E+11	681.10	232.90

5 - MOMENTS, SHEARS AND REACTIONS

5.1 Span Moments and Shears (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right	Shear Left	Shear Right
		kN-m	kN-m	kN-m	kN	kN
1	SW	0.00	0.00	0.00	0.00	0.00
2	SW	0.00	0.00	0.00	0.00	0.00
1	SDL	-610.65	612.42	-1222.90	-316.83	387.31
2	SDL	-1222.91	612.42	-610.65	-387.31	316.83
1	XL	0.00	0.00	0.00	0.00	0.00
2	XL	0.00	0.00	0.00	0.00	0.00

5.2 Reactions and Column Moments (Excluding Live Load)

Joint	Load Case	Reaction	Moment Lower Column	Moment Upper Column
		kN	kN-m	kN-m
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
1	SDL	316.83	-305.33	-305.33
2	SDL	774.61	0.00	0.00
3	SDL	316.83	305.33	305.33
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00

5.3 Span Moments and Shears (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN	kN
1	-177.45	-177.45	177.96	177.96	-355.36	-355.36	-92.07	112.55
2	-355.36	-355.36	177.96	177.96	-177.45	-177.45	-112.55	92.07

5.4 Reactions and Column Moments (Live Load)

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	92.07	92.07	-88.73	-88.73	-88.73	-88.73
2	225.09	225.09	0.00	0.00	0.00	0.00
3	92.07	92.07	88.73	88.73	88.73	88.73

6 - MOMENTS REDUCED TO FACE OF SUPPORT

6.1 Reduced Moments at Face of Support (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right
		kN-m	kN-m	kN-m
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
1	SDL	-531.50	612.40	-1126.00
2	SDL	-1126.00	612.40	-531.50
1	XL	0.00	0.00	0.00

2	XL	0.00	0.00	0.00

6.2 Reduced Moments at Face of Support (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	-154.40	-154.40	178.00	178.00	-327.20	-327.20
2	-327.20	-327.20	178.00	178.00	-154.40	-154.40

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile
Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
1	1	0.000	0.500	0.083	---
2	1	0.083	0.500	0.000	---

7.2 Selected Post-Tensioning Forces and Tendon Drape
Tendon A

Span	Force	CGS Left	CGS C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	kN	mm	mm	mm	mm	MPa	kN/-	
1	1505.700	681.00	---	76.00	812.00	1.82	26.756	66
2	1505.700	812.00	---	76.00	681.00	1.82	26.756	66

Approximate weight of strand: 340.6 Kg

7.4 Required Minimum Post-Tensioning Forces

	Based on Stress Conditions			Based on Minimum P/A		
Type	Left	Center	Right	Left	Center	Right
	kN	kN	kN	kN	kN	kN
1	0.00	1225.90	670.58	712.11	712.11	712.11
2	669.56	1225.71	0.00	712.11	712.11	712.11

7.5 Service Stresses (tension shown positive)

Envelope of Service 1

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	MPa	MPa	MPa	MPa	MPa	MPa
1	-0.81	-4.77	-2.88	1.27	0.45	-8.46
2	0.45	-8.44	-2.88	1.27	-0.81	-4.77

Envelope of Service 2

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	MPa	MPa	MPa	MPa	MPa	MPa
1	-0.31	-6.22	-3.45	2.95	1.51	-11.54
2	1.50	-11.52	-3.45	2.95	-0.31	-6.22

7.6 Post-Tensioning Balance Moments, Shears and Reactions
Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN	kN
1	358.20	-435.60	729.60	-7.57	-7.57
2	731.40	-435.70	358.20	7.66	7.66

Reactions and Column Moments

Joint	Reaction	Moment Lower	Moment Upper

		Column	Column
	kN	kN-m	kN-m
1	7.565	204.400	204.400
2	-15.220	-0.054	-0.054
3	7.657	-204.400	-204.400

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	-474.14	-333.40	1495.08	1332.76	-1334.72	-1036.40
2	-1334.82	-1036.50	1494.98	1332.66	-474.14	-333.40

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	535.04	451.08	-223.02	-303.93	-223.02	-303.93
2	1274.46	1069.22	-0.06	-0.06	-0.06	-0.06
3	535.13	451.18	303.93	223.02	303.93	223.02

8.3 Secondary Moments

Span	Left	Midspan	Right
	kN-m	kN-m	kN-m
1	410.70	475.40	540.00
2	539.90	475.30	410.70

Note: Moments are reported at face of support

10 - MILD STEEL - NO REDISTRIBUTION

10.1 Required Rebar

10.1.1 Total Strip Required Rebar

Span	Location	From	To	As Required	Ultimate	Minimum
		m	m	mm2	mm2	mm2
1	TOP	0.00	2.61	2336.00	0.00	2336.00
1	TOP	14.77	17.37	2336.00	1050.00	2336.00
2	TOP	0.00	2.61	2336.00	1050.00	2336.00
2	TOP	14.77	17.37	2336.00	0.00	2336.00
1	BOT	6.08	11.29	966.60	152.50	966.60
2	BOT	6.08	11.29	966.60	152.50	966.60

10.2 Provided Rebar

10.2.1 Total Strip Provided Rebar

Span	ID	Location	From	Quantity	Size	Length	Area
			m			m	mm2
1	1	TOP	0.00	9	19	3.48	2556.00
1	2	TOP	13.90	9	19	6.94	2556.00
2	3	TOP	13.90	9	19	3.48	2556.00
1	4	BOT	4.91	4	19	7.26	1136.00
2	5	BOT	5.21	4	19	7.26	1136.00

10.2.2 Total Strip Steel Disposition

Span	ID	Location	From	Quantity	Size	Length
			m			m
1	1	TOP	0.00	9	19	3.48
1	2	TOP	13.90	9	19	3.47
2	2	TOP	0.00	9	19	3.47
2	3	TOP	13.90	9	19	3.48
1	4	BOT	4.91	4	19	7.26
2	5	BOT	5.21	4	19	7.26

12 - SHEAR REINFORCEMENT

12.1 Shear Calculation Envelope

SPAN 1

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.01	0.25	731.20	-518.00	-478.80	1.10	206.70	600.00
0.05	0.87	731.20	-476.50	-170.10	1.01	137.90	600.00
0.10	1.74	731.20	-417.90	222.20	0.89	137.90	600.00
0.15	2.61	731.20	-359.30	563.20	0.94	137.90	600.00
0.20	3.48	731.20	-300.70	852.70	1.15	170.60	600.00
0.25	4.34	731.20	-242.10	1091.00	1.21	186.70	600.00
0.30	5.21	741.20	-183.50	1277.00	0.96	136.90	600.00
0.35	6.08	783.50	-124.80	1413.00	0.62	133.20	600.00
0.40	6.95	813.80	-66.22	1497.00	0.32	0.00	0.00
0.45	7.82	831.90	-7.62	1529.00	0.04	0.00	0.00
0.50	8.69	838.00	51.01	1510.00	0.24	0.00	0.00
0.55	9.56	829.20	109.60	1439.00	0.51	129.50	600.00
0.60	10.42	802.70	168.20	1318.00	0.81	131.60	600.00
0.65	11.29	758.60	226.90	1144.00	1.11	135.40	600.00
0.70	12.16	731.20	285.50	919.50	1.10	137.90	600.00
0.75	13.03	731.20	344.10	643.40	0.94	137.90	600.00
0.80	13.90	731.20	402.70	315.70	0.85	137.90	600.00
0.85	14.77	731.20	461.30	-63.43	0.98	137.90	600.00
0.90	15.64	731.20	520.00	-493.90	1.10	215.30	600.00
0.95	16.51	767.70	578.60	-975.60	1.17	352.60	600.00
0.99	17.12	799.00	620.10	-1348.00	1.41	729.90	550.90

SPAN 2

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.01	0.25	799.00	-620.10	-1348.00	1.41	730.10	550.80
0.05	0.87	767.70	-578.60	-975.80	1.17	352.60	600.00
0.10	1.74	731.20	-520.00	-494.00	1.10	215.30	600.00
0.15	2.61	731.20	-461.30	-63.53	0.98	137.90	600.00
0.20	3.48	731.20	-402.70	315.60	0.85	137.90	600.00
0.25	4.34	731.20	-344.10	643.30	0.94	137.90	600.00
0.30	5.21	731.20	-285.50	919.40	1.10	137.90	600.00
0.35	6.08	758.60	-226.90	1144.00	1.11	135.40	600.00
0.40	6.95	802.70	-168.20	1317.00	0.81	131.60	600.00
0.45	7.82	829.20	-109.60	1439.00	0.51	129.50	600.00
0.50	8.69	838.00	-51.01	1510.00	0.24	0.00	0.00
0.55	9.56	832.00	7.62	1529.00	0.04	0.00	0.00
0.60	10.42	813.80	66.22	1497.00	0.32	0.00	0.00
0.65	11.29	783.50	124.80	1413.00	0.62	133.20	600.00
0.70	12.16	741.20	183.50	1277.00	0.96	136.90	600.00
0.75	13.03	731.20	242.10	1091.00	1.21	186.70	600.00

0.80	13.90	731.20	300.70	852.80	1.15	170.50	600.00
0.85	14.77	731.20	359.30	563.30	0.94	137.90	600.00
0.90	15.64	731.20	417.90	222.20	0.89	137.90	600.00
0.95	16.51	731.20	476.50	-170.10	1.01	137.90	600.00
0.99	17.12	731.20	518.00	-478.80	1.10	206.70	600.00

Note: "Vu" is related to the load combination which produces the maximum "Ratio"
Note: Sections with **** have exceeded the maximum allowable shear stress.

14 - DEFLECTIONS

14.1 Maximum Span Deflections

Span	SW	SW+PT	SW+PT+ SDL	SW+PT+SDL +Creep	LL	X	Total
	mm	mm	mm	mm	mm	mm	mm
1	0.0	-5.7	3.0	9.0(1940)	2.8(6132)	0.0(****)	11.8(1473)
2	0.0	-5.7	3.0	8.9(1941)	2.8(6132)	0.0(****)	11.8(1474)

4.3 Verification

4.3.1 Verification of Report for American Units

The ADAPT-PT report is presented in numbered data blocks. Each data block data area provided in table. For example, looking at the report, it is observed that data block 2.7 third column is the *lower column lengths*. In notation form, this is referred to as (B2.1, C3).

For this example, ADAPT-PT concludes with the effective force that is required to meet the specified stress and strength requirements. The force determined by ADAPT-PT should be furnished with due considerations to friction, elongation and long-term stress losses. The furnished force should be such as to envelop the required force distribution determined by ADAPT-PT.

The variable force option of ADAPT-PT, in which the change of tendon stress along its length is accounted for, is more appropriate for this verification.

4.3.1.1 Geometry of Beam (Data Block 2)

Data block 2.1 and 2.7 identify the geometry of the beam and column supports.

4.3.1.2 Loading (Data Block 3)

Data block 3.1 and 3.2 identify the loading details.

4.3.1.3 Calculated Section Properties (Data Block 4)

Data block 4 reflects the calculated section properties of all the spans.

Area, A = 14*29+ 126*7
= 1288 in^2 (8.31e5 mm^2)
(ADAPT 1288, B4.1, C2)

Moment of inertia, I = [14 * 293/12 + 14*29*(26.83-14.5) 2] +
[126 * 73/12 + 126*7*(9.17- 3.5) 2]
= 1221e2 in^4 (5.08e10 in^4)
(ADAPT 0.12E6,B4.1, C3)

Distance from bottom fiber to centroid, Y_b = 26.83 in (681 mm) (ADAPT B4.1, C4)

Distance from top fiber to centroid, Y_t = 9.17 in (233 mm) (ADAPT B4.1, C5)

4.3.1.4 Material Properties (Data Block 1)

Concrete, post-tensioning strand and mild reinforcement material properties are given in data block 1.

4.3.1.5 Centerline Moments (Data Block 5)

Dead and live moments for support centerlines and in-span values are listed in ADAPT-PT data blocks 5.1 through 5.4. They are reproduced in the following table for dead loading:

TABLE 4.3.1-1 - CENTERLINE AND IN-SPAN DEAD LOAD MOMENTS (k-ft)

	Kip-ft (kNm)	Reference Number
Exterior column	-450.06 (-610.19)	B 5.1, C3
First in-span	451.72 (612.44)	B 5.1, C4
Interior column	-902.12 (-1223.09)	B 5.1, C5

4.3.1.6 Tendon Profile and Forces (Data Block 7)

Tendon shape and selected forces used by ADAPT-PT are given in data blocks 7.1 and 7.2. Here selected the reversed parabola as tendon shape.

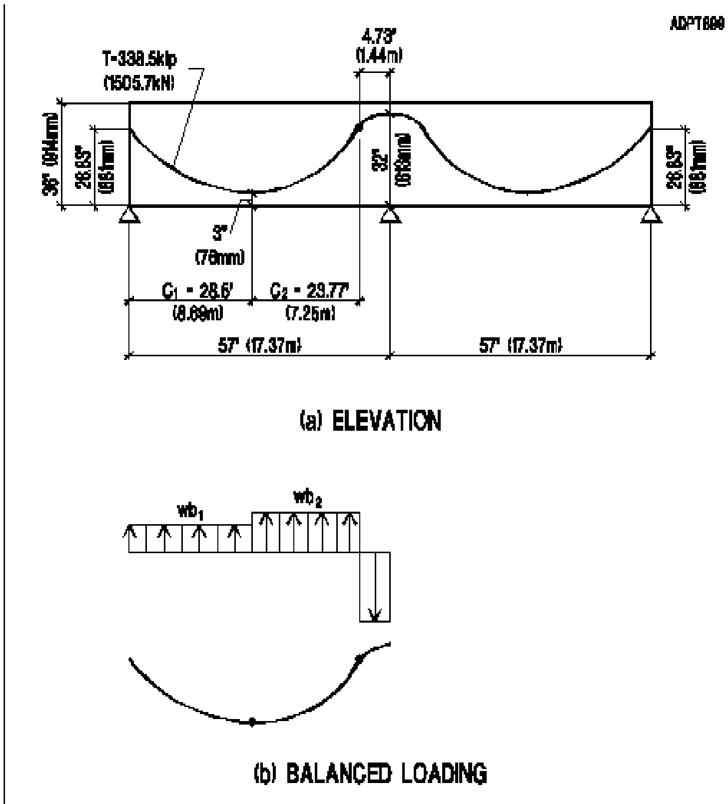
Data block 7.1 is the description of reversed parabola. In data block 7.1 of ADAPT-PT, column 3 and 5 indicate the inflection point distance from the central column in relation to the total length i.e., X1/L and X3/L. The parabolic profiles are selected so as to have their low points at mid-span.

Data Block 7.2, columns 3-6 (B 7.2, C 3-6) describe the tendon heights at critical points.

Data Block 7.2, column2 indicate the selection of tendon forces. In ADAPT-PT printout note that the forces selected (B 7.2, C2) are duly larger than those required (B 7.4, C 2-7). This ensures that the extreme fiber tensile stresses will be equal or less than the maximum allowable values specified by the user as part of input (B1).

Data Block 7.2, column 8 (C8) gives the calculated values of balanced loading. The ADAPT-PT solution is as follows:

Span 1



SPAN 1 BALANCED LOADING

FIGURE 4.3.1-1

Calculation of w_{b1}:

Provided PT force, T = 338.5 k (1505.72 kN) (B 7.2, C2)
a = 26.83 – 3= 23.83 in
c_1 = 28.5 ft (8.69 m)

w_{b1} / tendon = $(2 * T * a / c_1^2)$
= $2 * 338.5 * (23.83/12)/ 28.5^2$
= 1.655 klf (24.15 kN/m) (ADAPT 1.655, WBAL.DAT)

Calculation of w_{b2}:

Provided PT force, T = 338.5 k (1505.72 kN) (B 7.2, C2)
Total drape for right
of span a = 32-3 = 29 in (737 mm)
= (23.77/28.5)*29
= 24.19 in (614 mm)
c_2 = 23.77 ft(7.25 m)
w_{b2} / tendon = $(2 * T * a / c_2^2)$
= 2 * 338.5 * (24.19/12)/ 23.77 2
= 2.415 klf (35.24 kN/m) (ADAPT 2.415,WBAL.DAT)

Calculation of w_b:

w_b = $(w_{b1} * c_1 + w_{b1} * c_1) / L$
= (1.655 *28.5 +2.415 *23.77)/57
= 1.835 k/ft (26.78 kN/m)
(ADAPT 1.835, B7.2, C8)
% DL balanced Dead load = 2.777 k/ft (40.53 kN/m) (B3.1, C5)
Balanced Load = 1.835 k/ft (26.81 kN/m) (B7.2, C8)

% DL balanced = 1.835/ 2.777 = 0.66 *100
=66 (ADAPT 66, B 7.2, C9)

4.3.1.7 Required Post-Tensioning Forces (Data Block 7.4)

Consider the required post-tensioning at the right support of span one; given by ADAPT-PT as 149.02 kips (B 9.5, C 4).

The verification is carried out by demonstrating that the "required minimum post-tensioning force" suggested by ADAPT-PT, if used, leads to a tensile stress specified by the user as the maximum allowable. In this example the maximum allowable stress in tension is: 9√f'c.

Stress due to dead and live moments:

M = 1071.83 k-ft
M/S = 1071.83 * 12000*9.17/ 122100
= 965.96 psi (6.66 MPa)

Stress due to balanced moment is obtained by prorating the moment due to the selected force (338.5 kip) by the force suggested by ADAPT-PT (149.02 k).

M/S = (149.02/338.5)*539.33* 12000*9.17/ 122100
= 213.98 psi (1.48 MPa)

Stress due to direct compression:

P/A = 149.02 * 1000/ 1288
= 115.70 psi (0.80 Mpa)

Total tensile stress = 965.96 – 213.98 – 115.70
= 636.28 psi (4.39MPa)

Allowable stress:

$9\sqrt{f'_c}$ = 9 *√5000
= 636.40 psi (4.39 MPa) (OK)

It is shown that the calculated required post-tensioning corresponds to the maximum permissible tensile stress as specified by the user in data block 1.

4.3.1.8 Service Stresses (Data Block 7.5)

Data block 7.5 lists the service stresses at top and bottom for supports and mid span. This has two data blocks with service stresses, Envelope of Service 1 and Envelope of Service 2. Envelope of Service 1 is the envelope of service stresses from the Sustained Load Combinations. Similarly, Envelope of Service 2 is the envelope of service stresses from the Total Load combinations. This section provides the calculation for Envelope of Service 2.

Consider the right face of second support

Stresses:

$\sigma = (M_D+M_L+M_{PT})/S + (P/A)$
$S = I/Y_c$

Where M_D, M_L, M_{PT} are the moments across the entire tributary of the design strip. S is the section modulus; A is the area; I is the moment of inertia of the section; and Y_c is the distance of the centroid of the section to farthest tension fiber of the section.

Stress limits:

Top tension	= 9*√4000	
	= 636 psi (4.39 MPa)	(B1)
Bottom tension	= 9*√4000	
	= 636 psi (4.39 MPa)	
Compression (for service)	= 0.45 * 4000	
	= -1800 psi (12.41 MPa)	

A	= 1288 in^2 (8.31e5 mm^2)	(B4.1, C2)
I	= 122100 in^4 (5.08e10 in^4)	(B4.1, C3)
Y_b	= 26.83 in (681 mm)	(B4.1, C4)
Y_t	= 9.17 in (233 mm)	(B4.1, C5)

S_{bottom} = 122100/ 26.83
= 4551 in^3 (74.58e6 mm^3)

S_{top} = 122100/ 9.17
= 13315 in^3 (21.82e7 mm^3)

P	= 338.5 k (1505.72 kN)	(B7.2, C2)
M_D	= -830.50 k-ft (-1126 kNm)	(B6.1, C3)
M_L	= -241.33 k-ft (-327.20 kNm)	(B6.2, C2)
M_{PT}	= 539.92 k-ft (731.90 kNm)	(B7.6, C2)

$M_D+M_L+M_{PT}$ = -830.50 + -241.33 +539.92
= -531.91 k-ft (-721.16 kNm)

P/A = -338.5*1000/ 1288
= -262.81 psi (-1.81 MPa) (ADAPT 262.81, B7.2, C7)

Top fiber:

σ = (531.91*12000)/13315- 262.81
= 216.57 psi (1.49 MPa) < 636 psi (4.39 MPa)
(ADAPT 216.61, B7.5, C2)

Bottom fiber:

σ = (-531.91*12000)/4551- 262.81
= -1665.34 psi (-11.48 MPa) < -1800 psi
(ADAPT -1664.73, B7.5, C3)

4.3.1.9 Secondary Moments (Data Block 8.3)

The method used by ADAPT-PT for the calculation of secondary moments is described in Sections 2.3.1 and 5.6. The values from data block 8.3 are given in the following table.

TABLE 4.3.1-2 - HYPERSTATIC (SECONDARY MOMENTS) OF SPAN1

	k-ft (kN-m)	**Reference Number**
FIRST SPAN		
At left	302.75 (410.47)	B8.3, C2
At center	350.50 (475.32)	B8.3, C3
At right	398.33 (540.06)	B8.3, C4

Following the procedure outlined in Section 1 for the one-way slab and using the secondary reactions printed out in data block 7.6 of ADAPT-PT, it is verified that the ADAPT-PT secondary moments are the correct values.

4.3.1.10 Factored Moments and Reactions (Data Block 8.1)

This section provides the factored moments from the ADAPT-PT solutions.

Consider the verification of the moment at left of second support:

$1.2\ M_d$ = 1.2 * -830.50 = -996.60 k-ft (-1351.19 kNm)
$1.6\ M_l$ = 1.6 * -241.33 = -386.13 k-ft (-523.52 kNm)
$1.0\ M_{sec}$ = 1.0 * 398.33 = 398.33 k-ft (540.06 kNm)

M_u = $1.2\ M_d + 1.6\ M_l + 1.0\ M_{sec}$
= -984.40 k-ft (-1334.65 kNm) (ADAPT –984.40, B8.1, C6)

TABLE 4.3.1-3 FACTORED MOMENTS (k-ft)

	k-ft (kN-m)	Reference Number
First span		
At left	-349.38 (-473.69)	B8.1, C2
At center	1102.68 (1495.01)	B8.1, C4
At right	-984.40 (-1334.65)	B8.1, C6

4.3.1.11 Nonprestressed (Mild) Reinforcement (Data Block 10)

For the particular problem under consideration, the mild reinforcement required to supplement the post-tensioning is based either on the code requirements of minimum mild reinforcement, or the ultimate strength.

At critical locations of the beam, ADAPT-PT calculates the required steel for each of the governing criteria and also the minimum required. The computed values are tabulated and the largest is used in preparing the list of suggested rebar.

For a detailed review of the rebar calculation and verification refer to Section 5.8.

(i) Minimum Reinforcement

The minimum bonded reinforcement is A_s = 0.004*A, where A is the area of part of cross section between flexural tension face and center of gravity of gross section in mm^2.

For mid-span:

Y_b = Depth of neutral axis
= 26.83 in (681 mm) (B4.1, C4)
b = Width of section
= 14 in (356mm) (B2.1, C4)

A_s = 0.004*26.83*14
= 1.5 in2 (968 mm2) (ADAPT 1.5, B10.1.1, C7)

(ii) Ultimate Strength Requirement

At mid-span:

M_u = 1102.68 k-ft (1495.01 kN-m) (B8.1, C4)
P = 338.5 k (1505.72 kN) (B7.2, C2)
f_{se} = 175 ksi (1206 MPa), final average stress (B1)
A_{ps} = area of PT tendon
= 338.5/175 = 1.93 in^2

Span/depth ratio = 57*12/36 = 19 < 35

Hence, use ACI Equation (18-4).

b = 126 in (3200 mm) (B2.1,C6)
d_p = 36-3
= 33 in (838 mm)
ρ_p p for PT = $A_{ps}/b*d_p$
= 1.93/(126*33)
= 4.642*10-4
f'_c = 5000 psi (34 MPa) (B1)
f_{ps} = f_{se} + 10000 + $f'_c/(100*\rho_p)$ (ACI Equation 18 4)
f_{ps} = 175 + 10 + 5/(100*4.642*10-4)
= 292.71 ksi (2018.19 MPa)>{175+60= 235ksi}
So use f_{ps} =235 ksi (1620.28 MPa)

Area of the required rebar from the output of ADAPT-PT is 0.19 in^2 (B10.1.1, C7). The computations proceed by verifying that the calculated area is correct. Therefore, assume A_s = 0.19 in^2.

PT tension T_p = 1.93*235 = 453.55 k (2017.48 kN)
Rebar tension T_s = 0.19*60 = 11.4 k (26.69 kN)
Total tension T_u = 464.95 k (2044.17 kN)

a = Depth of compression zone
= $T_u/(0.85*b*f'_c)$
= [464.95 /(0.85*126*5)] = 0.87 in (22 mm)

d_r = 36-2-0.75/2
= 33.63 in (for #6 bar used)
$\phi*M_n$ = **[$T_p*(d_p-a/2) + T_s*(d_r-a/2)$]

ϕ*M_n = 0.9*[453.55(33 – (0.87/2)) + 11.4*(33.63-(0.87/2)]/12
= 1136.12 k-ft (1540.35 kN-m)
(ADAPT 1102.60 k-ft, B8.1,C4)

4.3.1.12 Shear Design (Data Block 12)

For the particular beam under consideration the magnitude of the induced shear stresses are low, to the extent that the design is governed by the maximum stirrup spacing of 24-inches. For detailed verification of beam shear design refer to Section 5-9.

The stirrup area and spacing are verified at X = 54.13 ft of the span 1:

D_p = 30.25 in (768mm) (PTCGS.DAT)
D = 36-2-0.75/2
= 33.63 in(854 mm) (B12, C3)
V_u = 130.07 kip (B12, C4)
M_u = 719.88 k-ft (B12, C5)
V_u *d_p/M_u = 130.07 *30.25/(719.88*12)
= 0.460< 1
v_{c1} = 0.6*(5000)1/2 + 700*0.46
= 364.43 psi (2.51 MPa)

{2*(f'c)1/2 = 141} < {vc1 = 364.43} < {5*(f'c)1/2 = 353.55}

Hence, maximum permissible value of 5*(f'$_C$) $^{1/2}$ governs.

v_u = V_u/(b*d_p)
= 130.07*1000/(14*30.25)
= 307.13 psi (1.90 MPa)

Stress ratio, v_u/*v_c = 307.13/0.75*353.55
= 1.16 (ADAPT 1.16, B12, C6)

For v_u >ϕ v_c , shear reinforcement is required.

A_v = (s* b_w *(v_u-ϕv_c)/ϕf_y
= 12* 14*(307.13-0.75*353.55)/(0.75*60000)
= 0.16 in^2/ft (101 mm^2/m)

A_{vmin} = 0.75*√f'$_c$*b_w*s/f_y > 50b_w*s/f_y
= 0.75*√5000*14*12/60000
= 0.15 in^2/ft>0.14 in^2/ft

A_{vmin} = $(A_{ps}*f_{pu}*s)/(80*f_y*d)*\sqrt{(d/b_w)}$
= $(1.93*270*12)/(80*60*30.25)*\sqrt{(30.25/14)}$
= 0.03 in^2/ft

So, Avmin = 0.16 in2/ft (101 mm2/m) (ADAPT 0.16 in2, B12, C7)

Select #5 with two legs:

2 * 0.31 =0.62 in^2 (400 mm^2)

hence,

Spacing = 0.62*12/0.16 = 46.5 in (1181 mm)

Maximum spacing = min (24 in or 0.75*h)
= min(24in , 27 in)

so,

s = 24 in. (610 mm) (ADAPT 23.62in, B12, C8)

4.3.2 Verification of SI Report

The metric version is verified by way of comparing its output with the American version. **Table 4.3.2-1** lists the critical values of the PTI T-beam for both the American and the metric version. Good agreement between the two versions is observed.

TABLE 4.3.2-1 - COMPARISON BETWEEN THE METRIC AND AMERICAN OUTPUTS OF ADAPT-PT FOR PTI T-BEAM EXAMPLE (PTI03M)

	Metric output		US output	Reference number
	[kN,m]	[kip,ft]	[kip,ft]	
DL Moment Span	612.42	451.70	451.72	B5.1, C4
DL Moment Support	-1222.90	-901.96	-902.12	B5.1, C5
LL Moment Span	177.96	131.26	131.27	B5.3, C4
LL Moment Support	-355.36	-262.10	-262.16	B5.3, C6
Required PT Span	1225.86	275.59	274.60	B7.4, C3
Required PT Support	670.57	150.75	149.02	B7.4, C4
Stress Bottom at Center	2.95	427.86	426.90	B7.5, C5
Stress Top at Center	-3.45	-500.39	-498.67	B7.5, C4
Secondary Moments	475.40	350.64	350.58	B8.3, C3
Rebar Bottom	966.60	1.50	1.50	B10.1.1, C5
Rebar Top	2336	3.62	3.65	B10.1.1, C2
Deflection DL+PT+CR	9.0	0.35	0.35	B14.1, C5

5 Specific Verification

5.1 Fixed End Moments of Non-prismatic Spans

When sections vary along the length of a span, ADAPT-PT computes the fixed end moments due to the applied loading with due consideration to the change in moment of inertia along the span length. This section:

- Demonstrates the correct calculation of the fixed end moments
- Provides additional information on the locations and magnitudes of moments of inertia along the span
- Describes the stiffness matrices used for each of the spans

Data on variations in moment of inertia and stiffness matrices are reported in the file (CS.DAT) that is generated in the subdirectory, where data is executed.

The verification is carried out for the numerical example given in the Post Tensioning Institute's booklet on *Design of Post-Tensioned Slabs*, Section 7.3, Two-Way Slab with Drop Panels.

The plan and typical elevations of the seven span slab example with drop panels are shown in **Figs 5.1-1** through **5.1-3**.

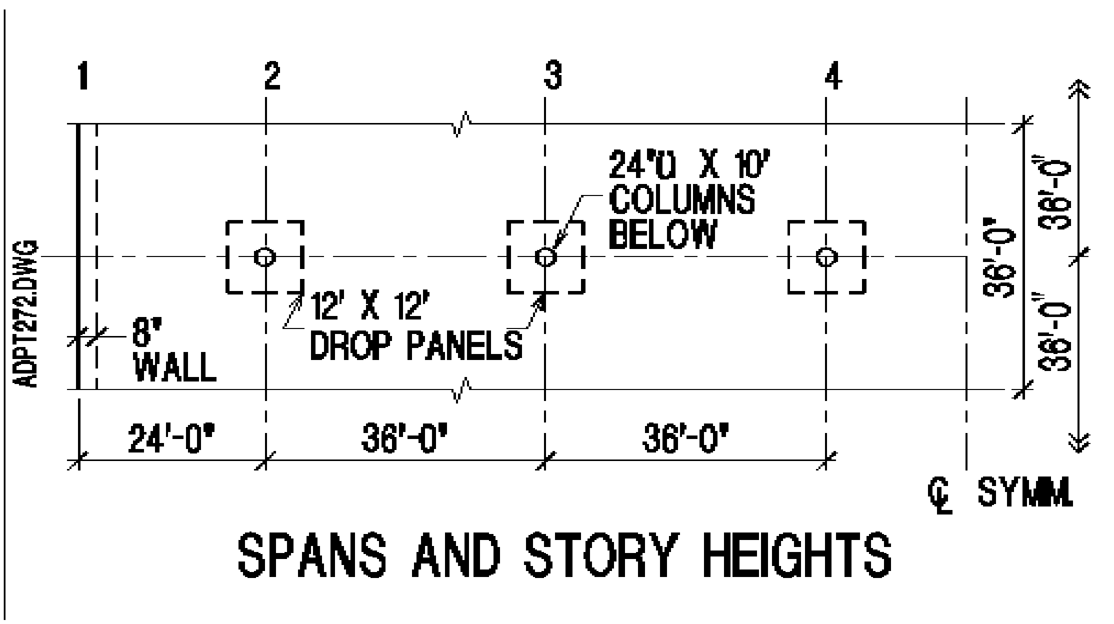


Figure 5.1-1

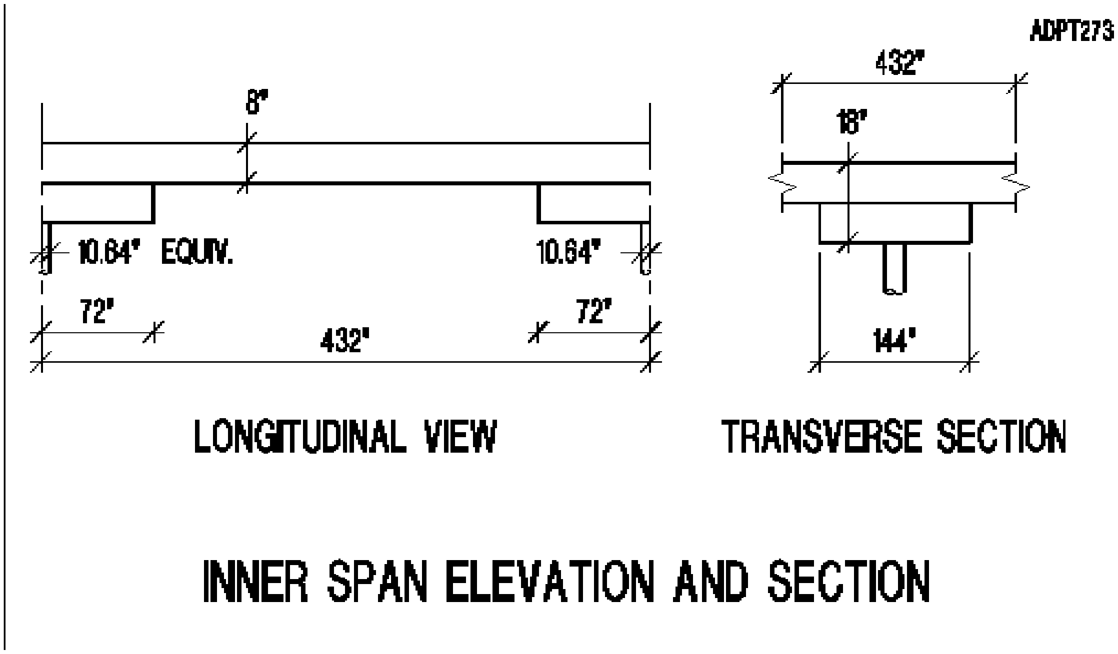


Figure 5.1-2

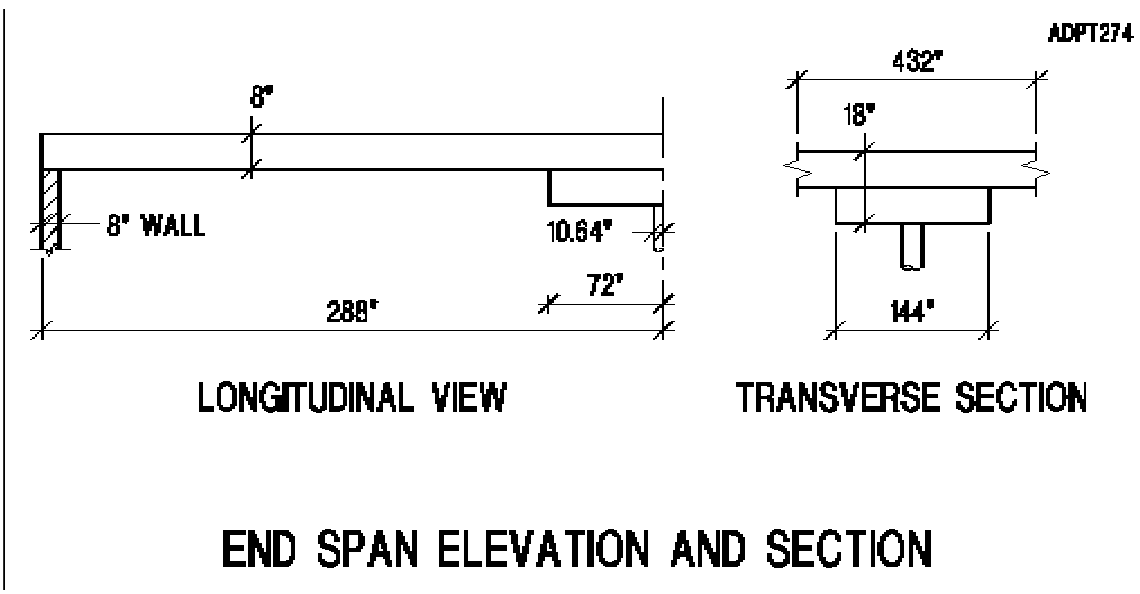


Figure 5.1-3

5.1.1 Fixed End Moments

For the specified live load of 0.10 k/ft^2 the calculated fixed end moments given by ADAPT-PT are:

TABLE 5.1-1 - LIVE LOADING FIXED END MOMENTS (units in k-in.)

Span	FEM-start	FEM-end
1	1600.657	-3366.100
2	5815.288	-5815.274
3	5815.288	-5815.274
4	5815.288	-5815.274
5	5815.288	-5815.274
6	5815.288	-5815.274
7	3366.650	-1600.656

L = 36 ft span length
w = 0.1 k/ft2. load intensity
FEM = Fixed End Moment (center line values)
$w*L^2$ = $0.1*36*36^2$ = 4665.6 k ft interior span
$FEM/(w*L^2)$ = 5815.10/(4665.6*12) = 0.1039 interior span
$FEM/(w*L^2)$ = 1597.60/(2073.6*12) = 0.0642 exterior span at A
$FEM/(w*L^2)$ = 3368.76/(2073.6*12) = 0.1355 exterior span at B

The comparisons of the fixed-end moment coefficients obtained from ADAPT-PT with other sources are given in Table 5.1-2.

TABLE 5.1-2 COMPARISONS OF FEM COEFFICIENTS

$FEM/(w*L^2)$	**PTI**	**ADAPT**	**SAP-IV**
Interior span	0.101	0.103	0.101
Exterior span - at A	0.061	0.064	0.064
at B	0.137	0.136	0.135

5.1.2 Variations in Moment of Inertia

A span with changes in cross section along its length is treated as a non-prismatic member. **Fig. 5.1-4** illustrates the general non-prismatic member geometry assumed for a typical span. The second moment of area of each section and the distance of a section from the support are reported in the file CS.DAT. For the above example, the values calculated are listed in **Table 5.1-3**.

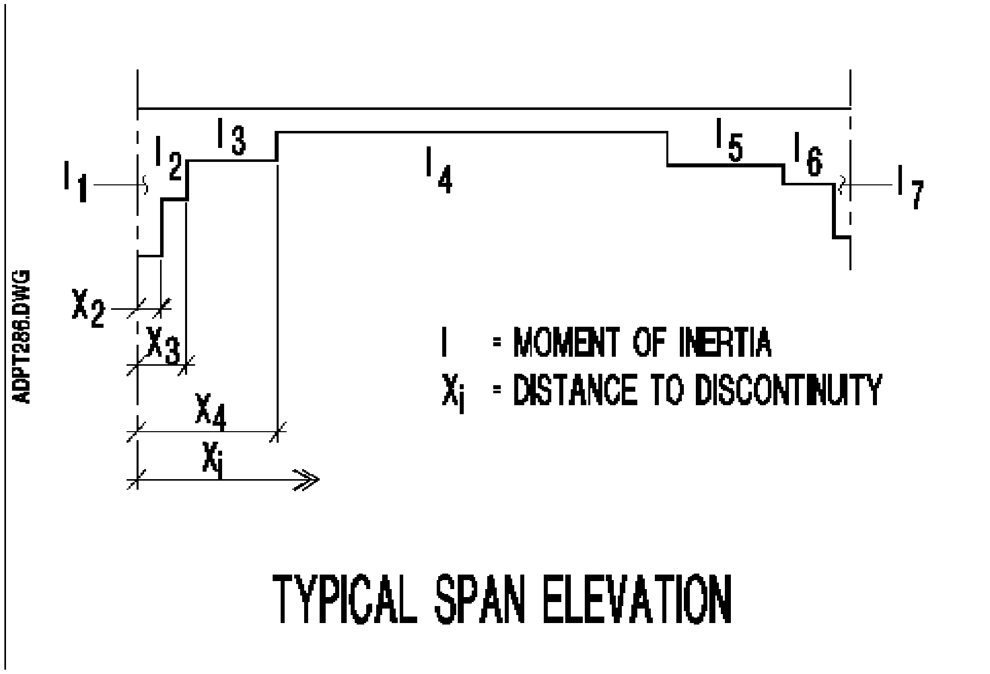


Figure 5.1-4

TABLE 5.1-3 VARIATION OF MOMENT OF INERTIA ALONG THE SPAN

I1	I2	I3	I4	I5	I6	I7
.4608E+06	.1843E+05	.1843E+05	.1843E+05	.1128E+06	.1128E+06	.1247E+06
.1247E+06	.1128E+06	.1128E+06	.1843E+05	.1128E+06	.1128E+06	.1247E+06
.1247E+06	.1128E+06	.1128E+06	.1843E+05	.1128E+06	.1128E+06	.1247E+06
.1247E+06	.1128E+06	.1128E+06	.1843E+05	.1128E+06	.1128E+06	.1247E+06
.1247E+06	.1128E+06	.1128E+06	.1843E+05	.1128E+06	.1128E+06	.1247E+06
.1247E+06	.1128E+06	.1128E+06	.1843E+05	.1128E+06	.1128E+06	.1247E+06
.1247E+06	.1128E+06	.1128E+06	.1843E+05	.1843E+05	.1843E+05	.4608E+06

X2	X3	X4	X5	X6	X7	X8
.4000E+01	.4000E+01	.4000E+01	.2160E+03	.2774E+03	.2774E+03	.2880E+03
.1063E+02	.1063E+02	.7200E+02	.3600E+03	.4214E+03	.4214E+03	.4320E+03
.1063E+02	.1063E+02	.7200E+02	.3600E+03	.4214E+03	.4214E+03	.4320E+03
.1063E+02	.1063E+02	.7200E+02	.3600E+03	.4214E+03	.4214E+03	.4320E+03
.1063E+02	.1063E+02	.7200E+02	.3600E+03	.4214E+03	.4214E+03	.4320E+03
.1063E+02	.1063E+02	.7200E+02	.3600E+03	.4214E+03	.4214E+03	.4320E+03
.1063E+02	.1063E+02	.7200E+02	.2840E+03	.2840E+03	.2840E+03	.2880E+03

Notes: Units are in inches, each line refers to one of the spans
Data extracted from data block (888 245) of file CS.DAT

5.1.3 Stiffness Coefficients and Carry Over Factors

The rotational stiffness coefficients generated and used by ADAPT-PT are summarized in a file called CS.DAT. The rotational stiffness matrix of each member is defined as:

$$E * \begin{vmatrix} S11 & S12 \\ S21 & S22 \end{vmatrix}$$

Where,

E = modulus of elasticity of the member

For the problem under consideration these are:

Span	S11	S12	S21	S22
1	.3305E+03	.2789E+03	.2789E+03	.6084E+03
2	.3721E+03	.2536E+03	.2536E+03	.3721E+03
3	.3721E+03	.2536E+03	.2536E+03	.3721E+03
4	.3721E+03	.2536E+03	.2536E+03	.3721E+03
5	.3721E+03	.2536E+03	.2536E+03	.3721E+03
6	.3721E+03	.2536E+03	.2536E+03	.3721E+03
7	.6084E+03	.2789E+03	.2789E+03	.3305E+03

Reproduced from data block 888 310 of CS.DAT file. Units are in^2.

For a typical interior span,

S11 = 372.1
S21 = 253.6

The corresponding values for a prismatic member with length L = 432 in., and mid-span I = 18432 in^4 are:

S11 = 4*I/L= 4*18432/432 = 170.67 in^3

For the interior span:

I = 18432 $in.^4$
L = 36*12 = 432 in.

The carry-over factor for the interior span is:

S21/11 = 0.68

The following table is a summary of carry-over factors from the three sources:

Carry-Over factor	PTI	ADAPT	SAP-IV
Interior span	0.68	0.68	0.68
Exterior span - at A	0.84	0.84	0.84
at B	0.44	0.46	0.46

Note: The coefficient for a prismatic member is 0.5.

5.2 Reduction of Moments to Face-of-Support

Moments computed from the matrix formulation refer to the structural system line (centerline of support). Spans, however, are commonly checked at the face-of-support. Thus centerline moments computed are adjusted to the face-of-support for design.

The face-of-support moment is calculated strictly from the statics of each span.

For a cantilever example, consider the right end of the two-way slab example given at the end of section 5.9 of this volume and identified as (MNL5-2M). The calculation for moment at face-of-support for dead loading is given below. The dimensions and loading are illustrated in **Fig 5.2-1(a)**.

Centerline moment:

M = 13.5*5.50*0.92/2 = 30.07 kNm (ADAPT 30.07,B5.1, C3 OK)

Note that the tributary of the cantilever is 5.50 m.

Moment at face-of-support:

M = 13.5*5.50* (0.9 - 0.2/2)2/2 = 23.76 kNm (ADAPT 23.76, B6.1, C3 OK)

For a span condition, consider the first span of the two-way system of Chapter 3, Volume 2 (case MNL5-2M). The pertinent parameters for the first span are extracted from the solution given in Chapter 3 and entered on **Fig. 5.2-1(b)**.

At left of span:

$M_{reduced}$ = 143.83*0.2/2 - 13.5*5.5*[(0.2/2)2/2] = 14.01 kNm (ADAPT 14.01,B6.1, C3)

At right of span:

$M_{reduced}$ = -400.42 + 283.11*0.225 - 13.5*5.50*0.2252/2
= -338.60 kNm (ADAPT 338.60,B6.1, C5)

At center:

Solution already includes added support stiffness adjustment.

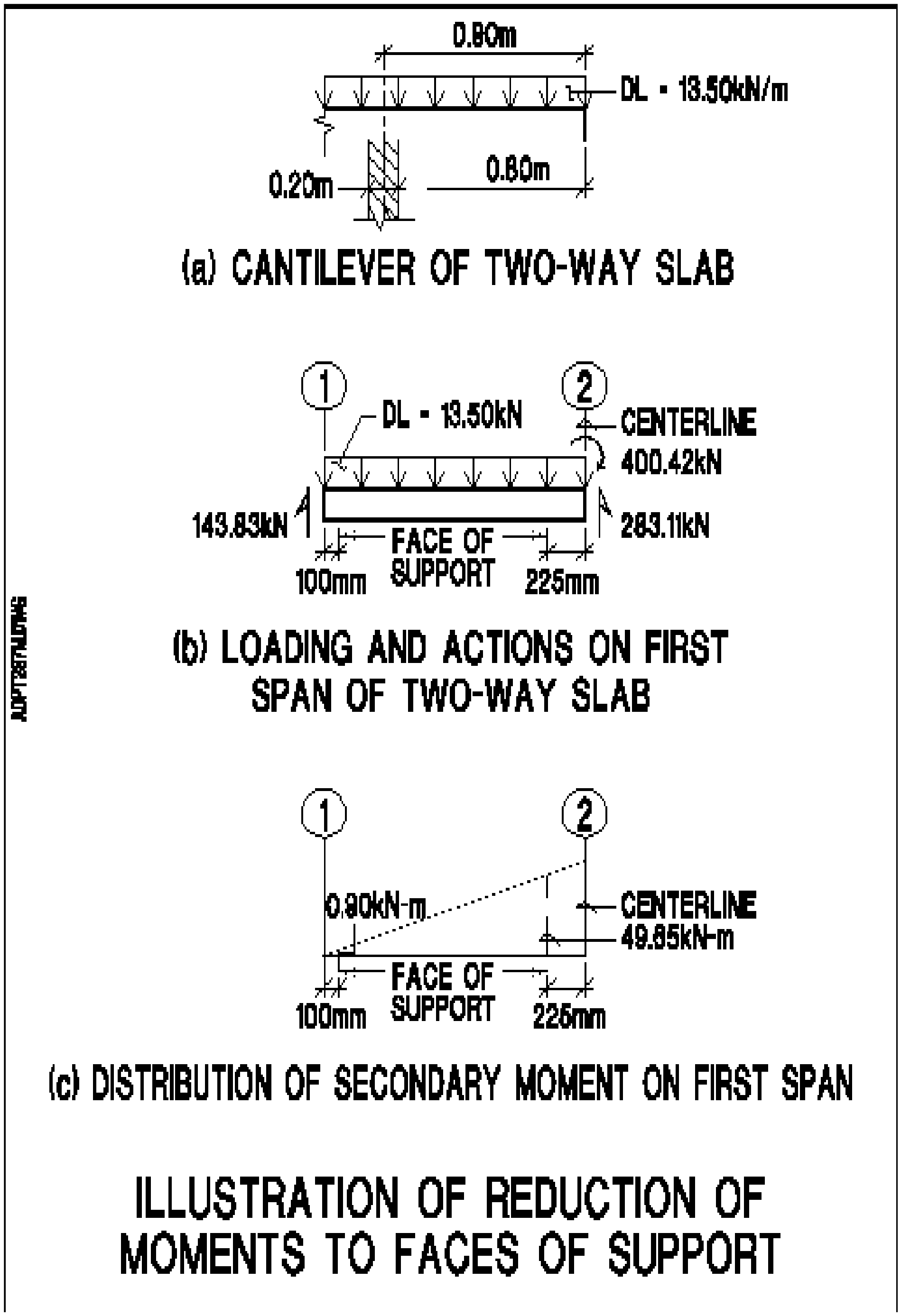

0.90m
DL = 13.50kN/m
0.20m
0.80m
(a) CANTILEVER OF TWO-WAY SLAB
1
2
DL = 13.50kN
CENTERLINE
400.42kN
143.83kN
283.11kN
FACE OF SUPPORT
100mm
225mm
(b) LOADING AND ACTIONS ON FIRST SPAN OF TWO-WAY SLAB
1
2
0.90kN-m
CENTERLINE
49.85kN-m
FACE OF SUPPORT
100mm
225mm
(c) DISTRIBUTION OF SECONDARY MOMENT ON FIRST SPAN
ILLUSTRATION OF REDUCTION OF MOMENTS TO FACES OF SUPPORT

Figure 5.2-1

TABLE 5.2-1 - ADJUSTMENT OF MOMENTS FOR A TWO-WAY SYSTEM (kNm)*

	ADAPT	Hand Calculation	Reference Number
First span			
Left	14.01	14.01	B6.1, C3
Right	-338.60	-338.60	B6.1, C5

*ADAPT-PT solution from Chapter 3, Volume II, case MNL5-2M

5.2.1 Secondary Moments

Secondary moments vary linearly from support to support. The magnitude at the face of support is determined from linear interpolation of centerline moments. Consider the secondary moments of the first span of the two-way system(MNL5-2M) given at the end of Section 5.9 of this chapter. Centerline secondary moments are listed in MSECSF.DAT file. See also **Fig. 5.2-1.**

M_{sec} at left of second support = -5.75*8.987
= -51.675 kNm (ADAPT 51.675, MSECSF.DAT)

At left of span:

$M_{reduced}$ = 51.675*(0.2/2)/5.75 = 0.90 kNm

At right of span:

$M_{reduced}$ = 51.675/5.75*(5.75 - 0.45/2) = 49.65 kNm

At center:

Solution already includes added support stiffness adjustment.

TABLE 5.2-2 - ADJUSTMENT OF SECONDARY MOMENTS (kNm)*

	ADAPT	Hand Calculation	Reference Number
First span			
Left	0.90	0.90	B8.3,C2
Right	49.65	49.65	B8.3,C4

*ADAPT-PT solution from Chapter 3, Volume II -case MNL5-2M

5.3 Balanced Loading

This section demonstrates:

- The correct generation of balanced loading by ADAPT-PT.
- The method and correct implementations of the average upward force (Wbal) reported by the program.

5.3.1 Generation of Balanced Loading

For each span the balanced loading is calculated from the geometry of the tendon and its force. **Fig. 5.3-1** illustrates the balanced loading for a reversed parabolic tendon. Observe that the loading consists of four partially distributed parts W1 through W4. Other profiles may involve concentrated loadings as it is described in Chapter 3, Analysis and Design Background, Volume II of the manual.

During the execution of the program, the force in a given span, as well as the tendon geometry may change from one iteration cycle to the next. Consequently, the values of the balanced loading forces will change between successive iterations. At the conclusion of the computations, ADAPT-PT records the final set of the balanced loading used in a text file (WBAL.DAT). Also it is provided in the detailed report under block 22.

In addition to the detailed set of balanced loading used in the computations, a representative value is also calculated for each span. This representative value is listed in the summary report. Its calculation and significance is discussed later in Section(B).

It is emphasized that in addition to the forces W1 through W4 shown in the **Fig. 5.3-1** from one tendon, a span may be subjected to balanced loads from other tendons. These may be due to added tendons that are anchored in the span or due to a shift in the neutral axis of the beam/slab at the supports or along the span length.

Consider the fourth span of the one-way slab example from Chapter 3, Volume 2 of ADAPT-PT manual. This example is identified by the code name (MNL5-1c). Excerpt from the ADAPT-PT printout is attached with this section.

The tendon profile used is a reversed parabola as shown in **Fig. 5.3-1** and indicated in (B7.1, C2). The parameters of this tendon are extracted from the report of ADAPT-PT, data blocks 7.1 and 7.2.

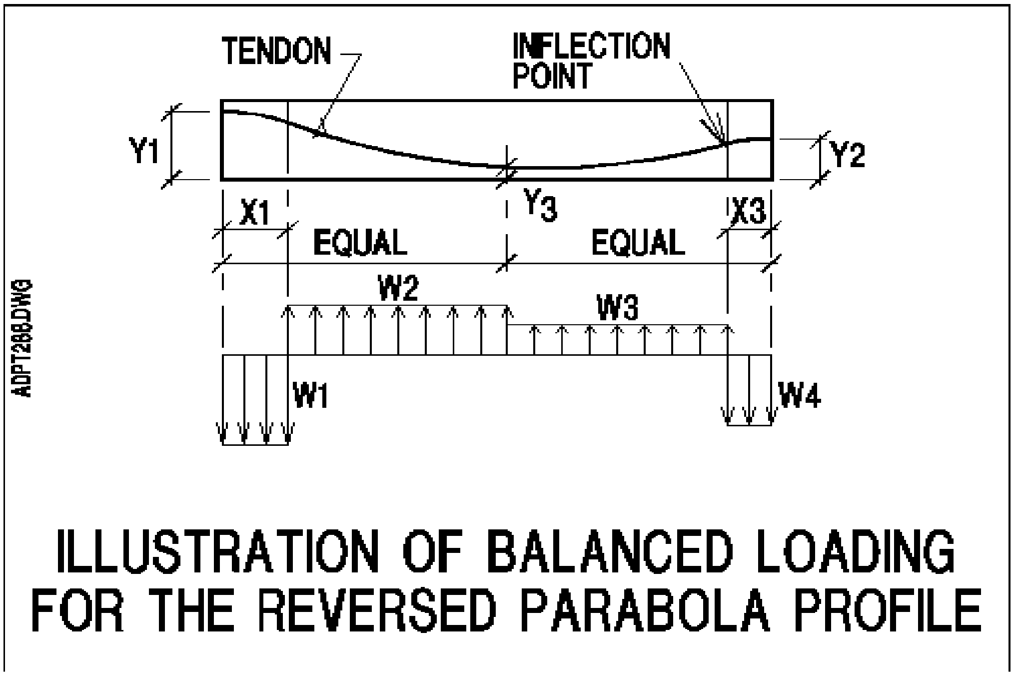


Figure 5.3-1

Force in tendon: F	= 500.00 kN	(B7.2,C2)
Span: L	= 9.00 m	(B2.1,C3)

Horizontal distances:

X1	= 0.1*9.00 = 0.90 m	(0.1 from B7.1, C2)
X3	= 0.1*9.00 = 0.90 m	

Vertical distances:

Y1	= 169 mm	(B7.2, C3)
Y2	= 100 mm	(B7.2, C6)
Y3	= 31 mm	(B7.2, C5)

The balanced loads W1 through W4 generated by ADAPT-PT are reproduced in the following from the balanced loading file:

W1

Total drape for left of span	= 169 - 31	
	= 138 mm	
Drape over length X1: a	= (0.9/4.5)*138	
	= 27.6 mm	
W1	= $2*F*a/X_12$	
	= $2*500*0.0276/0.9^2$	
	= 34.074 kN/m	(ADAPT 34.074 kN/m, B22, C3)

W2

a	= 138 - 27.6 = 110.4 mm
Length of curve	= 4.5 m - 0.9 m
	= 3.6 m
W2	= $2*500*0.1104/3.6^2$
	= 8.519 kN/m (ADAPT –8.519 kN/m, B22, C3)

W3

Total drape for right of span	= 100 - 31
	= 69 mm
a	= (3.6/4.5)*69
	= 55.2 mm
W3	= $2*500*0.0552/3.6^2$
	=4.259 kN/m (ADAPT –4.259 kN/m, B22, C3)

W4

a	= 69 - 55.2 = 13.8 mm
W4	= $2*500*0.0138/0.9^2$
	= 17.037 kN/m (ADAPT 17.037 kN/m, B22, C3)

Total upward force (due to W1 and W4):

Upward 34.074 *0.90 + 17.037 *0.90 = 46 kN

Total downward force:

Downward 8.519 *3.60 + 4.259 *3.60 = 46 kN

Sum of upward and downward forces:

46 - 46 = 0 OK

22 - POST-TENSIONING BALANCED LOADING

Span	Type	W	F	M	a	b
		kN/m	kN	kN-m	m	m
CL	3	-6.400			0.00	2.50
CL	2		16.00		0.00	
1	3	28.444			0.00	0.75
1	3	33.849			6.75	7.50
1	3	-7.111			0.75	3.75
1	3	-8.462			3.75	6.75
2	3	45.841			0.00	0.85
2	3	45.841			7.65	8.50
2	3	-11.460			0.85	4.25
2	3	-11.460			4.25	7.65
3	3	32.941			0.00	0.85
3	3	32.941			7.65	8.50
3	3	-8.235			0.85	4.25
3	3	-8.235			4.25	7.65
4	3	34.074			0.00	0.90
4	3	17.037			8.10	9.00
4	3	-8.519			0.90	4.50
4	3	-4.259			4.50	8.10
1	3	12.267			6.00	7.50
1	2		-18.40		6.00	
3	3	4.775			0.00	1.70
3	2		-8.12		1.70	

5.3.2 Average Balanced Loading

For a precise definition of the loads from post-tensioning, the table of balanced loading generated by ADAPT-PT and described in the preceding should be consulted.

For a quick estimate of the magnitude of the balanced loading, the concept of the AVERAGE BALANCED LOADING can be used. This is defined as the sum of all upward forces from post-tensioning divided by span length. The average balanced loading is reported under balanced loading "Wbal" in data block 7.2, column 8.

It is emphasized that the *average balanced loading* is not used in ADAPT-PT's computations. Its value is listed to provide a basis for approximate comparison.

Consider the example treated in the previous Section A. The total upward force is 46.00 kN. For the span length of 9.00 m, the average balanced loading is given by:

W_{bal} = 46.00/9.00 = 5.111 kN/m (ADAPT 5.111, B7.2, C8 OK)

5.4 Required Post-Tensioning Force

In addition to a detailed report, ADAPT-PT lists the post-tensioning force required at the critical locations in each span. The “post-tensioning force required” is defined as the minimum force necessary to meet the design criteria stated in the input data. These are:

- Limiting the maximum tensile stresses to a user pre-defined value.
- Providing a minimum average pre-compression.
- Limiting the percentage of dead load balanced to a pre-defined range.
- Limiting the maximum spacing between tendons to a pre-defined multiple of member thickness.

The following verifies the implementation of these criteria for the fourth span of the one-way slab example (MNL5-1C) given at the end of section 5.9 of this manual.

5.4.1 Based on Stress Criteria

The required post-tensioning computed by ADAPT-PT for the fourth span of the one-way example is 416.63 kN at in-span (B7.4, C3). This force is determined, such as to limit the maximum tensile stress under service condition to $0.5*(f'_c)^{1/2}$ (Data Block 1). The verification is carried out by assuming a force of 416.63 kN, and demonstrating that the resulting tensile stress is $0.50*(f'_c)^{1/2}$.

Tensile stress limit	$= 0.5*(28)^{1/2}$	
	$= 2.646$ N/mm^2	
Post tensioning	= 416.63 kN	
Cross sectional area A	$= 200.0*10^3$ mm^2	(B4.1, C2)
Section modulus S	$= 6.67*10^6$ mm^3	(B4.1, C3 & C4)
Combined dead and live moments M	= 57.47 kNm	(B6.1 &6.2, C4)
Post-tensioning force F	= 500 kN	(B7.2, C2)

The applicable post-tensioning moment M_b is determined by prorating the post-tensioning moment (–31.14 kNm (B7.6, C3)) for a force of 500 kN to the reported value of 416.63 kN.

M_b = -(416.63 /500)* 31.14
= -25.95 kNm

During the execution of the program the tendon heights and the forces of a span is likely to change with respect to other spans. Consequently, the required force calculated in one iteration cycle of the computation may be different from the force computed in the subsequent cycle. However, for the completed and reported output, as is the case in this verification, the proration is valid.

Stress = Average Compression + Bending Stresses
Stress = $-416.63*10^3/2.00*10^5 + [(57.47 - 25.95)*10^6]/6.67*10^6$
= 2.645 N/mm^2 (compare to 2.646 N/mm^2, OK)

5.4.2 Providing an Average Minimum Compression

For the same example as in (A), the minimum compression specified by the user is 0.85 N/mm^2 (B1). Hence,

Force required = Area * Average Compression
= 0.85*2.00*105
= 170 kN (ADAPT 170,B7.4, C6 OK)

5.4.3 Required Force Based on Tendon Spacing

The maximum tendon spacing specified is eight times the slab thickness (see data block 1). If each tendon consists of a minimum of one strand, the force required is:

Force per Tendon = Area * Effective Stress
Area of strand = 99 mm^2 (B1)

The effective stress is given as data input equal to 1200 N/mm^2 (B1).
Force per tendon = 99.0*1200
= 118.8 kN
Spacing = 8*200
= 1.60 m (slab thickness = 200 mm)
Force per meter = 118.8/1.6
= 74.25 kN/m

5.5 Service Stresses

Service stresses are due to dead load, live load and post-tensioning forces. For stress check, these are combined with a code or user defined factors. The factors selected for the combination are reported by the program in the Project Design Parameters and Load Combination of the concise report.

In the following the stresses at in-span and face-of-support of the two-way slab example (MNL5-2M) given at the end of section 5.9 of this manual are verified.

Fig. 5.5-1(a) shows the central span of the example under consideration. In addition to the face-of-support, ADAPT-PT calculates the stresses at 20 interval points along each span. At each interval point dead, live and post-tensioning moments are combined, and the sum is applied to the entire cross-section of tributary. In the case of the face-of-support, the default of the program is the actual face of column or the wall support. However, you have the option to override the program's default and specify a new distance. In either case, the selection is reported by ADAPT-PT in (B2.7,C2).

In the current example, the reported 450 mm support width means that the stress is checked at a distance of 450/2 = 225 mm from the support centerline (see figure). The largest value computed for the intervals in the support region is selected and reported by the program in data block 7.5.

It is emphasized that at each stress check location the actual cross section for the entire tributary (**Fig. 5.5-1(b)** and **Fig. 5.5-1(c)**) together with the applicable post-tensioning forces are considered. A tendon terminated in a span, as is indicated in the figure, is assumed to have continued and anchored beyond the next support at a distance of (span/5). Hence, the 1650 kN of post-tensioning specified for the third span of the example is taken as active when checking stresses at the right support of the second span. For the in-span and left support only 1238 kN are considered.

The axial component of the post-tensioning force is assumed to be acting at the centroid of the section. This is valid, since in ADAPT-PT moments arising from shifts in the centroidal axis of the section are accounted for. In this particular example the column caps have a different centroidal axis than the central regions of the slabs.

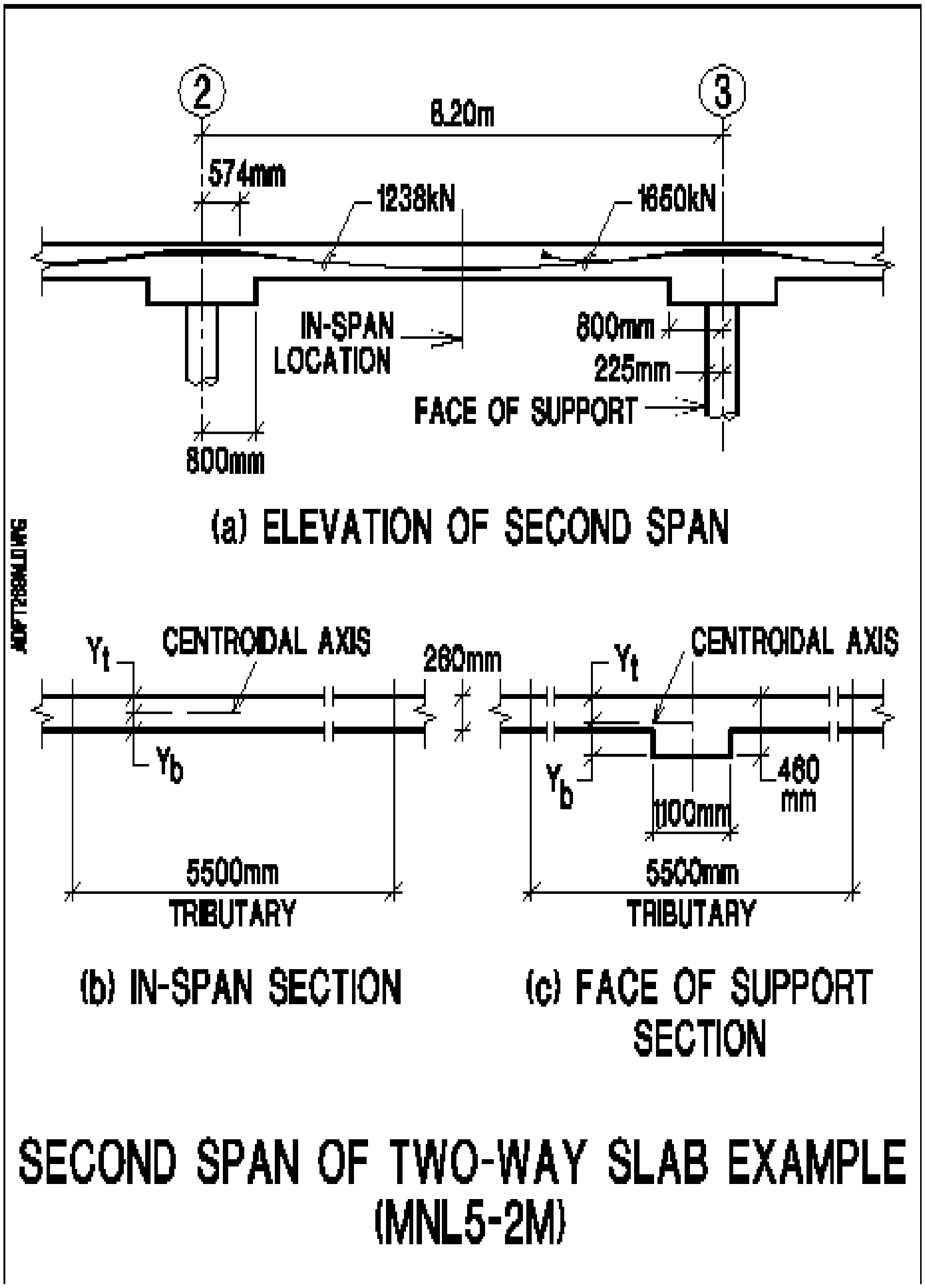

2
3
6.20m
574mm
1238kN
1650kN
IN-SPAN LOCATION
600mm
225mm
FACE OF SUPPORT
800mm
(a) ELEVATION OF SECOND SPAN
Yt
CENTROIDAL AXIS
Yb
260mm
460 mm
1100mm
5500mm TRIBUTARY
5500mm TRIBUTARY
(b) IN-SPAN SECTION
(c) FACE OF SUPPORT SECTION
SECOND SPAN OF TWO-WAY SLAB EXAMPLE (MNL5-2M)

Figure 5.5-1

TABLE 5.5-1 - STRESSES IN SECOND SPAN OF TWO-WAY SLAB EXAMPLE MNL5-2M

Description	**Span**	**Right Support**	**Reference Number***
GEOMETRY			
Area (mm^2)	$1.43*10^6$	$1.65*10^6$	B4.2, C3
Moment of inertia (mm^4)	$0.81*10^{10}$	$0.19*10^{11}$	B4.2, C4
Y_t (mm)	130	161	B4.2, C6
Y_b (mm)	130	299	B4.2, C5
MOMENTS			
Dead and live (kNm)	244.26	-576.80	B6.1 ,B6.2
Balanced (PT) (kNm)	-88.10	265.00	B7.6,C3-4
Net moment (kNm)	156.16	-311.80	
POST-TENSIONING FORCE			
P (kN)	1238	1650	B7.2, C2
STRESSES			
Axial P/A (N/mm^2)			
In-span = $1.238*10^6/1.43*10^6$ =	-0.866		B7.2,C7
Support = $1.65*10^6/1.65*10^6$=		-1.00	
Bending M*Y/I			
In-span			
$\pm 156.16*10^6*130/0.81*10^{10}$	$\pm$2.519		
Support			
$311.80*10^6*161/0.19*10^{11}$ =		2.656	
$-311.80*10^6*299/0.19*10^{11}$ =		-4.933	
Net stresses:			
In-span			

Top: -0.866 – 2.519=	-3.385		B7.5,C4
Bottom: -0.866 + 2.520 =	1.654		B7.5,C5
Support			
Top: -1.000 + 2.656=		1.656	B7.5,C6
Bottom: -1.000 – 4.912=		-5.933	B7.5,C7

*Abbreviation refers to data blocks and columns in ADAPT-PT printout of MNL5-2M, section 5.9

TABLE 5.5-2 - SUMMARY OF STRESS CALCULATIONS (N/mm^2)

Location	ADAPT	Hand Calculation	Reference Number
Top of in-span	-3.39	-3.39	B7.5,C4
Bottom of in-span	1.65	1.65	B7.5,C5
Top at support	1.65	1.66	B7.5,C6
Bottom at support	-5.95	-5.93	B7.5,C7

5.6 Secondary Moments

Secondary moments are the consequence of the support restraints to free movement of a member under prestressing. The background for the secondary moments is given in Chapter 3-Analysis and Design Background,Volume II of the manual. ADAPT-PT employs the direct definition of secondary actions (moments and shears), as stated above, when calculating the secondary moments.

In the following, first the direct method used in ADAPT-PT is verified using the two-way slab example (MNL5-2M). This is then checked against an alternative method. The method adopted by ADAPT-PT is more general and capable of extension to more complex applications.

Observe a typical frame as shown in Chapter 3,Volume II (**Fig. 3.8.2-1)**. The frame is acted upon by dead load, live load and forces exerted by the post-tensioning tendon. **Fig. 3.8.2-2** shows the free body diagram of the beam/slab member of the frame due to the post-tensioning forces only. In the free body diagram shown, by definition, the actions at the supports are the secondary actions, since these are the actions induced by the post-tensioning tendon. Hence, at any distance Xi, as shown in **Fig. 3.8.2-3**, the secondary shear is the algebraic sum of all reactions, and the secondary moment is the moment of all actions. The governing relationship is expressed in the figure.

The secondary actions of the two-way slab example are quoted from ADAPT-PT report (data block 7.6) and entered in **Fig. 5.6-1**.

The secondary actions constitute a self-equilibrating force system. Verify the validity of the solution by the sum of reactions being zero.

Sum of reactions = 8.987 - 8.976 - 9.017 + 9.006 = 0.0 kN (OK)

Likewise, the sum of moments of the secondary action must be zero.

Moment at left of support 2:

M_{sec} = 8.987*5.75 = 51.675 kNm

At right of support 2:

M_{sec} = 51.675 - 9.837 = 41.838 kNm

The remainders of the moments are calculated from the right of the frame to reduce accumulation of errors due to numerical computations.

The secondary moments given in ADAPT-PT are reduced to the face-of-support if dead and live moments are also reduced. The reduction to face is by proration, since the secondary moments vary linearly from support to support.

Secondary moment at left of support 3:

M_{sec} = 41.93 + [(0.45/2)/8.20]*(41.84 - 41.93) = 41.93 kNm (ADAPT 41.93, B8.3, C4, OK)

Secondary moment at mid-length of second span:

M_{sec} = 0.5*(41.84 + 41.93) = 41.89 kNm (ADAPT 41.88, B8.3, C3, OK)

Using the alternative method, the secondary moments at the locations used in the preceding are recalculated in the following:

$M_{sec} = M_{bal} - P*e$

At center of first span:

M_{bal} = -104.10 kNm (B7.6, C3)
P = 1238 kN (B7.2, C2)
e = 25 - 130 = -105 mm (B7.2,C3-4)
Note that eccentricity above neutral axis is taken as positive.

M_{sec} = -104.10 + 1238*105/1000 = 25.89 kNm (ADAPT 25.84, 8.3, C3, OK)

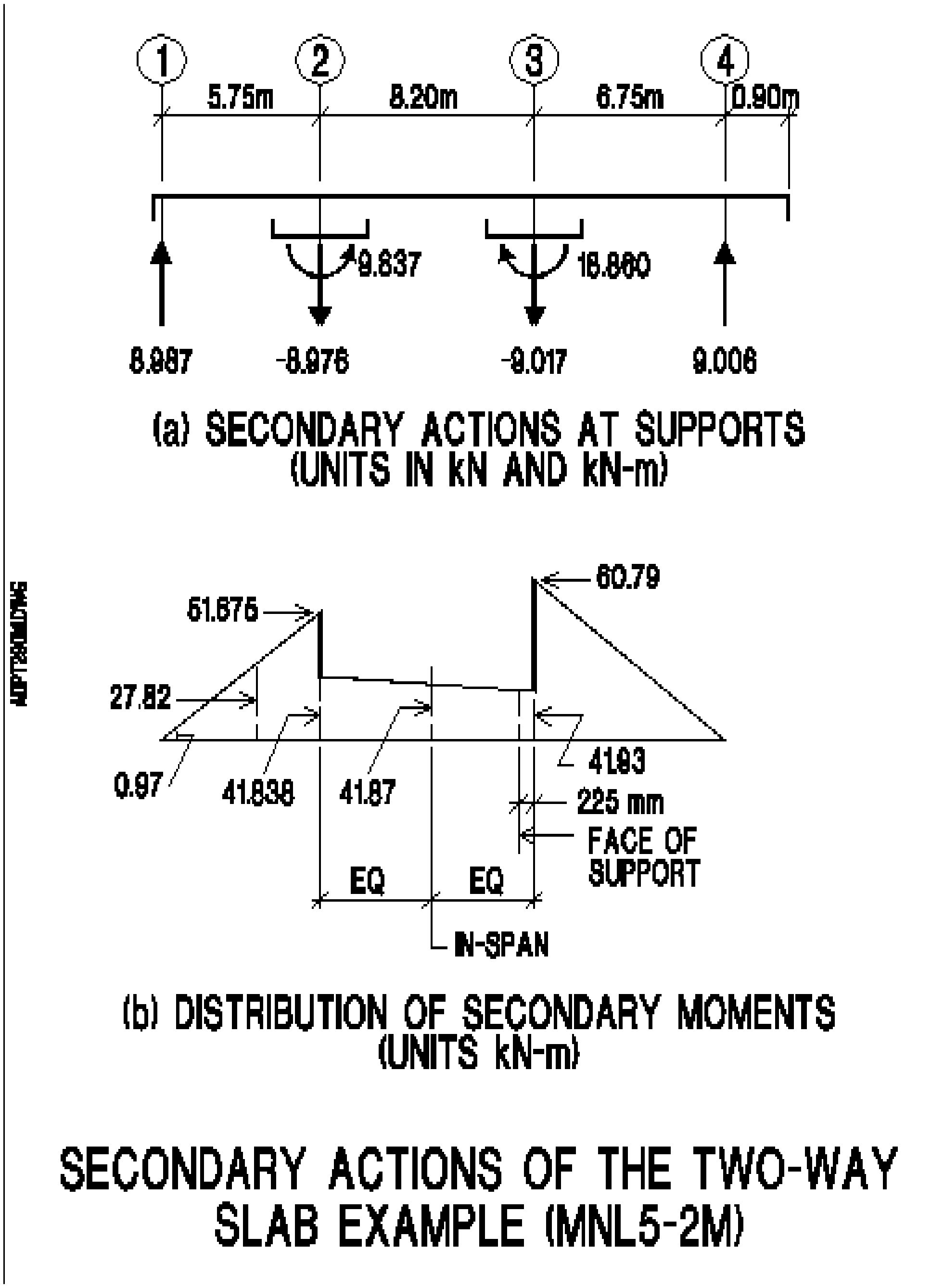


Figure 5.6-1

At the left of third support:

M_{bal} = 265.00 kNm (B7.6, C4)

The file PTBMSF.DAT is generated by ADAPT-PT contains the distribution of post-tensioning moments and shears. The moment of 265.00 kNm given in the output (B7.6, C4) is already reduced to face-of-support.

P	= 1650 kN	(B7.2, C2)
e	= 235 + 200 – 299.33	
	= 135.67 mm	(B7.2,C5, B4.2,C4)
M_{sec}	= 265.00 - 1650*135.67/1000	
	= 41.14 kNm	(ADAPT 41.93, Fig. 5.6-1)

5.7 Factored Moments and Design Moments

In the terminology of ADAPT-PT factored moments and design moments are synonymous and use the symbol M_u. The program checks and satisfies the following requirement.

Demand Moment <= Design Capacity

Depending on the building code specified, in the calculation of design capacity, the program uses “strength reduction factor ϕ “ or material factors. For the ACI version, the relationship used is:

$M_u <= \phi * M_n$

where,

M_u = factored moment
M_n = nominal moment, defined as the ultimate moment a section can develop
ϕ = code specified strength reduction factor

Using ACI318, factored moments are computed from the following relationship:

$M_u = 1.2*M_d + 1.6*M_l + 1.0*M_{sec}$

The factors 1.2, 1.6 and 1.0 are the default values used by ADAPT-PT. However, the user may select his/her own factors. Also user can enter unto four load combinations. Factors used in the computations, regardless whether they are ADAPT-PT's default values or user's selection, are given in the concise report under block A. Data block 8 gives the envelope of all the combinations. The moments for each combination are reported in BLK10.DAT file in the subdirectory, where data was executed.

The calculated design moments are listed in block 8. The values listed are based on gross cross-section and linear elastic material properties. Hence they are the elastic *design moments*.

The following is the calculation of factored moments for the three-span beam example (MNL5-3M) given at the end of section 5.9 of this manual.

TABLE 5.7-1 - CALCULATION AND COMPARISON OF DESIGN MOMENTS (kNm)

Moments	Hand Calculation	ADAPT	Reference Number
First span moment			
M_d = 1.2*746.40	895.68		B6.1,C4
M_l = 1.6*213.30	341.28		B6.2,C4
M_{sec} = 1.0*372.50	372.50		B8.3,C3
M_u = (sum of the above)	1609.46	1609.46	B8.1,C4
Second support (left side)			
M_d = 1.2*-1066	-1279.20		B6.1,C4
M_l = 1.6*-304.60	-487.36		B6.2,C6
M_{sec} = 1.0*612.40	612.40		B8.3,C4
M_u = (sum of the above)	-1154.16	-1154.16	B8.1,C6

Values are from example MNL5-3M

5.8 Mild Reinforcement

5.8.1 Reinforcement Required for Strength

ADAPT-PT checks the reinforcement requirements at 1/20th points along each span, in addition to the face-of-supports. At each location, the design capacity of the design section is first calculated. If the capacity does not equal or exceed the design moment, the program calculates the reinforcement necessary to cover the shortfall. The reinforcement calculated is reported under the columns marked with "Ultimate" referring to ultimate strength rebar (data blocks 10.1 through 10.2 of printout).

Herein, the first field and the second support rebar of the beam example MNL5-3M are verified. Refer the example and the ADAPT-PT report given at the end of the section 5.9 of this chapter. The geometries of the field and support sections and the locations of the post-tensioning and rebar are extracted from the input data of Chapter 3 and shown in **Fig. 5.8-1**.

5.8.1.1 ACI Strength Requirements

(i) At Support

M_u = -1154.16 kNm (B8.1,C6)
P = 1660 kN, post tensioning force (B7.2,C2)
f_{se} = 1200 N/mm^2, final average stress (B1)
A_{ps} = area of PT tendon
= 1660 *1000/1200 = 1383 mm^2
which is 14 strands 12.7 mm diameter,
99 mm^2 each = 1386 mm^2

Span/depth ratio = 20*1000/900 = 22.22 < 35

Hence, use ACI Equation (18-4)

b = 460 mm (B2.1,C4)
d_p = 900 - 56
= 844 mm (at centerline of the column
(PTCGS.DAT)

d_p(face-of- support) = 819 mm (From linear interpolation)

ρ_p for PT = A_{ps}/b*d_p = 1383/(460*819)
= 3.67*10-3
f'_c = 30 N/mm^2 (B1)
f_{ps} = f_{se} + 70 + f'_c/(100*ρ_p) (ACI Equation 18 4)
= 1200 + 70 + 30/(100*3.67*10-3)
= 1351.68 N/mm^2 < {1200 + 400 = 1600 N/mm^2} OK

Area of the required rebar from the output file of ADAPT-PT is 0 mm^2. The report gives the envelope of rebar from strength and UBC requirement. The computations proceed by verifying that the calculated area is correct. Therefore, assume A_s= 0 mm^2

PT tension T_p = 1383*1351.68 = 1869.37 kN
Rebar tension T_s = 0
Total tension T_u = 1869.37 kN

a = Depth of compression zone
= T_u/(0.85*b*f'_c)
= [1869.37/ (0.85*460*30)]*1000
= 159 mm

c = 159/0.85
= 188 mm
d_r = 900 - 50 -8
= 842 mm (for 16 mm bar used)
c/d_r = 188/842 = 0.22 <0.375, hence ϕ = 0.9

ϕ*Mn = ϕ*[T_p*(d_p-a/2) + T_s*(d_r-a/2)]

ϕ*Mn = 0.9*[1869.37 *(819 - 159/2)]/1000
= 1244.16 kNm (ADAPT 1154.16 kNm, B8.1, C6)

(ii) At In-Span

M_u = 1609.46 kNm (B8.1, C4)
P = 1660 kN, post tensioning force (B7.1, C2)

f_{se}, A_{ps} and the applicable ACI equation are same as at support.

b = 5190 mm (B2.1,C6)
d_p = 820 mm
ρ for PT = A_{ps}/b*d_p
= 1383/(5190*820)
= 3.25*10-4
f_{ps} = 1200 + 70 + 30/(100*3.25*10-4)
= 2193.08 N/mm^2 > {1200 + 400 = 1600 N/mm^2},

Hence, use f_{ps} = 1600 N/mm^2

Area of the required rebar from the output of ADAPT-PT is 0 mm^2 (from Section 29, X=10m). Therefore, assume A_s = 0 mm^2.

PT tension T_p = 1383*1600 = 2212.80 kN
Rebar tension T_s = 0 kN
Total tension T_u = 2212.80 kN

a = 2212.80*1000/(0.85*5190*30)
= 16.72 mm < 120 mm OK
c = 16.72 /0.85 = 19.67 mm
d_r = 900 - 50 -8
= 842 mm (for 16 mm bar used)
c/d_r = 19.67/842 = 0.023 <0.375, hence ϕ = 0.9

ϕ*M_n = 0.9*[2212.80*(820 – 16.72/2)]/1000
= 1616.40 kNm (ADAPT 1609.46, B8.1, C4)

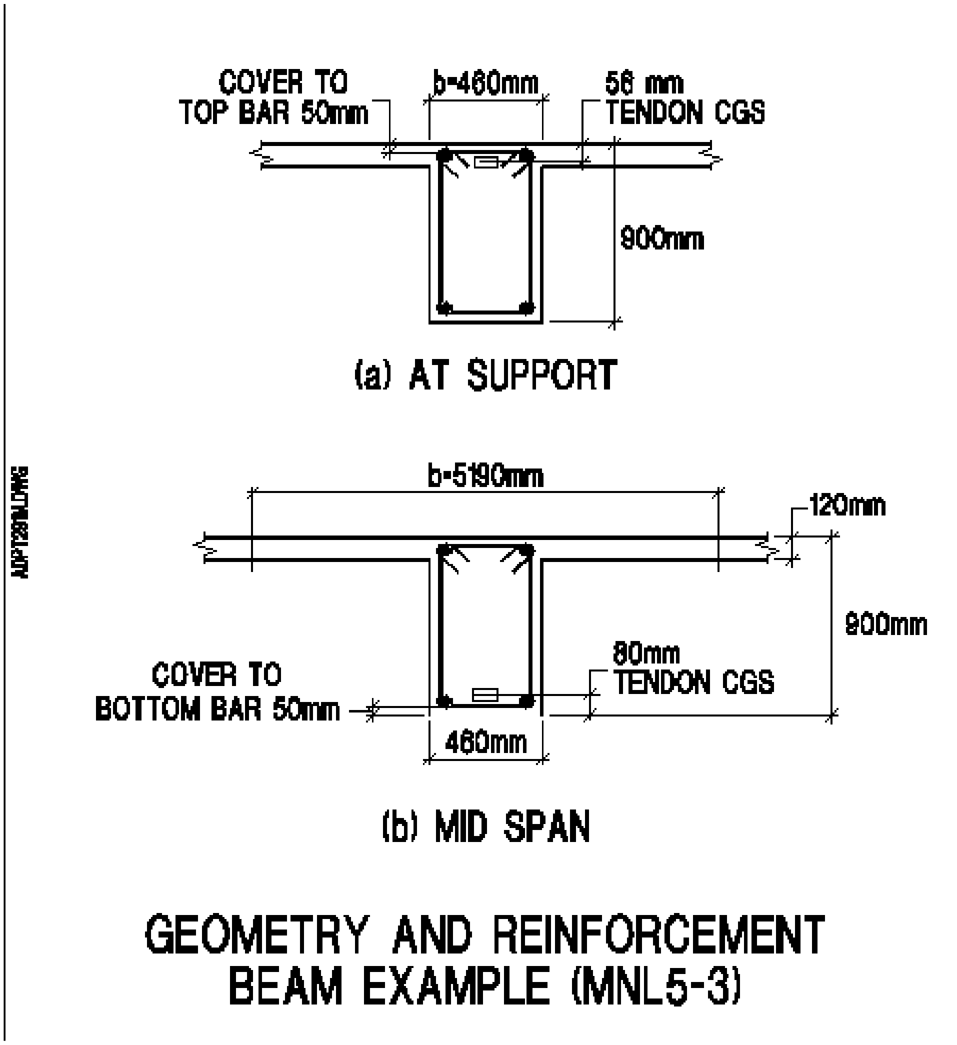


Figure 5.8-1

5.8.1.2 UBC's Strength Requirement

UBC –1997 Section 2618 requires that one-way slabs and beams reinforced with unbonded post-tensioning be designed to develop a nominal capacity (M_n) to carry their self-weight plus 25 percent of unreduced live loading by means other than the primary post-tensioning, using a strength reduction factor of 1. This option may be suppressed by users, where UBC does not apply.

The reinforcement calculated by ADAPT-PT for the in-span location of the first span of beam under consideration is 2466 mm^2 (B10.1.1, C6). The following is the verification of this reinforcement. The reinforcement calculated for this requirement will be reported under column "Ultimate" in the report.

Demand:

M_d = 746.40 kNm (B6.1,C4)
M_l = 213.30 kNm (B6.2,C4)
M_u = $1*M_d + 0.25*M_l$
= 799.73 kNm

Provided:

T_s = 2322*460 = 1068.12 kN
d_r = 842 mm (from preceding Section A)
b = 5190 mm
a = 1068.12*103/(0.85*5190*30)
= 8.07 mm < 120 mm (OK)
ϕM_n = 0.9*1068.12*(842 – 8.07/2)
= 805.54 kNm Required M_u= 799.73 kNm OK

ϕ is 1 for UBC, but conservatively program using 0.9.

5.8.2 Code Specified Minimum Reinforcement

Prestressed members made with unbonded tendons are checked for the minimum mild reinforcement stipulated in respective codes. The requirements are different for the one-way and two-way systems. Herein the values obtained for the one-way beam example (MNL5-3M) and the two-way system example (MNL5-2M) (Examples given in the section 5.9 of this manual) are verified.

Minimum reinforcement over the supports is generally provided at the top, since this is the face where tension commonly occurs. Where loading and span conditions cause tension at bottom, ADAPT-PT reports the minimum rebar at the bottom. The test used by the program for the location of minimum rebar at the supports is the sign of the governing design moment M_u (B8.1).

5.8.2.1 One-way system

Consider the beam example MNL5-3M. The minimum bonded reinforcement is $A_s = 0.004*A$, where A is the area of part of cross section between flexural tension face and center of gravity of the section in mm^2. For minimum rebar calculation, the section associated with bending of the member is used. The section is based on effective width-not the entire tributary.

(i) For In-Span

Y_b = Depth of neutral axis = 589.44 mm (B4.1, C7)
b = Width of section = 460 mm (B2.1,C4)
A_s = 0.004*589.44*460
= 1084.57 mm^2 (ADAPT 1085, B10.1.1, C7 OK)

(ii) Over the Support

Y_t = Depth of neutral axis
= 310.56 mm (B4.1, C8)

Width of flange	= 2380 mm	(B2.3, C2)
Width of web	= 460 mm	(B2.1,C4)
Flange thickness	= 120 mm	(B2.1, C7)

A = 2380*120 + 460*(310.56 - 120)
= 373,258 mm^2
A_s = 0.004*373258
= 1493 mm^2 (ADAPT 1493, B10.1.1, C7, OK)

5.8.2.2 Two-Way System

(i) Over the Support

The area of steel required is A_s = 0.00075 * A_{cf}

where,

A_{cf} is the larger gross cross-sectional area of the design strips of the two orthogonal slab frames intersecting at the column in question.

A_{cf} may be calculated by multiplying the average of two adjacent spans in one direction by the average slab thickness of the corresponding design strip in the other direction. This calculation is done for both directions and the larger value from the two directions is chosen for design.

Consider the second support of two-way example MNL5-2M:

h = slab thickness = 260 mm (B2.1,C5)
L_1 = average of backward and forward spans in feet
= 0.5*(5.75 + 8.20) (orthogonal direction)
= 6.975 m
L_2 = 0.5*(2.50 + 3.0) = 2.75 m

A_s = 0.00075 * A_{cf}
= 0.00075*260*6975
= 1360.125 mm2 (ADAPT 1360, B10.1.1, C7 OK)

(ii) Field

The field minimum rebar is required if tensile stress under working condition is more than $0.166*(f'_c)^{1/2}$. The tensile force N_c generated in the tensile block is to be carried by mild reinforcement using the following relationship:

A_s = $N_c/(0.5*f_y)$

Consider the second span of the two-way slab example MNL5-2M:

Tensile stress at bottom= 1.65 N/mm^2 (B7.5, Env-2,C5)
1.65 > $\{0.166*(f'_c)^{1/2}$= $0.166*(28)^{1/2}$ = 0.878 N/mm$^2\}$

Hence, the rebar required.

Compression stress at top = -3.39 N/mm^2 (B7.5, Env-2, C4)

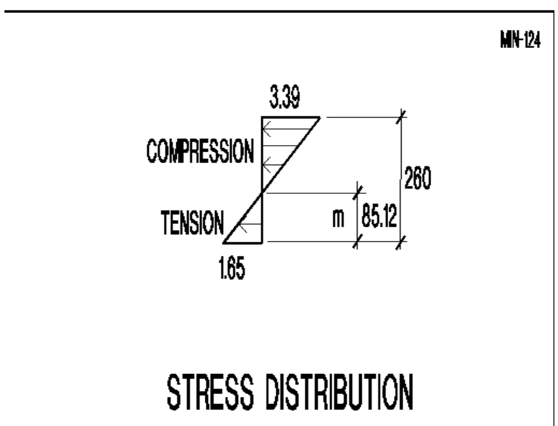


Figure 5.8.2-1

Depth of neutral axis from bottom **(Fig.5.8.2-1)**:

1.65*260/(1.65 + 3.39) = 85.12 mm

N_c = 85.12*1.65*5.5/2 = 386.23 kN (for 5.50 m)
A_s = 386232/(0.5*460)
= 1679 mm^2 (ADAPT 1675 mm2, B29, C6)

5.9 Beam Shear

In the following, the one-way shear for the first span of the beam example (MNL5-3M) of this section is verified.

The factored moments and shears used in the determination of stirrup requirements are given at 20th points along each span in data block 12 columns 4 and 5. Consider the moments and shears of span one at distances X = 0.18 and X = 19.76 m from the left support. These are the face-of support locations.

Note that ACI code recommends checking shear stresses from a distance h/2 (1/2 of depth of member) from the face-of-support. But the program calculates the shear stress at each 1/20th points along the span regardless of the ACI recommendation. Obviously, the 20th point divisions used by the program would not necessarily coincide with h/2 distance from the face-of-support. Where considered critical, the user should follow the checking procedure outlined in the following for the h/2 distance.

Using the previous calculations, the stirrup area and spacing are verified at X = 19.76 m:

d_p = 844 mm(at centerline of the column)
d_p(face-of- support) = 819 mm (From linear interpolation) (B7.2,C6)
V_u*d_p/M_u = 509.7*819/(1166*1000) (B12, C4-5)
= 0.358 < 1,
v_{c1} = $0.0498*(30)^{1/2} + 0.358*4.826 = 2N/mm^2$

$\{0.166*(f'_c)^{1/2} = 0.87\} < \{v_{c1} = 2\ N/mm^2\} < \{0.412*(f'_c)^{1/2} = 2.18\}$

Hence, v_{c1} governs.

V_u = $V_u/(**b* d_p)$
= 509.70*1000/(0.75*819*460)
= 1.80 N/mm^2

Stress ratio v_u/v_c = 1.80/2.00 = 0.90

$V_{c/2} < v_u < v_c$

Minimum reinforcement is required.

'A_v' is the minimum of the following:

A_v = $(s*0.33*b_w)/f_y$
= (1000*0.33*460)/ 460
= 330 mm^2
A_v = $s*A_{ps}/(80* (f_y/f_{pu})*d*(b_w/d)0.5)$
= 1000* 1383/(80 *(460/ 1860) * 819*(460/ 819)^0.5)

= 113.88 mm^2

A_v = s*b_w*$f'_c{}^{0.5}$/16*f_y

= 1000*460 *30 0.5/ (16* 460)

= 342 mm^2

∴ Av = 113.88 mm^2 (ADAPT 113.90 mm2, B12, C7)

Select 16 mm with two legs:

2 * 199 = 398 mm^2

Hence,

Spacing = 398*1000/ 113.90 = 3494 mm

Maximum spacing = 600mm or 0.75*h = 0.75* 900 = 675 mm

So s = 600 mm (ADAPT 600 mm, B12, C8)

TABLE 5.9-1 - SHEAR STRESSES AND THE REQUIRED STIRRUPS FOR BEAM EXAMPLE MNL5-3M

Description	**X = 0.18**	**X = 19.76 m**	**Reference Number**
Dead load moments (M_d)	-121.80	-1066.00	B6.1, C3, C5
Live load moments (M_l)	-34.79	-304.60	B6.2, C2, C6
Secondary moments (M_{sec})	131.10	612.40	B8.3, C2,C4
M_u = 1.2M_d+1.6M_l+M_{sec} =	-70.72	-1154.16	
From ADAPT-PT output[considered 1% increase]:	-71.40	-1166.00	B12, C5
Dead load shear (V_d)	-225.90	322.40	section_fc_dup.dat
Live load shear (V_l)	-64.54	92.10	-do-
Secondary shear (V_{sec})	-24.58	-24.58	B7.6, C5, C6
V_u = 1.2V_d+1.6V_l+V_{sec} =	-398.92	509.66	
From ADAPT-PT output:	-398.90	509.70	B12, C4

Note: Units are in kN-m, kN unless noted otherwise.

Example of One-way Slab, Canadian Code &SI units (MNL5-1C)

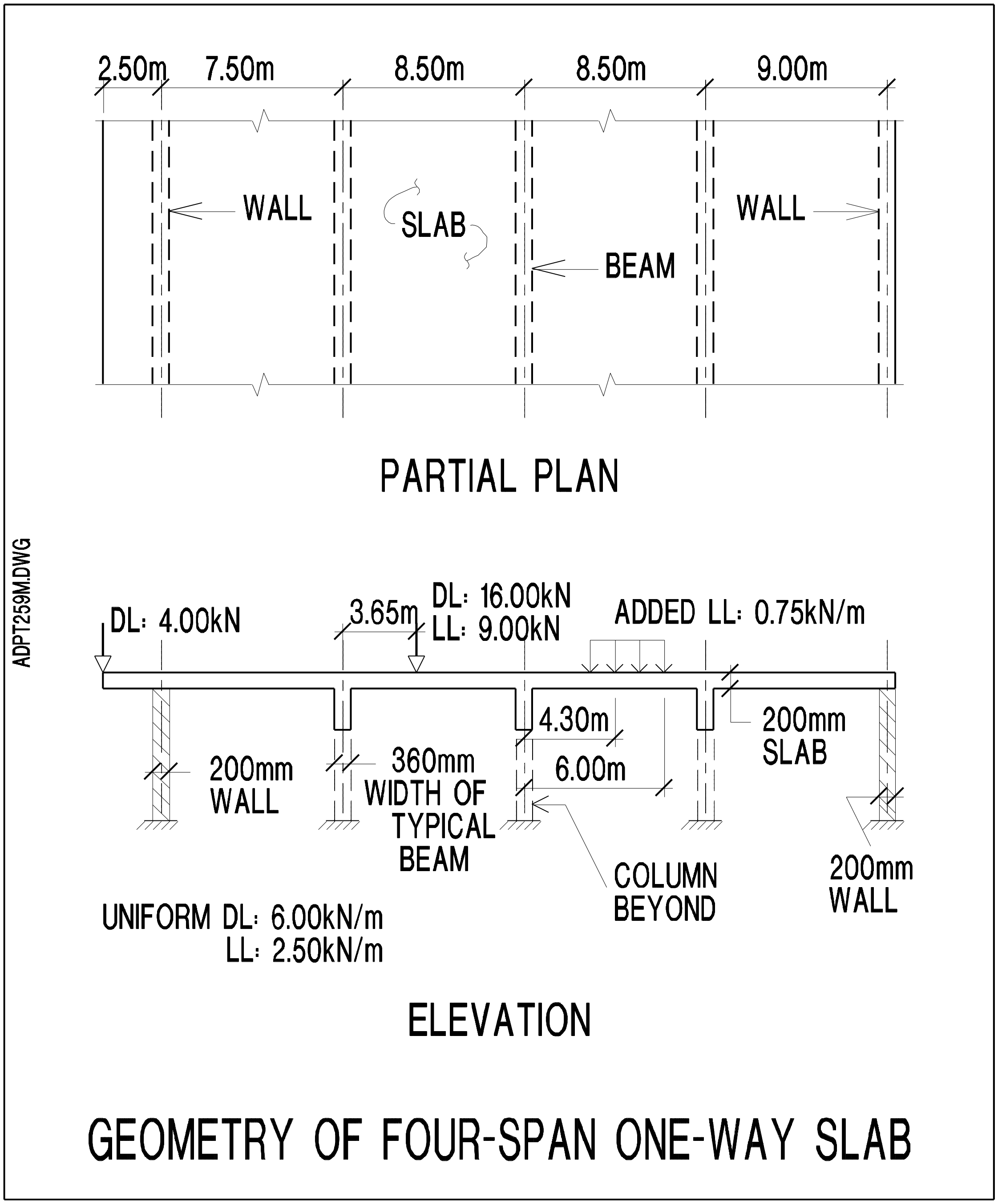


Figure 5.9-1

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		SYSTEM	UNBONDED
F'c for BEAMS/SLABS	28.00 N/mm 2	Fpu	1860.00 N/mm 2
Ec for BEAMS/SLABS	25968.00 N/mm 2	Fse	1200.00 N/mm 2
CREEP factor	2.00	Strand area	99.000 mm 2
CONCRETE WEIGHT	NORMAL	Min CGS from TOP	31.00 mm
Tension stress limits / (f'c)1/2		Min CGS from BOT for interior spans	31.00 mm
At Top	0.500	Min CGS from BOT for exterior spans	31.00 mm
At Bottom	0.500	Min average precompression	0.85 N/mm 2
Compression stress limits / f'c		Max spacing / slab depth	8.00
At all locations	0.450	Analysis and design options	
Reinforcement		Structural system	ONE-WAY
Fy (Main bars)	460.00 N/mm 2	Moment of Inertia over support is	NOT INCREASED
Fy (Shear reinforcement)	460.00 N/mm 2	Moments reduced to face of support	YES
Minimum Cover at TOP	15.00 mm	Moment Redistribution	NO
Minimum Cover at BOTTOM	15.00 mm	DESIGN CODE SELECTED	Canadian-CSA04 (2004)
Post-tensioning			

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		m	mm	mm	mm	mm	mm	mm	mm		
C	1	2.50	1000	200					200	0.50	0.50
1	1	7.50	1000	200					200	0.50	0.50
2	1	8.50	1000	200					200	0.50	0.50
3	1	8.50	1000	200					200	0.50	0.50
4	1	9.00	1000	200					200	0.50	0.50

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	mm	m	mm	mm			m	mm	mm		
1	200.0	0.0	0.0	0.0	100	(1)					
2	360.0	0.0	0.0	0.0	100	(1)					
3	360.0	0.0	0.0	0.0	100	(1)					
4	360.0	0.0	0.0	0.0	100	(1)					
5	200.0	0.0	0.0	0.0	100	(1)					

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			kN/m2	kN/m	kN/m	m	m	m	kN	kN-m
CANT	LL	U	2.500							
CANT	SDL	U	6.000							
CANT	SDL	C				2.500			4.000	
1	LL	U	2.500							
1	SDL	U	6.000							
2	LL	U	2.500							
2	LL	C				3.650			9.000	
2	SDL	U	6.000							

2	SDL	C				3.650			16.000	
3	LL	U	2.500							
3	LL	P	0.750			4.300	6.000			
3	SDL	U	6.000							
4	LL	U	2.500							
4	SDL	U	6.000							

NOTE: LIVE LOADING is SKIPPED with a skip factor of 1.00

3.2 Compiled loads

Span	Class	Type	P1	P2	F	M	A	B	C	Reduction Factor
			kN/m	kN/m	kN	kN-m	m	m	m	%
CL	LL	U	2.500							0.000
CL	SDL	U	6.000							
CL	SDL	C			4.000		2.500			
1	LL	U	2.500							0.000
1	SDL	U	6.000							
2	LL	U	2.500							0.000
2	LL	C			9.000		3.650			0.000
2	SDL	U	6.000							
2	SDL	C			16.000		3.650			
3	LL	U	2.500							0.000
3	LL	P	0.750				4.300	6.000		0.000
3	SDL	U	6.000							
4	LL	U	2.500							0.000
4	SDL	U	6.000							

4 - CALCULATED SECTION PROPERTIES

4.1 Section Properties of Uniform Spans and Cantilevers

Span	Area	I	Yb	Yt
	mm2	mm4	mm	mm
CANT	200000.00	0.67E+09	100.00	100.00
1	200000.00	0.67E+09	100.00	100.00
2	200000.00	0.67E+09	100.00	100.00
3	200000.00	0.67E+09	100.00	100.00
4	200000.00	0.67E+09	100.00	100.00

5 - MOMENTS, SHEARS AND REACTIONS

5.1 Span Moments and Shears (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right	Shear Left	Shear Right
		kN-m	kN-m	kN-m	kN	kN
CANT	SW	-----	-----	0.00	-----	0.00
1	SW	0.00	0.00	0.00	0.00	0.00
2	SW	0.00	0.00	0.00	0.00	0.00
3	SW	0.00	0.00	0.00	0.00	0.00
4	SW	0.00	0.00	0.00	0.00	0.00
CANT	SDL	-----	-----	-28.75	-----	19.00
1	SDL	-28.75	5.71	-44.20	-20.44	24.56
2	SDL	-44.20	39.66	-43.25	-34.74	32.26
3	SDL	-43.25	9.05	-47.02	-25.06	25.94
4	SDL	-47.02	37.24	0.00	-32.22	21.78
CANT	XL	-----	-----	0.00	-----	0.00

1	XL	0.00	0.00	0.00	0.00	0.00
2	XL	0.00	0.00	0.00	0.00	0.00
3	XL	0.00	0.00	0.00	0.00	0.00
4	XL	0.00	0.00	0.00	0.00	0.00

5.2 Reactions and Column Moments (Excluding Live Load)

Joint	Load Case	Reaction	Moment Lower Column	Moment Upper Column
		kN	kN-m	kN-m
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
4	SW	0.00	0.00	0.00
5	SW	0.00	0.00	0.00
1	SDL	39.44	0.00	0.00
2	SDL	59.30	0.00	0.00
3	SDL	57.32	0.00	0.00
4	SDL	58.17	0.00	0.00
5	SDL	21.78	0.00	0.00
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00
4	XL	0.00	0.00	0.00
5	XL	0.00	0.00	0.00

5.3 Span Moments and Shears (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN	kN
CL	-----	-----	-----	-----	-7.81	-----	-----	6.25
1	-7.81	0.00	14.55	-11.34	-25.69	-5.09	-9.74	12.80
2	-25.69	-5.09	25.71	-7.12	-25.97	-4.96	-17.74	16.24
3	-25.97	-4.96	15.65	-10.94	-23.76	-5.65	-13.52	13.61
4	-23.76	-5.65	20.23	-4.98	0.00	0.00	-13.89	10.12

5.4 Reactions and Column Moments (Live Load)

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	15.99	5.31	0.00	0.00	0.00	0.00
2	30.54	9.03	0.00	0.00	0.00	0.00
3	29.76	8.90	0.00	0.00	0.00	0.00
4	27.50	9.63	0.00	0.00	0.00	0.00
5	10.12	-1.11	0.00	0.00	0.00	0.00

6 - MOMENTS REDUCED TO FACE OF SUPPORT

6.1 Reduced Moments at Face of Support (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right
		kN-m	kN-m	kN-m
CANT	SW	-----	-----	0.00
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
4	SW	0.00	0.00	0.00

CANT	SDL	-----	-----	-26.88
1	SDL	-26.74	5.71	-39.88
2	SDL	-38.04	39.66	-37.54
3	SDL	-38.84	9.05	-42.45
4	SDL	-41.32	37.24	2.15
CANT	XL	-----	-----	0.00
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00
4	XL	0.00	0.00	0.00

6.2 Reduced Moments at Face of Support (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
CL	-----	-----	-----	-----	-7.20	-----
1	-7.91	0.84	14.55	-11.34	-23.43	-3.50
2	-22.54	-5.08	25.71	-7.11	-23.09	-4.97
3	-23.58	-3.40	15.65	-10.94	-21.35	-4.06
4	-21.30	-5.53	20.23	-4.99	-0.11	1.00

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile
Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
CL	1	---	---	0.000	---
1	1	0.100	0.500	0.100	---
2	1	0.100	0.500	0.100	---
3	1	0.100	0.500	0.100	---
4	1	0.100	0.500	0.100	---

7.2 Selected Post-Tensioning Forces and Tendon Drape
Tendon A

Span	Force	CGS Left	CGS C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	kN	mm	mm	mm	mm	MPa	kN/-	
CL	400.000	100.00	---	---	150.00	2.00	6.400	84
1	400.000	150.00	---	50.00	169.00	2.00	6.229	104
2	600.000	169.00	---	31.00	169.00	3.00	9.168	116
3	500.000	169.00	---	50.00	169.00	2.50	6.588	110
4	500.000	169.00	---	31.00	100.00	2.50	5.111	85

Approximate weight of strand: 124.7 Kg

7.4 Required Minimum Post-Tensioning Forces

	Based on Stress Conditions			Based on Minimum P/A		
Type	Left	Center	Right	Left	Center	Right
	kN	kN	kN	kN	kN	kN
CL	-----	-----	207.03	-----	-----	170.00
1	204.62	33.61	422.24	170.00	170.00	170.00
2	396.50	496.47	404.61	170.00	170.00	170.00
3	420.25	96.00	402.91	170.00	170.00	170.00
4	393.13	416.63	0.00	170.00	170.00	170.00

7.5 Service Stresses (tension shown positive)
Envelope of Service 1

Span	Left Top	Left Top	Left Bot	Left Bot	Center Top	Center Top	Cetner Bot	Cetner Bot	Right Top	Right Top	Right Bot	Right Bot

	Max-T	Max-C	Max-T	Max-C	Max-T	Max-C	Max-T	Max-C	Max-T	Max-C	Max-T	Max-C
	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
CL	-----	-----	-----	-----	-----	-----	-----	-----	-----	-0.73	-----	-3.59
1	-----	-1.01	-----	-3.38	0.33	-0.84	-----	-4.33	-----	-3.60	-----	-3.30
2	-----	-3.81	-----	-2.97	-----	-4.45	-----	-3.02	-----	-3.71	-----	-3.11
3	-----	-3.61	-----	-3.30	-----	-1.55	-----	-4.65	-----	-2.04	-----	-3.74
4	-----	-2.13	-----	-3.58	-----	-4.33	-----	-1.81	-----	-2.87	-----	-2.18

Envelope of Service 2

Span	Left Top Max-T	Left Top Max-C	Left Bot Max-T	Left Bot Max-C	Center Top Max-T	Center Top Max-C	Cetner Bot Max-T	Cetner Bot Max-C	Right Top Max-T	Right Top Max-C	Right Bot Max-T	Right Bot Max-C
	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
CL	-----	-----	-----	-----	-----	-----	-----	-----	0.35	-0.73	-----	-4.35
1	0.21	-1.10	-----	-4.21	1.52	-2.36	-----	-5.52	-----	-3.23	-----	-5.76
2	-----	-3.28	-----	-5.34	-----	-7.15	1.15	-3.77	-----	-3.19	-----	-5.53
3	-----	-3.25	-----	-5.77	0.80	-3.19	-----	-5.80	0.98	-1.62	-----	-5.98
4	0.81	-1.55	-----	-5.81	-----	-6.45	1.45	-2.33	-----	-2.97	-----	-2.20

7.6 Post-Tensioning Balance Moments, Shears and Reactions

Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN	kN
CL	-----	-----	18.43	-----	15.36
1	19.92	-17.82	44.90	-0.58	-0.58
2	44.98	-37.69	43.75	0.15	0.15
3	43.93	-20.10	40.62	-0.43	-0.43
4	40.54	-31.14	-0.01	0.75	0.75

Reactions and Column Moments

Joint	Reaction	Moment Lower Column	Moment Upper Column
	kN	kN-m	kN-m
1	0.580	0.000	0.000
2	-0.731	0.000	0.000
3	0.582	0.000	0.000
4	-1.179	0.000	0.000
5	0.748	0.000	0.000

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
CL	-----	-----	-----	-----	-44.40	-----
1	-45.23	-32.10	31.14	-7.70	-80.75	-50.86
2	-77.04	-50.85	91.85	42.61	-78.47	-51.28
3	-80.78	-50.50	39.69	-0.20	-78.43	-52.51
4	-77.00	-53.35	80.26	42.44	2.59	4.26

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	73.87	57.85	0.00	0.00	0.00	0.00

2	119.20	86.93	0.00	0.00	0.00	0.00
3	116.87	85.58	0.00	0.00	0.00	0.00
4	112.78	85.98	0.00	0.00	0.00	0.00
5	43.15	26.31	0.00	0.00	0.00	0.00

8.3 Secondary Moments

Span	Left	Midspan	Right
	kN-m	kN-m	kN-m
1	0.06	2.17	4.25
2	4.32	3.71	3.09
3	3.14	4.90	6.65
4	6.60	3.37	0.07

Note: Moments are reported at face of support

10 - MILD STEEL - NO REDISTRIBUTION

10.1 Required Rebar

10.1.1 Total Strip Required Rebar

Span	Location	From	To	As Required	Ultimate	Minimum
		m	m	mm2	mm2	mm2
CL	TOP	0.13	2.50	300.00	245.30	300.00
1	TOP	0.00	1.13	300.00	245.40	300.00
1	TOP	2.63	4.88	300.00	0.00	300.00
1	TOP	6.00	7.50	300.00	291.90	300.00
2	TOP	0.00	1.27	311.90	311.90	300.00
2	TOP	2.98	5.53	300.00	0.00	300.00
2	TOP	7.22	8.50	300.00	292.10	300.00
3	TOP	0.00	1.70	311.90	311.90	300.00
3	TOP	2.98	5.53	300.00	0.00	300.00
3	TOP	6.80	8.50	300.00	282.10	300.00
4	TOP	0.00	1.35	300.00	299.30	300.00
4	TOP	3.15	4.05	300.00	0.00	300.00
4	TOP	7.65	9.00	300.00	0.00	300.00
1	BOT	1.50	5.63	300.00	245.40	300.00
2	BOT	1.70	6.80	311.90	311.90	300.00
3	BOT	2.13	6.38	300.00	246.80	300.00
4	BOT	1.80	9.00	300.00	299.30	300.00

10.2 Provided Rebar

10.2.1 Total Strip Provided Rebar

Span	ID	Location	From	Quantity	Size	Length	Area
			m			m	mm2
CL	1	TOP	0.00	2	10	31.50	200.00
4	2	TOP	7.20	3	10	1.80	300.00
CL	3	TOP	1.33	2	10	30.18	200.00
1	4	BOT	0.83	2	10	5.48	200.00
2	5	BOT	0.97	2	10	6.56	200.00
3	6	BOT	1.40	2	10	5.70	200.00
4	7	BOT	1.05	2	10	7.96	200.00
1	8	BOT	1.58	1	10	4.36	100.00
2	9	BOT	1.82	2	10	4.86	200.00
3	10	BOT	2.25	1	10	4.00	100.00
4	11	BOT	1.95	1	10	6.00	100.00

10.2.2 Total Strip Steel Disposition

Span	ID	Location	From	Quantity	Size	Length
			m			m
CL	1	TOP	0.00	2	10	2.50
CL	3	TOP	1.33	2	10	1.18
1	1	TOP	0.00	2	10	7.50
1	3	TOP	0.00	2	10	7.50
2	1	TOP	0.00	2	10	8.50
2	3	TOP	0.00	2	10	8.50
3	1	TOP	0.00	2	10	8.50
3	3	TOP	0.00	2	10	8.50
4	1	TOP	0.00	2	10	4.50
4	2	TOP	7.20	3	10	1.80
4	3	TOP	0.00	2	10	4.50
1	4	BOT	0.83	2	10	5.48
1	8	BOT	1.58	1	10	4.36
2	5	BOT	0.97	2	10	6.56
2	9	BOT	1.82	2	10	4.86
3	6	BOT	1.40	2	10	5.70
3	10	BOT	2.25	1	10	4.00
4	7	BOT	1.05	2	10	7.96
4	11	BOT	1.95	1	10	6.00

10.3 Base Reinforcement
10.3.1 Isolated bars
10.3.2 Mesh Reinforcement

12 - SHEAR REINFORCEMENT

12.1 Shear Calculation Envelope

CL

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.00	0.00	179.40	5.00	-0.00	0.05	0.00	0.00
0.05	0.13	179.40	6.40	-0.69	0.06	0.00	0.00
0.10	0.25	179.40	7.82	-1.50	0.07	0.00	0.00
0.15	0.38	179.40	9.22	-2.43	0.08	0.00	0.00
0.20	0.50	179.40	10.63	-3.47	0.10	0.00	0.00
0.25	0.63	179.40	12.03	-4.64	0.11	0.00	0.00
0.30	0.75	179.40	13.45	-5.92	0.12	0.00	0.00
0.35	0.88	179.40	14.85	-7.32	0.14	0.00	0.00
0.40	1.00	179.40	16.25	-8.84	0.15	0.00	0.00
0.45	1.13	179.40	17.65	-10.47	0.16	0.00	0.00
0.50	1.25	179.40	19.07	-12.23	0.17	0.00	0.00
0.55	1.38	179.40	20.47	-14.10	0.19	0.00	0.00
0.60	1.50	179.40	21.88	-16.10	0.20	0.00	0.00
0.65	1.63	179.40	23.28	-18.21	0.21	0.00	0.00
0.70	1.75	179.40	24.70	-20.44	0.22	0.00	0.00
0.75	1.88	179.40	26.10	-22.79	0.24	0.00	0.00
0.80	2.00	179.40	27.50	-25.25	0.25	0.00	0.00
0.85	2.13	179.40	28.90	-27.84	0.26	0.00	0.00
0.90	2.25	179.40	30.32	-30.54	0.28	0.00	0.00
0.95	2.38	179.40	31.72	-33.36	0.29	0.00	0.00
0.96	2.40	179.40	32.00	-33.94	0.29	0.00	0.00

SPAN 1

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.01	0.10	179.40	-39.61	-32.42	0.36	0.00	0.00

0.05	0.38	179.40	-36.52	-22.34	0.33	0.00	0.00
0.10	0.75	179.40	-32.30	-9.97	0.29	0.00	0.00
0.15	1.13	179.40	-28.09	0.80	0.26	0.00	0.00
0.20	1.50	179.40	-23.87	9.98	0.22	0.00	0.00
0.25	1.88	179.40	-19.64	17.55	0.18	0.00	0.00
0.30	2.25	179.40	-15.42	23.53	0.14	0.00	0.00
0.35	2.63	179.40	-11.21	27.90	0.10	0.00	0.00
0.40	3.00	179.40	-6.99	30.68	0.06	0.00	0.00
0.45	3.38	179.40	2.92	31.86	0.03	0.00	0.00
0.50	3.75	179.40	7.14	31.45	0.06	0.00	0.00
0.55	4.13	179.40	11.35	29.44	0.10	0.00	0.00
0.60	4.50	179.40	15.57	25.83	0.14	0.00	0.00
0.65	4.88	179.40	19.79	20.60	0.18	0.00	0.00
0.70	5.25	179.40	24.02	13.80	0.22	0.00	0.00
0.75	5.63	179.40	28.22	5.39	0.26	0.00	0.00
0.80	6.00	179.40	32.45	-4.61	0.30	0.00	0.00
0.85	6.38	179.40	36.67	-16.21	0.33	0.00	0.00
0.90	6.75	179.40	40.89	-29.26	0.37	0.00	0.00
0.95	7.13	179.40	45.10	-43.38	0.41	0.00	0.00
0.98	7.32	179.40	47.30	-51.37	0.43	0.00	0.00

SPAN 2

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.02	0.18	179.40	-67.86	-51.36	0.62	0.00	0.00
0.05	0.42	179.40	-65.11	-41.22	0.59	0.00	0.00
0.10	0.85	179.40	-60.33	-17.10	0.55	0.00	0.00
0.15	1.27	179.40	-55.55	5.37	0.51	0.00	0.00
0.20	1.70	179.40	-50.76	25.78	0.46	0.00	0.00
0.25	2.13	179.40	-45.98	45.23	0.42	0.00	0.00
0.30	2.55	179.40	-41.21	62.90	0.37	0.00	0.00
0.35	2.98	179.40	-36.43	78.52	0.33	0.00	0.00
0.40	3.40	179.40	-31.64	92.09	0.29	0.00	0.00
0.45	3.83	179.40	12.24	97.68	0.11	0.00	0.00
0.50	4.25	179.40	17.03	92.77	0.15	0.00	0.00
0.55	4.67	179.40	21.81	85.81	0.20	0.00	0.00
0.60	5.10	179.40	26.59	76.79	0.24	0.00	0.00
0.65	5.53	179.40	31.36	65.71	0.29	0.00	0.00
0.70	5.95	179.40	36.16	52.59	0.33	0.00	0.00
0.75	6.38	179.40	40.93	37.40	0.37	0.00	0.00
0.80	6.80	179.40	45.71	20.39	0.42	0.00	0.00
0.85	7.22	179.40	50.50	2.15	0.46	0.00	0.00
0.90	7.65	179.40	55.28	-18.15	0.50	0.00	0.00
0.95	8.07	179.40	60.06	-40.50	0.55	0.00	0.00
0.98	8.32	179.40	62.81	-51.79	0.57	0.00	0.00

SPAN 3

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.02	0.18	179.40	-50.01	-51.01	0.45	0.00	0.00
0.05	0.42	179.40	-47.26	-40.68	0.43	0.00	0.00
0.10	0.85	179.40	-42.47	-24.39	0.39	0.00	0.00
0.15	1.27	179.40	-37.69	-10.15	0.34	0.00	0.00
0.20	1.70	179.40	-32.91	2.33	0.30	0.00	0.00
0.25	2.13	179.40	-28.13	13.75	0.26	0.00	0.00
0.30	2.55	179.40	-23.34	23.12	0.21	0.00	0.00
0.35	2.98	179.40	-18.56	30.43	0.17	0.00	0.00
0.40	3.40	179.40	-13.79	35.71	0.13	0.00	0.00
0.45	3.83	179.40	-9.01	38.92	0.08	0.00	0.00

0.50	4.25	179.40	-4.21	40.08	0.04	0.00	0.00
0.55	4.67	179.40	7.88	39.10	0.07	0.00	0.00
0.60	5.10	179.40	13.14	35.88	0.12	0.00	0.00
0.65	5.53	179.40	18.40	30.39	0.17	0.00	0.00
0.70	5.95	179.40	23.67	22.65	0.22	0.00	0.00
0.75	6.38	179.40	28.51	12.73	0.26	0.00	0.00
0.80	6.80	179.40	33.29	0.75	0.30	0.00	0.00
0.85	7.22	179.40	38.06	-11.75	0.35	0.00	0.00
0.90	7.65	179.40	42.84	-26.16	0.39	0.00	0.00
0.95	8.07	179.40	47.63	-42.61	0.43	0.00	0.00
0.98	8.32	179.40	50.39	-53.03	0.46	0.00	0.00

SPAN 4

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.02	0.18	179.40	-58.34	-53.89	0.53	0.00	0.00
0.05	0.45	179.40	-55.31	-42.71	0.50	0.00	0.00
0.10	0.90	179.40	-50.25	-19.75	0.46	0.00	0.00
0.15	1.35	179.40	-45.19	0.90	0.41	0.00	0.00
0.20	1.80	179.40	-40.11	19.26	0.36	0.00	0.00
0.25	2.25	179.40	-35.05	35.31	0.32	0.00	0.00
0.30	2.70	179.40	-29.99	49.06	0.27	0.00	0.00
0.35	3.15	179.40	-24.92	60.52	0.23	0.00	0.00
0.40	3.60	179.40	-19.87	69.67	0.18	0.00	0.00
0.45	4.05	179.40	-14.79	76.51	0.13	0.00	0.00
0.50	4.50	179.40	-9.73	81.06	0.09	0.00	0.00
0.55	4.95	179.40	-4.67	83.31	0.04	0.00	0.00
0.60	5.40	179.40	2.65	83.26	0.02	0.00	0.00
0.65	5.85	179.40	7.72	80.91	0.07	0.00	0.00
0.70	6.30	179.40	12.78	76.24	0.12	0.00	0.00
0.75	6.75	179.40	17.85	69.29	0.16	0.00	0.00
0.80	7.20	179.40	22.91	60.05	0.21	0.00	0.00
0.85	7.65	179.40	27.98	48.49	0.25	0.00	0.00
0.90	8.10	179.40	33.03	34.62	0.30	0.00	0.00
0.95	8.55	179.40	38.10	18.46	0.35	0.00	0.00
0.99	8.90	179.40	42.03	4.30	0.38	0.00	0.00

Note: "Vu" is related to the load combination which produces the maximum "Ratio"
Note: Sections with **** have exceeded the maximum allowable shear stress.

14 - DEFLECTIONS

14.1 Maximum Span Deflections

Span	SW	SW+PT	SW+PT+ SDL	SW+PT+SDL +Creep	LL	X	Total
	mm	mm	mm	mm	mm	mm	mm
CL	0.0	-4.7	5.2	15.7(159)	1.0(2429)	0.0(****)	16.7(149)
1	0.0	7.2	-3.8	-11.4(659)	-0.8(9130)	0.0(****)	-11.4(660)
2	0.0	-66.8	2.4	7.2(1175)	4.9(1743)	0.0(****)	11.8(719)
3	0.0	10.0	-3.8	-11.4(748)	-0.9(9718)	0.0(****)	-11.3(754)
4	0.0	-180.2	4.1	12.3(733)	6.5(1378)	0.0(****)	18.7(480)

Example of Two-way Slab, ACI Code & SI units (MNL5-2M)

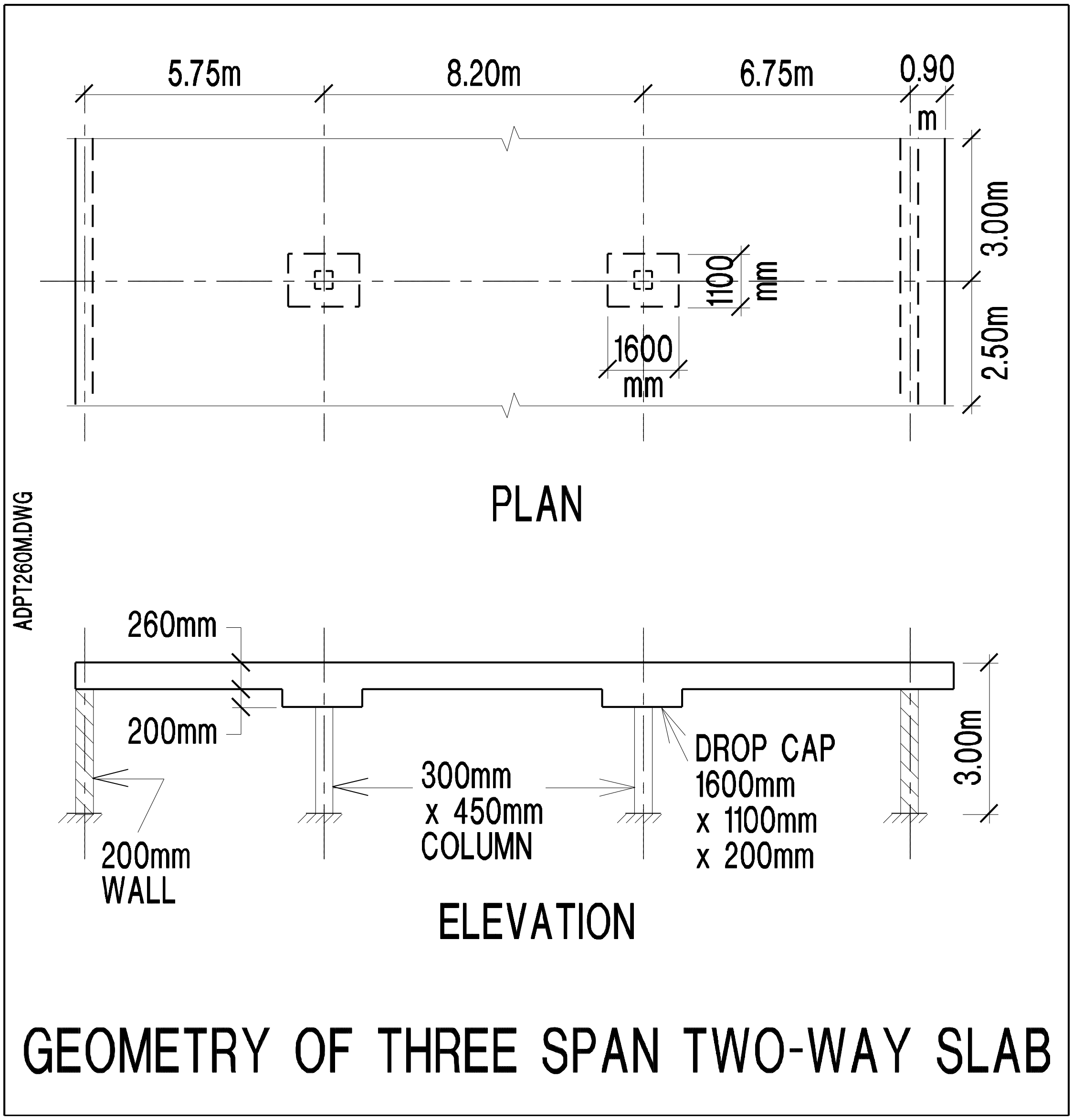


Figure 5.9-2

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		Minimum Cover at BOTTOM	25.00 mm
F'c for BEAMS/SLABS	28.00 N/mm 2	Post-tensioning	
For COLUMNS/WALLS	28.00 N/mm 2	SYSTEM	UNBONDED
Ec for BEAMS/SLABS	24870.00 N/mm 2	Fpu	1860.00 N/mm 2
For COLUMNS/WALLS	24870.00 N/mm 2	Fse	1200.00 N/mm 2
CREEP factor	2.00	Strand area	99.000 mm 2
CONCRETE WEIGHT	NORMAL	Min CGS from TOP	25.00 mm
Tension stress limits / (f'c)1/2		Min CGS from BOT for interior spans	25.00 mm
At Top	0.500	Min CGS from BOT for exterior spans	25.00 mm
At Bottom	0.500	Min average precompression	0.85 N/mm 2
Compression stress limits / f'c		Max spacing / slab depth	8.00
At all locations	0.450	Analysis and design options	
Reinforcement		Structural system - Equiv Frame	TWO-WAY
Fy (Main bars)	460.00 N/mm 2	Moments reduced to face of support	YES
Fy (Shear reinforcement)	460.00 N/mm 2	Moment Redistribution	NO
Minimum Cover at TOP	25.00 mm	DESIGN CODE SELECTED	ACI-318 (2014)

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		m	mm	mm	mm	mm	mm	mm	mm		
1	1	5.75	1000	260					260	3.00	2.50
2	1	8.20	1000	260					260	3.00	2.50
3	1	6.75	1000	260					260	3.00	2.50
C	1	0.90	1000	260					260	3.00	2.50

2.5 Drop Cap and Drop Panel Data

Joint	Cap T	Cap B	Cap DL	Cap DR	Drop TL	Drop TR	Drop B	Drop L	Drop R
	mm	mm	mm	mm	mm	mm	mm	mm	mm
1	0	0	0	0	0	0	0	0	0
2	460	1100	800	800	0	0	0	0	0
3	460	1100	800	800	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	mm	m	mm	mm			m	mm	mm		
1	200.0	3.0	5500.0	200.0	100	(2)					
2	450.0	3.0	300.0	450.0	100	(1)					
3	450.0	3.0	300.0	450.0	100	(1)					
4	200.0	3.0	5500.0	200.0	100	(2)					

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			kN/m2	kN/m	kN/m	m	m	m	kN	kN-m
1	LL	U	6.400							
1	SDL	U	13.500							

2	LL	U	5.500							
2	SDL	U	13.500							
3	LL	U	6.000							
3	SDL	U	13.500							
CANT	LL	U	6.000							
CANT	SDL	U	13.500							

4 - CALCULATED SECTION PROPERTIES

4.2 Section Properties for Non-Uniform Spans

Span	Segment	Area	I	Yb	Yt
		mm2	mm4	mm	mm
1	1	1430000.00	0.20E+12	130.00	130.00
1	2	1430000.00	0.81E+10	130.00	130.00
1	3	1650000.00	0.19E+11	299.33	160.67
1	4	1650000.00	0.21E+11	299.33	160.67
2	1	1650000.00	0.21E+11	299.33	160.67
2	2	1650000.00	0.19E+11	299.33	160.67
2	3	1430000.00	0.81E+10	130.00	130.00
2	4	1650000.00	0.19E+11	299.33	160.67
2	5	1650000.00	0.21E+11	299.33	160.67
3	1	1650000.00	0.21E+11	299.33	160.67
3	2	1650000.00	0.19E+11	299.33	160.67
3	3	1430000.00	0.81E+10	130.00	130.00
3	4	1430000.00	0.20E+12	130.00	130.00
CR	1	1430000.00	0.81E+10	130.00	130.00

5 - MOMENTS, SHEARS AND REACTIONS

5.1 Span Moments and Shears (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right	Shear Left	Shear Right
		kN-m	kN-m	kN-m	kN	kN
1	SW	0.00	0.00	0.00	0.00	0.00
2	SW	0.00	0.00	0.00	0.00	0.00
3	SW	0.00	0.00	0.00	0.00	0.00
CANT	SW	0.00	-----	-----	0.00	-----
1	SDL	0.00	106.65	-400.42	-143.83	283.11
2	SDL	-418.91	176.90	-475.43	-297.53	311.32
3	SDL	-476.02	169.83	-30.08	-316.66	184.53
CANT	SDL	-30.07	-----	-----	-66.82	-----
1	XL	0.00	0.00	0.00	0.00	0.00
2	XL	0.00	0.00	0.00	0.00	0.00
3	XL	0.00	0.00	0.00	0.00	0.00
CANT	XL	0.00	-----	-----	0.00	-----

5.2 Reactions and Column Moments (Excluding Live Load)

Joint	Load Case	Reaction	Moment Lower Column	Moment Upper Column
		kN	kN-m	kN-m
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
4	SW	0.00	0.00	0.00
1	SDL	143.83	0.00	0.00
2	SDL	580.64	-18.48	0.00

3	SDL	627.98	-0.60	0.00
4	SDL	251.35	0.00	0.00
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00
4	XL	0.00	0.00	0.00

5.3 Span Moments and Shears (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN	kN
1	0.00	0.00	57.81	57.81	-175.33	-175.33	-70.71	131.69
2	-176.58	-176.58	67.36	67.36	-197.20	-197.20	-121.51	126.54
3	-202.92	-202.92	79.80	79.80	-13.37	-13.37	-139.46	83.29
CR	-13.36	-----	-----	-----	-----	-----	-29.70	-----

5.4 Reactions and Column Moments (Live Load)

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	70.71	70.71	0.00	0.00	0.00	0.00
2	253.20	253.20	-1.24	-1.24	0.00	0.00
3	266.00	266.00	-5.72	-5.72	0.00	0.00
4	112.99	112.99	0.00	0.00	0.00	0.00

6 - MOMENTS REDUCED TO FACE OF SUPPORT

6.1 Reduced Moments at Face of Support (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right
		kN-m	kN-m	kN-m
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
CANT	SW	0.00	-----	-----
1	SDL	14.01	106.60	-338.60
2	SDL	-353.80	176.90	-407.30
3	SDL	-406.70	169.80	-12.00
CANT	SDL	-23.76	-----	-----
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00
CANT	XL	0.00	-----	-----

6.2 Reduced Moments at Face of Support (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	6.89	6.89	57.81	57.81	-146.60	-146.60
2	-150.00	-150.00	67.36	67.36	-169.50	-169.50
3	-172.40	-172.40	79.80	79.80	-5.20	-5.20
CR	-10.56	-----	-----	-----	-----	-----

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile
Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
1	2	0.050	0.500	0.080	---
2	2	0.070	0.500	0.070	---
3	2	0.070	0.500	0.070	---
CR	2	0.000	---	---	---

7.2 Selected Post-Tensioning Forces and Tendon Drape
Tendon A

Span	Force	CGS Left	CSG C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	kN	mm	mm	mm	mm	MPa	kN	
1	1238.000	130.00	---	25.00	235.00	0.87	54.918	74
2	1238.000	235.00	---	25.00	235.00	0.87	35.967	48
3	1650.000	235.00	---	25.00	150.00	1.15	56.426	76
CR	1650.000	150.00	---	---	130.00	1.15	81.481	110

Approximate weight of strand: 214.9 Kg

7.4 Required Minimum Post-Tensioning Forces

	Based on Stress Conditions			Based on Minimum P/A		
Type	Left	Center	Right	Left	Center	Right
	kN	kN	kN	kN	kN	kN
1	0.00	3.98	706.01	1215.50	1215.50	1402.50
2	801.81	701.39	1147.47	1402.50	1215.50	1402.50
3	1106.33	659.52	0.00	1402.50	1215.50	1215.50
CR	0.00	-----	-----	1215.50	-----	-----

7.5 Service Stresses (tension shown positive)
Envelope of Service 1

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	MPa	MPa	MPa	MPa	MPa	MPa
1	-1.14	-0.59	-1.19	-0.55	0.65	-3.37
2	0.86	-3.75	-2.62	0.89	0.64	-4.06
3	0.50	-3.79	-1.98	-0.33	-1.48	-0.83
CR	-1.14	-1.17	-----	-----	-----	-----

Envelope of Service 2

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	MPa	MPa	MPa	MPa	MPa	MPa
1	-1.22	-0.51	-1.84	0.11	1.53	-4.99
2	1.75	-5.41	-3.39	1.65	1.65	-5.95
3	1.52	-5.70	-2.88	0.57	-1.42	-0.88
CR	-1.02	-1.29	-----	-----	-----	-----

7.6 Post-Tensioning Balance Moments, Shears and Reactions
Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN	kN
1	0.90	-104.10	217.60	-8.99	-8.99
2	209.80	-88.10	265.00	-0.01	-0.01
3	282.60	-142.90	33.90	9.01	9.01
CR	26.07	-----	-----	65.19	-----

Reactions and Column Moments

Joint	Reaction	Moment Lower Column	Moment Upper Column

	kN	kN-m	kN-m
1	8.987	0.000	0.000
2	-8.976	-9.837	0.000
3	-9.017	18.860	0.000
4	9.006	0.000	0.000

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	28.74	28.74	246.26	246.26	-591.23	-591.23
2	-622.72	-622.72	361.94	361.94	-718.03	-718.03
3	-705.12	-705.12	361.84	361.84	-21.82	-21.82
CR	-45.41	-----	-----	-----	-----	-----

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	294.68	294.68	0.00	0.00	0.00	0.00
2	1092.86	1092.86	-34.00	-34.00	0.00	0.00
3	1170.18	1170.18	9.00	9.00	0.00	0.00
4	491.49	491.49	0.00	0.00	0.00	0.00

8.3 Secondary Moments

Span	Left	Midspan	Right
	kN-m	kN-m	kN-m
1	0.90	25.84	49.65
2	41.84	41.88	41.93
3	58.76	30.40	0.90

Note: Moments are reported at face of support

10 - MILD STEEL - NO REDISTRIBUTION

10.1 Required Rebar

10.1.1 Total Strip Required Rebar

Span	Location	From	To	As Required	Ultimate	Minimum
		m	m	mm2	mm2	mm2
1	TOP	0.00	0.86	1073.00	0.00	1073.00
1	TOP	4.60	5.75	3010.00	3010.00	1360.00
2	TOP	0.00	1.23	3374.00	3374.00	1360.00
2	TOP	6.97	8.20	3518.00	3518.00	1458.00
3	TOP	0.00	1.01	3316.00	3316.00	1458.00
3	TOP	5.74	6.75	1073.00	0.00	1073.00
CR	TOP	0.00	0.14	1073.00	0.00	1073.00
2	BOT	2.87	4.92	1675.00	416.70	1675.00
3	BOT	3.71	5.40	1285.00	237.50	1285.00

29 - DETAILED REBAR

SPAN 1

XL	X	Analysis Top	Analysis Bot	Minimum Top	Minimum Bot	Selected Top	Selected Bot
	m	mm2	mm2	mm2	mm2	mm2	mm2
0.00	0.00	0.00	0.00	1073.00	0.00	1073.00	0.00
0.05	0.29	0.00	0.00	1073.00	0.00	1073.00	0.00
0.10	0.57	0.00	0.00	1073.00	0.00	1073.00	0.00
0.15	0.86	0.00	0.00	1073.00	0.00	1073.00	0.00
0.20	1.15	0.00	0.00	0.00	0.00	0.00	0.00
0.25	1.44	0.00	0.00	0.00	0.00	0.00	0.00
0.30	1.73	0.00	0.00	0.00	0.00	0.00	0.00
0.35	2.01	0.00	0.00	0.00	771.90	0.00	771.90
0.40	2.30	0.00	0.00	0.00	0.00	0.00	0.00
0.45	2.59	0.00	0.00	0.00	0.00	0.00	0.00
0.50	2.88	0.00	0.00	0.00	0.00	0.00	0.00
0.55	3.16	0.00	0.00	0.00	0.00	0.00	0.00
0.60	3.45	0.00	0.00	0.00	0.00	0.00	0.00
0.65	3.74	0.00	0.00	0.00	0.00	0.00	0.00
0.70	4.03	0.00	0.00	0.00	0.00	0.00	0.00
0.75	4.31	0.00	0.00	0.00	0.00	0.00	0.00
0.80	4.60	142.60	0.00	0.00	0.00	142.60	0.00
0.85	4.89	748.50	0.00	1360.00	0.00	1360.00	0.00
0.90	5.17	1294.00	0.00	1360.00	0.00	1360.00	0.00
0.95	5.46	2601.00	0.00	1360.00	0.00	2601.00	0.00
1.00	5.75	3010.00	0.00	1360.00	0.00	3010.00	0.00

SPAN 2

XL	X	Analysis Top	Analysis Bot	Minimum Top	Minimum Bot	Selected Top	Selected Bot
	m	mm2	mm2	mm2	mm2	mm2	mm2
0.00	0.00	3374.00	0.00	1360.00	0.00	3374.00	0.00
0.05	0.41	2218.00	0.00	1360.00	0.00	2218.00	0.00
0.10	0.82	566.90	0.00	1360.00	0.00	1360.00	0.00
0.15	1.23	0.00	0.00	1360.00	0.00	1360.00	0.00
0.20	1.64	0.00	0.00	0.00	0.00	0.00	0.00
0.25	2.05	0.00	0.00	0.00	0.00	0.00	0.00
0.30	2.46	0.00	0.00	0.00	0.00	0.00	0.00
0.35	2.87	0.00	0.00	0.00	915.50	0.00	915.50
0.40	3.28	0.00	0.00	0.00	1384.00	0.00	1384.00
0.45	3.69	0.00	368.00	0.00	1645.00	0.00	1645.00
0.50	4.10	0.00	416.70	0.00	1675.00	0.00	1675.00
0.55	4.51	0.00	247.30	0.00	1474.00	0.00	1474.00
0.60	4.92	0.00	0.00	0.00	1058.00	0.00	1058.00
0.65	5.33	0.00	0.00	0.00	0.00	0.00	0.00
0.70	5.74	0.00	0.00	0.00	0.00	0.00	0.00
0.75	6.15	0.00	0.00	0.00	0.00	0.00	0.00
0.80	6.56	0.00	0.00	0.00	0.00	0.00	0.00
0.85	6.97	0.00	0.00	1458.00	0.00	1458.00	0.00
0.90	7.38	629.90	0.00	1458.00	0.00	1458.00	0.00
0.95	7.79	2275.00	0.00	1458.00	0.00	2275.00	0.00
1.00	8.20	3518.00	0.00	1458.00	0.00	3518.00	0.00

SPAN 3

XL	X	Analysis Top	Analysis Bot	Minimum Top	Minimum Bot	Selected Top	Selected Bot
	m	mm2	mm2	mm2	mm2	mm2	mm2
0.00	0.00	3316.00	0.00	1458.00	0.00	3316.00	0.00
0.05	0.34	2546.00	0.00	1458.00	0.00	2546.00	0.00
0.10	0.68	1184.00	0.00	1458.00	0.00	1458.00	0.00

0.15	1.01	324.70	0.00	1458.00	0.00	1458.00	0.00
0.20	1.35	0.00	0.00	0.00	0.00	0.00	0.00
0.25	1.69	0.00	0.00	0.00	0.00	0.00	0.00
0.30	2.02	0.00	0.00	0.00	0.00	0.00	0.00
0.35	2.36	0.00	0.00	0.00	0.00	0.00	0.00
0.40	2.70	0.00	0.00	0.00	0.00	0.00	0.00
0.45	3.04	0.00	0.00	0.00	0.00	0.00	0.00
0.50	3.38	0.00	0.00	0.00	0.00	0.00	0.00
0.55	3.71	0.00	0.00	0.00	692.00	0.00	692.00
0.60	4.05	0.00	0.00	0.00	1043.00	0.00	1043.00
0.65	4.39	0.00	88.05	0.00	1285.00	0.00	1285.00
0.70	4.72	0.00	237.50	0.00	0.00	0.00	237.50
0.75	5.06	0.00	178.60	0.00	0.00	0.00	178.60
0.80	5.40	0.00	57.89	0.00	0.00	0.00	57.89
0.85	5.74	0.00	0.00	1073.00	0.00	1073.00	0.00
0.90	6.08	0.00	0.00	1073.00	0.00	1073.00	0.00
0.95	6.41	0.00	0.00	1073.00	0.00	1073.00	0.00
1.00	6.75	0.00	0.00	1073.00	0.00	1073.00	0.00

CR

XL	X	Analysis Top	Analysis Bot	Minimum Top	Minimum Bot	Selected Top	Selected Bot
	m	mm2	mm2	mm2	mm2	mm2	mm2
0.00	0.00	0.00	0.00	1073.00	0.00	1073.00	0.00
0.05	0.04	0.00	0.00	1073.00	0.00	1073.00	0.00
0.10	0.09	0.00	0.00	1073.00	0.00	1073.00	0.00
0.15	0.14	0.00	0.00	1073.00	0.00	1073.00	0.00
0.20	0.18	0.00	0.00	0.00	0.00	0.00	0.00
0.25	0.23	0.00	0.00	0.00	0.00	0.00	0.00
0.30	0.27	0.00	0.00	0.00	0.00	0.00	0.00
0.35	0.32	0.00	0.00	0.00	0.00	0.00	0.00
0.40	0.36	0.00	0.00	0.00	0.00	0.00	0.00
0.45	0.41	0.00	0.00	0.00	0.00	0.00	0.00
0.50	0.45	0.00	0.00	0.00	0.00	0.00	0.00
0.55	0.50	0.00	0.00	0.00	0.00	0.00	0.00
0.60	0.54	0.00	0.00	0.00	0.00	0.00	0.00
0.65	0.58	0.00	0.00	0.00	0.00	0.00	0.00
0.70	0.63	0.00	0.00	0.00	0.00	0.00	0.00
0.75	0.68	0.00	0.00	0.00	0.00	0.00	0.00
0.80	0.72	0.00	0.00	0.00	0.00	0.00	0.00
0.85	0.77	0.00	0.00	0.00	0.00	0.00	0.00
0.90	0.81	0.00	0.00	0.00	0.00	0.00	0.00
0.95	0.85	0.00	0.00	0.00	0.00	0.00	0.00
1.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00

Example of a Beam, ACI Code &SI units (MNL5-3M)

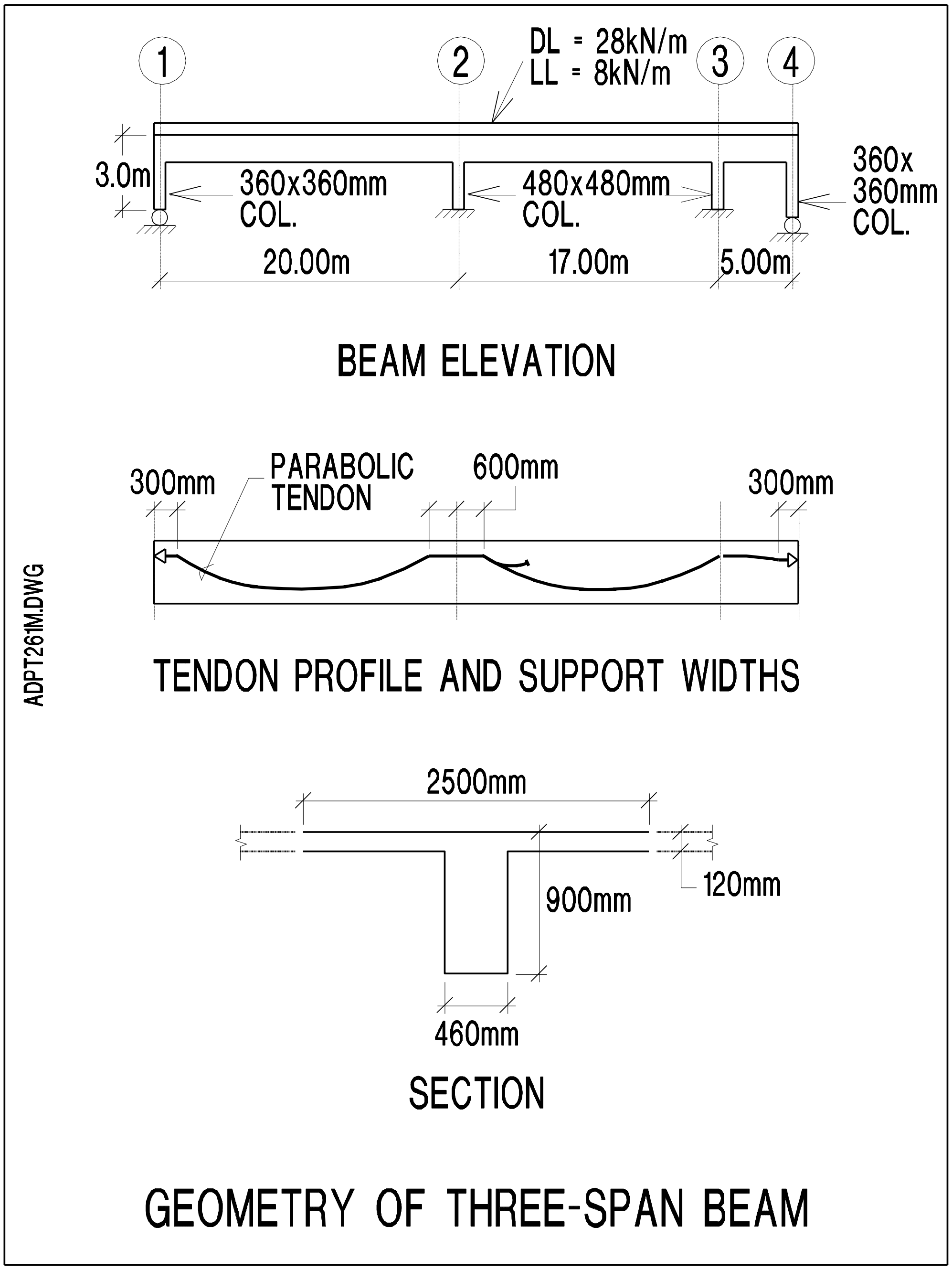


Figure 5.9-3

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		SYSTEM	UNBONDED
F'c for BEAMS/SLABS	30.00 N/mm 2	Fpu	1860.00 N/mm 2
For COLUMNS/WALLS	30.00 N/mm 2	Fse	1200.00 N/mm 2
Ec for BEAMS/SLABS	25743.00 N/mm 2	Strand area	99.000 mm 2
For COLUMNS/WALLS	25743.00 N/mm 2	Min CGS from TOP	56.00 mm
CREEP factor	2.00	Min CGS from BOT for interior spans	80.00 mm
CONCRETE WEIGHT	NORMAL	Min CGS from BOT for exterior spans	80.00 mm
Tension stress limits / (f'c)1/2		Min average precompression	0.85 N/mm 2
At Top	0.750	Max spacing / slab depth	8.00
At Bottom	0.750	Analysis and design options	
Compression stress limits / f'c		Structural system	BEAM
At all locations	0.450	Moment of Inertia over support is	NOT INCREASED
Reinforcement		Moments reduced to face of support	YES
Fy (Main bars)	460.00 N/mm 2	Moment Redistribution	NO
Fy (Shear reinforcement)	460.00 N/mm 2	Effective flange width consideration	YES
Minimum Cover at TOP	50.00 mm	Effective flange width implementation method	ACI-318
Minimum Cover at BOTTOM	50.00 mm	DESIGN CODE SELECTED	ACI-318 (2014)
Post-tensioning			

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		m	mm	mm	mm	mm	mm	mm	mm		
1	2	20.00	460	900	5190	120			900	0.50	0.50
2	2	17.00	460	900	5190	120			900	0.50	0.50
3	2	5.00	460	900	5190	120			900	0.50	0.50

2.3 Effective Width Data of Uniform Spans

Span	Effective Width
	mm
1	2380
2	2380
3	1250

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	mm	m	mm	mm			m	mm	mm		
1	360.0	3.0	360.0	360.0	100	(1)					
2	480.0	3.0	480.0	480.0	100	(1)					
3	480.0	3.0	480.0	480.0	100	(1)					
4	360.0	3.0	360.0	360.0	100	(1)					

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			kN/m2	kN/m	kN/m	m	m	m	kN	kN-m
1	LL	L		8.000		0.000	20.000			

1	SDL	L		28.000		0.000	20.000			
2	LL	L		8.000		0.000	17.000			
2	SDL	L		28.000		0.000	17.000			
3	LL	L		8.000		0.000	5.000			
3	SDL	L		28.000		0.000	5.000			

4 - CALCULATED SECTION PROPERTIES

4.1 Section Properties of Uniform Spans and Cantilevers

Span	Area	Yb	Yt	b_eff	I	Yb	Yt
	mm2	mm	mm	mm	mm4	mm	mm
1	981600.00	675.51	224.49	2380.00	0.5074E+11	589.44	310.56
2	981600.00	675.51	224.49	2380.00	0.5074E+11	589.44	310.56
3	981600.00	675.51	224.49	1250.00	0.3979E+11	522.67	377.33

5 - MOMENTS, SHEARS AND REACTIONS

5.1 Span Moments and Shears (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right	Shear Left	Shear Right
		kN-m	kN-m	kN-m	kN	kN
1	SW	0.00	0.00	0.00	0.00	0.00
2	SW	0.00	0.00	0.00	0.00	0.00
3	SW	0.00	0.00	0.00	0.00	0.00
1	SDL	-162.87	746.41	-1144.32	-230.93	329.07
2	SDL	-1009.94	301.62	-409.81	-273.30	202.70
3	SDL	-346.57	-82.68	6.22	-140.56	-0.56
1	XL	0.00	0.00	0.00	0.00	0.00
2	XL	0.00	0.00	0.00	0.00	0.00
3	XL	0.00	0.00	0.00	0.00	0.00

5.2 Reactions and Column Moments (Excluding Live Load)

Joint	Load Case	Reaction	Moment Lower Column	Moment Upper Column
		kN	kN-m	kN-m
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
4	SW	0.00	0.00	0.00
1	SDL	230.93	-162.85	0.00
2	SDL	602.37	134.37	0.00
3	SDL	343.26	63.25	0.00
4	SDL	-0.56	-6.22	0.00
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00
4	XL	0.00	0.00	0.00

5.3 Span Moments and Shears (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN	kN
1	-46.53	-46.53	213.26	213.26	-326.95	-326.95	-65.98	94.02
2	-288.55	-288.55	86.18	86.18	-117.09	-117.09	-78.09	57.91
3	-99.02	-99.02	-23.62	-23.62	1.78	1.78	-40.16	-0.16

5.4 Reactions and Column Moments (Live Load)

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	65.98	65.98	-46.53	-46.53	0.00	0.00
2	172.11	172.11	38.39	38.39	0.00	0.00
3	98.07	98.07	18.07	18.07	0.00	0.00
4	-0.16	-0.16	-1.78	-1.78	0.00	0.00

6 - MOMENTS REDUCED TO FACE OF SUPPORT

6.1 Reduced Moments at Face of Support (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right
		kN-m	kN-m	kN-m
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
1	SDL	-121.80	746.40	-1066.00
2	SDL	-945.20	301.60	-362.00
3	SDL	-313.60	-82.68	5.66
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00

6.2 Reduced Moments at Face of Support (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	-34.79	-34.79	213.30	213.30	-304.60	-304.60
2	-270.00	-270.00	86.18	86.18	-103.40	-103.40
3	-89.61	-89.61	-23.62	-23.62	1.62	1.62

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile
Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
1	1	0.015	0.500	0.030	---
2	1	0.035	0.500	0.000	---
3	1	0.000	0.500	0.060	---

7.2 Selected Post-Tensioning Forces and Tendon Drape
Tendon A

Span	Force	CGS Left	CGS C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	kN	mm	mm	mm	mm	MPa	kN/-	
1	1660.000	676.00	---	80.00	844.00	1.69	22.576	81
2	925.000	844.00	---	80.00	844.00	0.94	19.563	70
3	925.000	844.00	---	630.00	676.00	0.94	38.480	137

Approximate weight of strand: 381.5 Kg

7.4 Required Minimum Post-Tensioning Forces

	Based on Stress Conditions			Based on Minimum P/A		
Type	Left	Center	Right	Left	Center	Right
	kN	kN	kN	kN	kN	kN

1	0.00	1321.04	1004.32	834.36	834.36	834.36
2	864.45	105.01	0.00	834.36	834.36	834.36
3	0.00	0.00	0.00	834.36	834.36	834.36

7.5 Service Stresses (tension shown positive)

Envelope of Service 1

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	MPa	MPa	MPa	MPa	MPa	MPa
1	-1.62	-1.82	-2.88	0.57	0.01	-4.91
2	-0.11	-4.68	-1.60	0.30	-0.25	-2.25
3	0.05	-2.31	-0.26	-1.89	-1.01	-0.85

Envelope of Service 2

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	MPa	MPa	MPa	MPa	MPa	MPa
1	-1.48	-2.10	-3.79	2.30	1.31	-7.39
2	1.04	-6.88	-1.97	1.00	0.19	-3.09
3	0.64	-3.14	-0.10	-2.10	-1.02	-0.84

7.6 Post-Tensioning Balance Moments, Shears and Reactions

Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN	kN
1	121.30	-616.00	879.90	-24.58	-24.58
2	768.50	-220.30	280.20	20.21	20.21
3	236.00	17.93	0.84	24.92	24.92

Reactions and Column Moments

Joint	Reaction	Moment Lower Column	Moment Upper Column
	kN	kN-m	kN-m
1	24.580	126.700	0.000
2	-44.780	-115.900	0.000
3	-4.707	-36.510	0.000
4	24.920	2.263	0.000

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	-70.72	-70.72	1609.46	1609.46	-1154.16	-1154.16
2	-1068.74	-1068.74	830.41	830.41	-436.14	-436.14
3	-403.30	-403.30	-76.97	-76.97	11.61	11.61

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	407.23	407.23	-143.23	-143.23	0.00	0.00
2	953.46	953.46	106.80	106.80	0.00	0.00
3	564.16	564.16	68.30	68.30	0.00	0.00
4	23.99	23.99	-8.05	-8.05	0.00	0.00

8.3 Secondary Moments

Span	Left	Midspan	Right
	kN-m	kN-m	kN-m
1	131.10	372.50	612.40
2	497.50	330.60	163.70
3	116.40	60.04	2.22

Note: Moments are reported at face of support

10 - MILD STEEL - NO REDISTRIBUTION

10.1 Required Rebar

10.1.1 Total Strip Required Rebar

Span	Location	From	To	As Required	Ultimate	Minimum
		m	m	mm2	mm2	mm2
1	TOP	0.00	3.00	1493.00	384.70	1493.00
1	TOP	16.00	20.00	3637.00	3637.00	1493.00
2	TOP	0.00	4.25	3125.00	3125.00	1493.00
2	TOP	14.45	17.00	1493.00	1162.00	1493.00
3	TOP	0.00	5.00	1073.00	998.40	1073.00
1	BOT	1.00	15.00	2466.00	2466.00	1085.00
2	BOT	5.10	14.45	1085.00	1006.00	1085.00
3	BOT	4.50	5.00	17.53	17.53	0.00

10.2 Provided Rebar

10.2.1 Total Strip Provided Rebar

Span	ID	Location	From	Quantity	Size	Length	Area
			m			m	mm2
1	1	TOP	0.00	8	16	4.00	1608.80
1	2	TOP	14.70	10	16	10.70	2011.00
2	3	TOP	13.60	8	16	8.40	1608.80
1	4	TOP	17.70	9	16	4.30	1809.90
1	8	BOT	0.00	3	16	0.00	603.30
1	5	BOT	0.00	7	16	16.30	1407.70
2	6	BOT	3.95	3	16	11.66	603.30
3	7	BOT	3.95	1	16	1.06	201.10
1	9	BOT	2.70	6	16	11.60	1206.60
2	10	BOT	4.80	3	16	9.10	603.30

10.2.2 Total Strip Steel Disposition

Span	ID	Location	From	Quantity	Size	Length
			m			m
1	1	TOP	0.00	8	16	4.00
1	2	TOP	14.70	10	16	5.30
1	4	TOP	17.70	9	16	2.30
2	2	TOP	0.00	10	16	5.40
2	3	TOP	13.60	8	16	3.40
2	4	TOP	0.00	9	16	2.00
3	3	TOP	0.00	8	16	5.00
1	8	BOT	0.00	3	16	0.00
1	5	BOT	0.00	7	16	16.30
1	9	BOT	2.70	6	16	11.60
2	6	BOT	3.95	3	16	11.66
2	10	BOT	4.80	3	16	9.10
3	7	BOT	3.95	1	16	1.06

12 - SHEAR REINFORCEMENT

12.1 Shear Calculation Envelope

SPAN 1

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.01	0.18	720.00	-398.90	-71.40	0.71	121.50	600.00
0.05	1.00	720.00	-360.90	243.30	0.64	121.50	600.00
0.10	2.00	720.00	-314.50	584.40	0.92	121.50	600.00
0.15	3.00	720.00	-268.10	878.40	1.04	121.50	600.00
0.20	4.00	720.00	-221.70	1126.00	0.98	121.50	600.00
0.25	5.00	720.00	-175.30	1326.00	0.78	121.50	600.00
0.30	6.00	721.70	-128.90	1480.00	0.57	121.30	600.00
0.35	7.00	764.70	-82.46	1587.00	0.34	0.00	0.00
0.40	8.00	795.40	-36.06	1646.00	0.14	0.00	0.00
0.45	9.00	813.90	10.34	1659.00	0.04	0.00	0.00
0.50	10.00	820.00	56.74	1626.00	0.22	0.00	0.00
0.55	11.00	811.90	103.10	1545.00	0.41	0.00	0.00
0.60	12.00	787.50	149.50	1417.00	0.61	116.20	600.00
0.65	13.00	746.90	195.90	1243.00	0.84	119.30	600.00
0.70	14.00	720.00	242.30	1021.00	0.92	121.50	600.00
0.75	15.00	720.00	288.70	753.20	0.82	121.50	600.00
0.80	16.00	720.00	335.10	438.10	0.61	121.50	600.00
0.85	17.00	720.00	381.50	76.21	0.68	121.50	600.00
0.90	18.00	720.00	427.90	-332.70	0.76	121.50	600.00
0.95	19.00	738.30	474.30	-788.20	0.82	120.00	600.00
0.99	19.76	818.60	509.70	-1166.00	0.90	113.90	600.00

SPAN 2

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.01	0.24	816.20	-421.60	-1079.00	0.83	114.10	600.00
0.05	0.85	745.40	-393.30	-828.50	0.77	119.40	600.00
0.10	1.70	720.00	-353.80	-507.80	0.63	121.50	600.00
0.15	2.55	720.00	-314.40	-220.80	0.56	121.50	600.00
0.20	3.40	720.00	-274.90	32.02	0.49	0.00	0.00
0.25	4.25	720.00	-235.50	251.10	0.42	0.00	0.00
0.30	5.10	720.00	-196.10	436.40	0.45	0.00	0.00
0.35	5.95	746.10	-156.60	587.90	0.49	0.00	0.00
0.40	6.80	787.10	-117.20	705.30	0.47	0.00	0.00
0.45	7.65	811.80	-77.73	788.90	0.31	0.00	0.00
0.50	8.50	820.00	-38.29	838.70	0.15	0.00	0.00
0.55	9.35	812.40	6.41	854.70	0.03	0.00	0.00
0.60	10.20	789.40	40.59	836.80	0.16	0.00	0.00
0.65	11.05	751.20	80.03	785.00	0.34	0.00	0.00
0.70	11.90	720.00	119.50	699.40	0.53	67.70	600.00
0.75	12.75	720.00	158.90	579.90	0.58	67.70	600.00
0.80	13.60	720.00	198.30	426.60	0.53	67.70	600.00
0.85	14.45	720.00	237.80	239.30	0.42	0.00	0.00
0.90	15.30	720.00	277.20	18.22	0.49	0.00	0.00
0.95	16.15	720.00	316.70	-236.70	0.56	67.70	600.00
0.99	16.76	803.00	345.00	-440.50	0.55	64.10	600.00

SPAN 3

XL	X	d	Vu	Mu	Ratio	Req.	Spacing
	m	mm	kN	kNm		mm2	mm
0.05	0.24	805.00	-196.80	-407.40	0.33	0.00	0.00

0.05	0.25	803.40	-196.40	-405.40	0.33	0.00	0.00
0.10	0.50	767.00	-184.80	-357.30	0.32	0.00	0.00
0.15	0.75	734.90	-173.20	-312.00	0.30	0.00	0.00
0.20	1.00	720.00	-161.60	-269.80	0.29	0.00	0.00
0.25	1.25	720.00	-150.00	-230.60	0.27	0.00	0.00
0.30	1.50	720.00	-138.40	-194.00	0.25	0.00	0.00
0.35	1.75	720.00	-126.80	-160.60	0.22	0.00	0.00
0.40	2.00	720.00	-115.20	-130.10	0.20	0.00	0.00
0.45	2.25	720.00	-103.60	-102.40	0.18	0.00	0.00
0.50	2.50	720.00	-92.01	-77.74	0.16	0.00	0.00
0.55	2.75	720.00	-80.41	-55.96	0.14	0.00	0.00
0.60	3.00	720.00	-68.81	-37.13	0.12	0.00	0.00
0.65	3.25	720.00	-57.21	-21.22	0.10	0.00	0.00
0.70	3.50	720.00	-45.61	-8.24	0.08	0.00	0.00
0.75	3.75	720.00	-38.10	-17.69	0.07	0.00	0.00
0.80	4.00	720.00	-30.60	-9.02	0.05	0.00	0.00
0.85	4.25	720.00	-23.10	-2.25	0.04	0.00	0.00
0.90	4.50	720.00	7.45	14.39	0.03	0.00	0.00
0.95	4.75	720.00	15.85	12.72	0.04	0.00	0.00
0.96	4.82	720.00	18.20	11.73	0.04	0.00	0.00

Note: "Vu" is related to the load combination which produces the maximum "Ratio"
Note: Sections with **** have exceeded the maximum allowable shear stress.

14 - DEFLECTIONS

14.1 Maximum Span Deflections

Span	SW	SW+PT	SW+PT+ SDL	SW+PT+SDL +Creep	LL	X	Total
	mm	mm	mm	mm	mm	mm	mm
1	0.0	-187.9	3.8	11.4(1758)	5.7(3520)	0.0(****)	17.0(1177)
2	0.0	6.5	1.2	3.5(4819)	1.1(15498)	0.0(****)	4.6(3676)
3	0.0	0.2	-0.2	-0.6(8958)	-0.1(54170)	0.0(****)	-0.6(7692)

5.10 Punching Shear

5.10.1 Overview

Punching shear calculation applies to column-supported slabs, classified as two-way structural systems.

This section (i) defines the different conditions for punching shear calculation, (ii) presents the relationships used for code check of each condition using ACI-318, (iii) presents a numerical example for each condition, and (iv) demonstrates that the program ADAPT-PT correctly recognizes each case, and accordingly.

Depending on the location of a column with respect to the slab edges, four conditions are identified. These are:

- **Interior** column, where the distance from each face of a column to the slab edge is at least four times the slab thickness (columns 4 and 5 in **Fig. 5.10-1**)
- **Edge** column, where one face of a column in direction of design strip is closer to the slab edge in the same direction by four times the slab thickness (column 2 in **Fig. 5.10-1**
- **Corner** column, where two adjacent faces of a column are closer to their associated slab edges by less than four times the slab thickness (column 1 in **Fig. 5.10-1**
- **End** column, where a column face is closer to a slab edge normal to the design strip by less than four times the slab thickness (Column 6 in **Fig. 5.10-1**)

Columns at re-entrant corners, such as column 3 in **Fig. 5.10-1** are conservatively treated as edge columns. Punching shear relationships of the code do not apply to columns that are connected to one or more beams, nor do they apply to walls/supports. Adequacy of shear transfer in such cases has to be established differently.

The calculations are presented by way of a numerical example. The geometry, material, loading and other particulars of the structure selected for the numerical example are given below and in **Fig. 5.10-1.**

Thickness of slab = 9 in (229 mm)

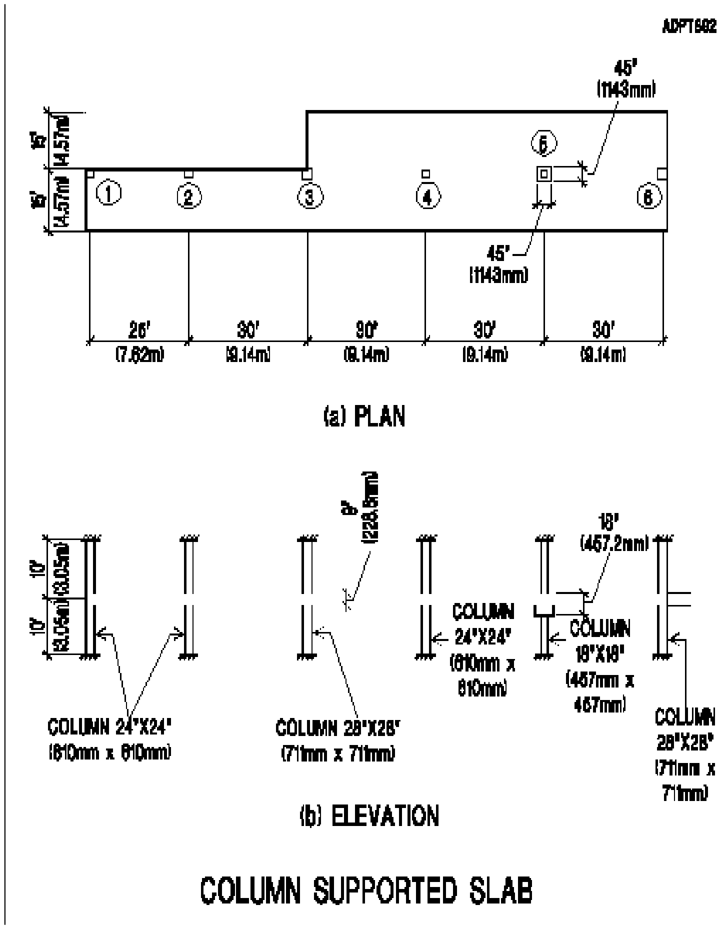


Figure 5.10-1

5.10.1.1 Material Properties

(i) Concrete

Compressive strength, f'_c	= 4000 psi (27.58 MPa)
Weight	= 150 pcf (2403 kg/m^3)
Modulus of elasticity	= 3605 ksi (24856 MPa)

(ii) Prestressing

Low relaxation, unbonded system

Strand diameter	= ½ in (13 mm)
Strand area	= 0.153 in2 (98 mm2)
Modulus of elasticity	= 28000 ksi (193054 MPa)
Ultimate strength of strand, f_{pu}	= 270 ksi (1862 MPa)
Minimum strand cover	
From top fiber	= 1 in all spans (25 mm)
From bottom fiber	

Interior spans = 1 in (25 mm)
Exterior spans = 1 in (25 mm)

(iii) Nonprestressed Reinforcement

Yield stress f_y = 60 ksi (413.69 MPa)
Modulus of elasticity = 29000 ksi (199,949 MPa)
Minimum rebar cover = 0.75 in top and bottom (19 mm)

(iv) Loading

Dead load = self-weight + 20 psf (superimposed)
Live load = (1.92 kN/m^2)

5.10.2 Relationships

The calculations are intended to determine whether or not a given slab-column connection meets the minimum safety requirements of the code against failure. It is not the intent of the calculations to find the "actual" condition of stress distribution at the column-slab location. The relationships used are empirical. Using test results, the relationships are calibrated to deliver safe designs.

The calculation steps are:

- Determine the factored column moment (design moment M_u) and the factored shear (design shear V_u). In many instances, column reaction is conservatively used as design value for punching shear.
- Consider a fraction of the unbalanced moment (γM_u) to contribute to the punching shear demand. The unbalanced moment is conservatively taken as the sum of upper and column moments at a joint.
- Using the code relationships, select an assumed (critical) failure surface and calculate a hypothetical maximum punching shear stress for the assumed surface.
- Using the geometry of the column-slab location and its material properties, calculate an "allowable" punching shear stress.
- If the maximum punching shear stress calculated does not exceed the allowable value, the section is considered safe.
- If the hypothetical maximum punching shear stress exceeds the allowable value by a moderate amount, punching shear reinforcement may be provided to bring the connection within the safety requirements of the code.
- If the hypothetical maximum punching shear reinforcement exceeds the allowable values by a large margin, the section must be enlarged.

The basic relationship is as follows:

$$v_u = \frac{V_u}{A_c} + \frac{\gamma \times M_u \times c}{J_c}$$

where,

V_u = absolute value of the direct shear
M_u = unbalanced column moment
A_c = area of concrete of assumed critical section
γ_v = fraction of the moment transferred by shear
c = distance from centroidal axis of critical section to the perimeter of the critical section in the direction of analysis
J_c = a geometry property of critical section, analogues to polar moment of inertia of segments forming area A_c

The first critical shear failure plane is assumed at a distance *d/2* from the face of support, where "d" is the effective depth of the section.

Expressions for A_c, J_c, and γ_v for all types of columns are given below.

5.10.2.1 Interior Column (Fig. 5.10-2)

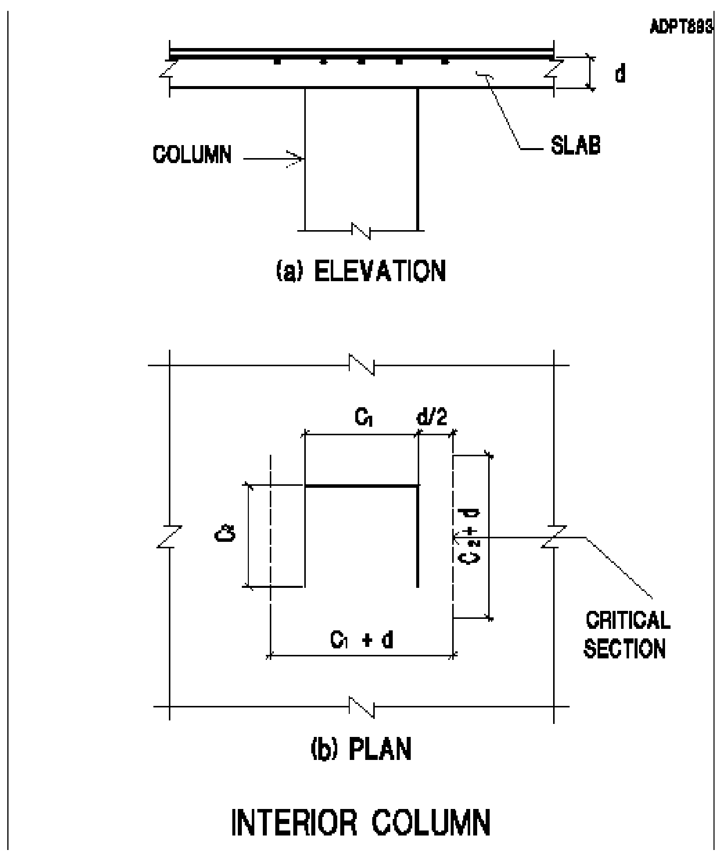


Figure 5.10-2

A_c = $2d(c_1 + c_2 + 2d)$

J_c = $(c_1 + d) * d^3/6 + (c_1 + d)^3 * d/6 + d * (c_2 + d) * (c_1 + d)^2/2$

γ_V = $1- \{1/[1+ (2/3) * ((c_1 + d) / (c_2 + d))^{½}]\}$

Where c_1 and c_2 are the column dimensions with c_1 perpendicular to the axis of moment, and d is the effective depth.

5.10.2.2 End Column (Refer Fig. 5.10-3)

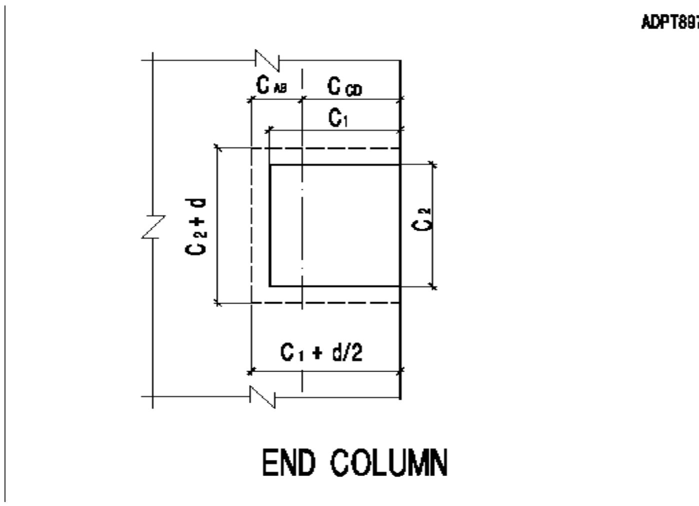


Figure 5.10-3 - For a Design Strip in Left-Right Direction

A_c = $d(2c_1+c_2+2d)$

c_{AB} = $(c_1+d/2)^2/(2c_1+c_2+2d)$

c_{CD} = $(c_1+d/2)-c_{AB}$

J_c = $(c_1+d/2)*d^3/6+2d*(c_{AB}^3 + c_{CD}^3/3+d*(c_2+d)c_{AB}^2$

γ_V = $1- \{1/[1+ (2/3) * ((c_1 + d/2) / () c_2 + d))^{1/2}]\}$

Where c_1 and c_2 are the column dimensions with c_1 parallel to the axis of moment, and d is the effective depth.

5.10.2.3 Edge Column (Refer Fig. 5.10-4)

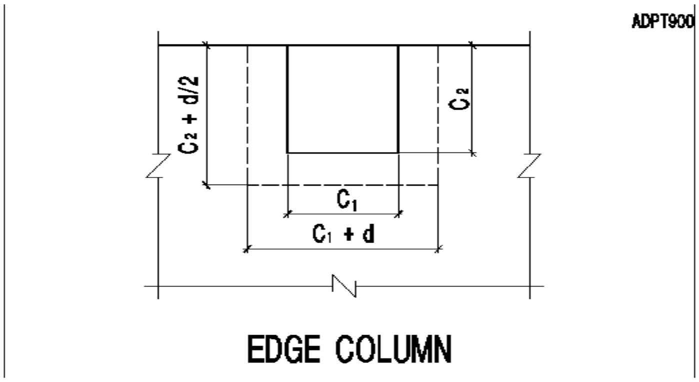


Figure 5.10-4 - For a Design Strip in Left-Right Direction

A_c = $d\,(2c_2 + c_1 + 2d)$

J_c = $(c_1 + d)^3 * d/12 + (c_1 + d) * d^3/12 + d*(c_2 + d/2) * (c_1 + d)^2/2$

γ_V = $1 - \{1/[1 + (2/3) * ((c_1 + d) / (c_2 + d/2))^{1/2}]\}$

Where c_1 and c_2 are the column dimensions with c_1 perpendicular to the axis of moment and d is the effective depth.

Column at the re-entrant corner as shown in **Fig.5.10-5** is treated as Edge-column.

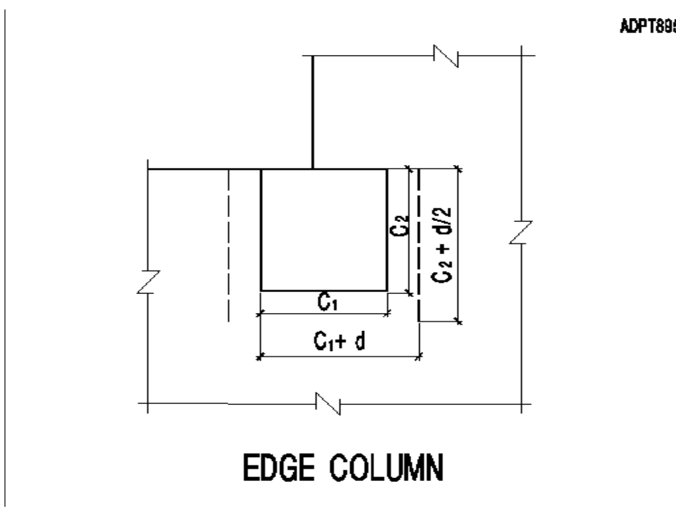


Figure 5.10-5

5.10.2.4 Corner Column (Refer Fig. 5.10-6)

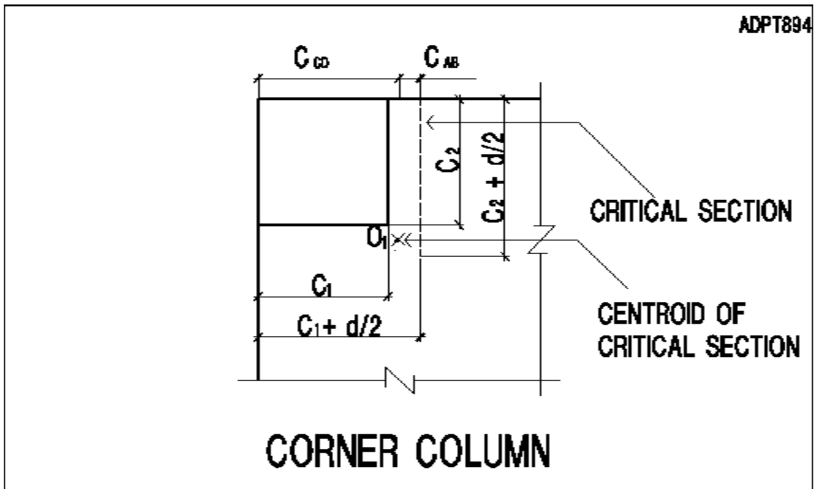


Figure 5.10-6

A_c = d (c_1 + c_2 + d)

c_{AB} = $(c_1+d/2)^2$ /2*(c_1+c_2+d)

c_{CD} = (c_1+d/2) - c_{AB}

J_c = (c_1+d/2)*d^3/12+d*(c_{AB}^3 + c_{CD}^3)/3+d*(c_2 + d/2)c_{AB}^2

γ_V = 1- {1/[1+ (2/3) * $((c_2+d/2)/(c_1+d/2))^{1/2}$]}

Where c_1 and c_2 are the column dimensions with c_1 parallel to the axis of moment and d is the effective depth.

For corner columns (Fig. 1.1-6) the column reaction does not act at the centroid of the critical section. The governing moment for the analysis of the design section is:

M_{ue} = M_u – V_u* e

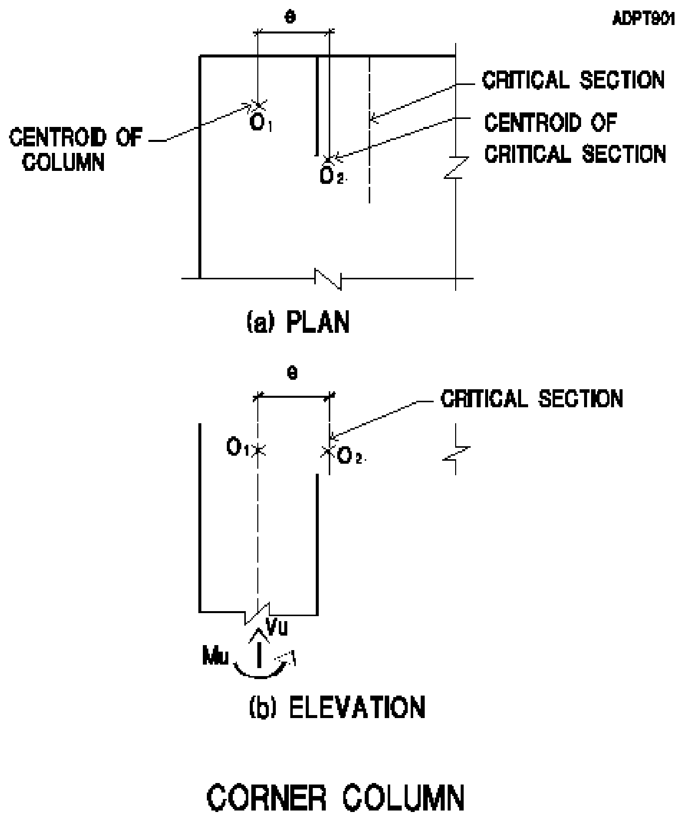


Figure 5.10-7

5.10.2.5 Support with Drop Cap (Refer Fig. 5.10-8)

For supports provided with drop caps, or drop panels, a minimum of two punching shear checks are necessary. The first check is at distance "$d_1/2$" from the face of the column, where d_1 is the effective depth of the thickened section (drop cap or drop panel). The second check is at a distance $d_2/2$ from the face of drop cap/panel, where d_2 is the slab thickness.

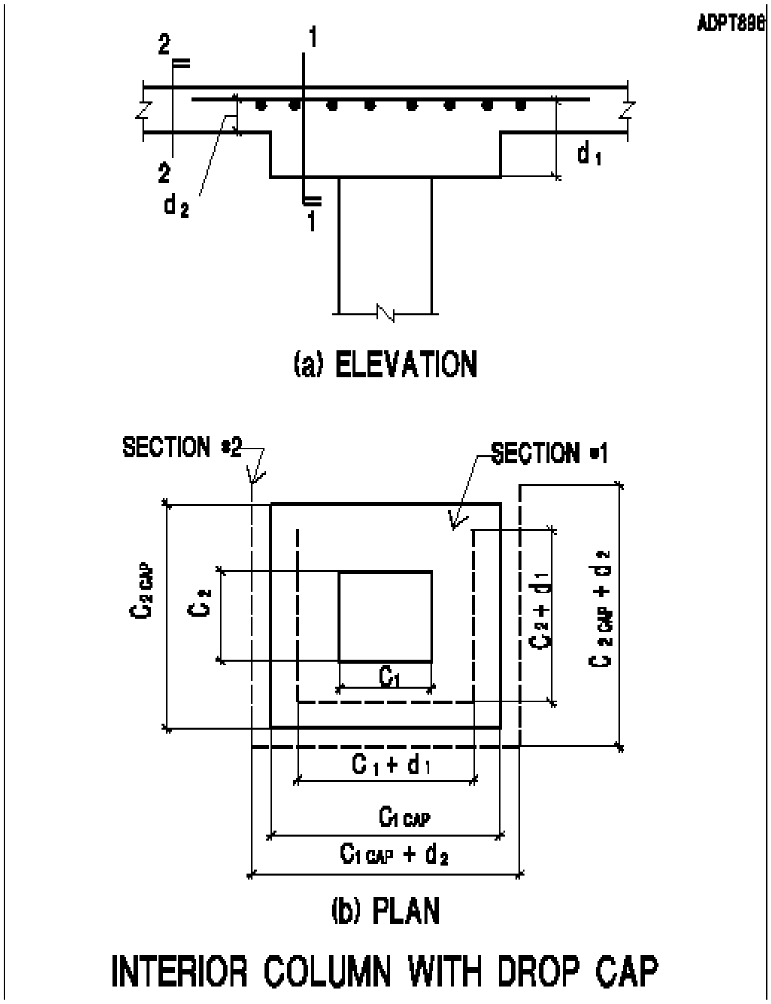


Figure 5.10-8

5.10.3 Punching Shear Stress Calculations

In order to keep the focus on punching shear stress calculation, the work starts by assuming that the design values (M_u and V_u) for each column-slab condition are given. In the general case, these are calculated from the analysis of a design strip, using the Equivalent Frame Method, or Finite Elements. The values used in this writing are obtained from an ADAPT-PT computer run. The hand calculations of the stresses are compared with the computer output for verification. Excellent agreement is obtained.

5.10.3.1 Support #1 – Corner Column (Refer Fig. 5.10-6)

Actions at the joint are:

V_u = 44.96 kips (199.99 kN) (B 13.2, C4)

M_u = 111.67 kip-ft (151.40 kN-m) (B 13.2, C5)

Layer-1- d/2 from the face of support:

(i) Section Properties for Shear Stress

Column width, c_1 = 24 in (610 mm)
Column depth, c_2 = 24 in (610 mm)
Slab depth, h = 9 in (229 mm)
Rebar used #5, diameter = 0.625 in (16 mm)
Top Cover to rebar = 0.75 in (19 mm)
d = 9 - 0.75 - 0.625
= 7.625 in (194 mm)

Since top bars in one direction are placed above the top bars in the other direction, the d value in this case is measured from the bottom of the slab to the bottom of the top layer of rebar.

For corner columns (**Fig. 5.10-7**) the column reaction does not act at the centroid of the critical section. The governing moment for the analysis of the design section is:

$M_{ue} = M_u – V_u * e$

Where "e" is the eccentricity between the centroid of the column and that of the critical section being considered.

$c_1 + d/2$ = 24+(7.625/2) = 27.81 in (706 mm)
$c_2 + d/2$ = 24+(7.625/2) = 27.81 in (706 mm)
A_c = $d(c_1+c_2+d)$ = 7.625 * (24+ 24+ 7.625)
= 424.14 in^2 (2.736e+5 mm^2)
c_{AB} = $(c_1+d/2)^2/2*(c_1 + c_2 + d)$
= 27.8132/(2*(24+24+7.625))
= 6.953 in (177 mm)
c_{CD} = $(c_1 + d/2)-c_{AB}$
= 27.813 - 6.953 = 20.860 in (530 mm)

J_c = $(c_1 + d/2)*d^3/12+d*(c_{AB}^3 + c_{CD}^3)/3 +d* (c_2 + d/2) c_{AB}^2$
= 27.813* 7.625 3/12+ 7.625 *(6.953 3 + 20.8603)/3+ 7.625 *27.813 * 6.953^2
= 35,205 in^4 (1.465e+10 mm^4)

γ_V = $1- \{1/[1+ (2/3) * ((c_2 +d/2) / (c_1 +d/2))^{1/2}]\}$
= $1- \{1/[1+ (2/3) * (27.813 / 27.813)^{1/2}]\}$
= 0.40

(ii) Stress Due to Shear

V_u/A_c = 44.96 / 424.14
= 0.106 ksi (0.73 MPa) (ADAPT-PT 0.11 ksi, B13.2, C6)

(iii) Stress Due to Bending

For the first support, if the column moment is clockwise, the moment due to shear must be deducted from the column moment.

Eccentricity, e = $(c_1+d/2) - c_{AB} - c_1/2$ =27.813 – 6.953 – 12
= 8.860 in (225 mm)
M_{ue} = 111.67 - 44.96 * 8.860 /12
= 78.47 kip-ft (106.40 kN-m)
M_{stress} = $(\gamma V * M_{ue} * c_{AB})/ J_c$
= (0.40 * 78.47 * 12 * 6.953)/ 35,205
= 0.074 ksi (0.51 MPa)
(ADAPT-PT 0.074 ksi, B13.2, C7)

(iii) Total Stress

Total stress = Stress due to shear + stress due to bending
= 0.106 +0.074
= 0.180 ksi (1.24 MPa)
(ADAPT-PT 0.180 ksi, B13.2, C8)

(v) Allowable Stress

Column cross section is closer to a discontinuous edge than 4 times the slab thickness. Therefore, according to ACI-318(2014):

∴ Allowable stress is the least of

$\phi\, v_c$ = $\phi*(2+4/\beta_c)* \sqrt{f'_c}$
ϕ = 0.75
β_c = long side of column/ short side of column
= long side of column/ short side of column
$\therefore \phi v_c$ = 0.75 *(2 + 4/1)* $\sqrt{4000}$/1000
= 0.285 ksi (1.96 MPa)

ϕv_c = $\phi*((\alpha_s* d/ b_0)+2)* \sqrt{f'_c}$
α_s = 20 for corner columns
d = 7.625 in (194 mm)
b_0 = Perimeter of the critical section
= 2 * 27.813 = 55.626 in (1413 mm)

ϕv_c = 0.75 *((20 * 7.625/ 55.626)+ 2)*√4000/1000
= 0.225 ksi (1.55 MPa)

ϕv_c = ϕ*4*√f'$_c$
= 0.75 * 4 * √4000/1000
= 0.190 ksi (1.31 MPa) ----------------- Controls

∴ Allowable Stress = 0.190 ksi (1.31 MPa)
(ADAPT-PT 0.190 ksi, B13.2, C9)

(iv) Stress Ratio

Stress ratio = Actual / Allowable
= 0.180 / 0.190
= 0.95 < 1 (ADAPT-PT 0.951, B13.2, C10)

∴ No reinforcement required.

5.10.3.2 Support #2 – Edge Column (Refer Fig. 5.10-4)

Actions at the joint are:

V_u = 99.65 kips (443.26 kN) (B 13.2, C4)
M_u = 35.45 kip-ft (48.06 kN-m) (B 13.2, C5)

Layer-1- d/2 from the face of support:

(i) Section Properties for Shear Stress Computations

Column width, c_1 = 24 in (610 mm)
Column depth, c_2 = 24 in (610 mm)
Slab depth, h = 9 in (229 mm)
Rebar used #5, diameter = 0.625 in (16 mm)
Top Cover to rebar = 0.75 in (19 mm)
d = 9 - 0.75 - 0.625
= 7.625 in (194 mm)

Since top bars in one direction are placed above the top bars in the other direction, the d value in this case is measured from the bottom of the slab to the bottom of the top layer of rebar.

c_1+ d = 24 + 7.625 = 3 1.63 in (803 mm)
c_2 +d/2 = 24 + 7.625/2 = 27.81 in (706 mm)
A_c = d (2c_2 + c_1 + 2d) = 7.625 * (2*24+ 24+ 2*7.625)
= 665.28 in^2 (4.292e+5 mm^2)

J_c = $(c_1+d)^3 *d /12 + (c_1 + d)*d^3/12+d*(c_2+d/2)*(c_1+ d)^2/2$
= $31.625^3 *7.625 / 12 + 31.625 * 7.625^3 / 12+7.625 * 27.813 *31.625^2/2$
= 127,318 in^4 (5.299e+10 mm^4)

γ_V = $1- \{1/[1+ (2/3) * ((c_1 +d) / (c_2 +d/2)^{1/2}]\}$
= $1- \{1/[1+ (2/3) * (31.625 / 27.813)^{1/2}]\}$
= 0.416

(ii) Stress Due to Direct Shear

V_u/A_c = 99.65 / 665.28
= 0.150 ksi (1.03 MPa) (ADAPT-PT 0.15 ksi, B13.2, C6)

(iii) Stress Due to Bending

M_{stress} = $\gamma_V * M_u * (c_1+ d))/2* Jc$
= (0.416 * 35.46 * 12 * 31.625) / 2*127,318
= 0.022 ksi (0.15 MPa) (ADAPT-PT 0.022 ksi, B13.2, C7)

(iv) Total Stress

Total stress = Stress due to shear + stress due to bending
= 0.150 + 0.022
= 0.172 ksi (1.18 MPa)
(ADAPT-PT 0.172 ksi, B13.2, C8)

(v) Allowable Stress

Column cross section is closer to a discontinuous edge than 4 times the slab thickness. Therefore, according to ACI-318(2014):

∴ Allowable stress is the least of

ϕv_c = $\phi *(2 + 4/ \beta_c)* \sqrt{f'_c}$
ϕ = 0.75
β_c = long side of column/ short side of column
= 24/24 =1
∴ ϕv_c = $0.75 *(2 + 4/1)* \sqrt{4000}/1000$
= 0.285 ksi (1.96 MPa)

ϕv_c = $\phi *((\alpha_s* d/ b_0)+ 2)* \sqrt{f'_c}$
α_s = 30 for edge column
d = 7.625 in (194 mm)
b_0 = Perimeter of the critical section
= 2 * 27.813 +31.625 = 87.251 in (2216 mm)

ϕv_c = 0.75 *((30 * 7.625/ 87.251)+ 2)* √4000/1000
= 0.219 ksi (1.51 MPa)

ϕv_c = ϕ *4* √f'$_c$
= 0.75 * 4 * √4000/1000
= 0.190 ksi (1.31 MPa) ----------------- Controls

Allowable Stress = 0.190 ksi (1.31 MPa)
(ADAPT-PT 0.190 ksi, B13.2, C9)

(v) Stress Ratio

Stress ratio = Actual / Allowable
= 0.172 / 0.190
= 0.91 < 1 (ADAPT-PT 0.905, B13.2, C10)

∴ No reinforcement required.

5.10.3.3 Support #3 – Edge Column (Refer Fig. 5.10-5)

Actions at the joint are:

V_u = 155.12 kips (690.00 kN) (B 13.2, C4)
M_u = 172.43 kip-ft (233.78 kN-m) (B 13.2, C5)

Layer-1- d/2 from the face of support:

(i) Section Properties for Shear Stress Computations

Column width, c_1 = 28 in (711 mm)
Column depth, c_2 = 28 in (711 mm)
Slab depth, h = 9 in (229 mm)
Rebar used #5, diameter = 0.625 in (16 mm)
Top Cover to rebar = 0.75 in (19 mm)
d = 9 - 0.75 - 0.625
= 7.625 in (194 mm)

Since top bars in one direction are placed above the top bars in the other direction, the d value in this case is measured from the bottom of the slab to the bottom of the top layer of rebar.

c_1+ d = 28 + 7.625 = 35.63 in (905 mm)
c_2 +d/2 = 28 + 7.625/2 = 31.81 in (808 mm)
A_c = d (2c_2 + c_1 + 2d) = 7.625 * (2*28+ 28+ 2*7.625)
= 756.78 in^2 (4.882e+5 mm^2)

J_c = $(c_1+d)^3 * d / 12 + (c_1 + d)*d^3/12 + d*(c_2+d/2)*(c_1+ d)^2/2$
= $35.625^3 * 7.625 / 12 + 35.625 * 7.625^3/12 + 7.625 * 31.813 * 35.625^2/2$
= 183,976 in^4 (7.658e+10 mm^4)

γ_V = $1- \{1/[1+ (2/3) * ((c_1 +d) / (c_2 +d/2)^{1/2}]\}$
= $1- \{1/[1+ (2/3) * (35.625 / 31.813)^{1/2}]\}$
= 0.414

(ii) Stress Due to Direct Shear

V_u / A_c = 155.12 / 756.78
= 0.205 psi (1.41 MPa)

(iii) Stress Due to Bending

M_{stress} = $(\gamma_V * M_u * (c_1+ d))/2* Jc$
= (0.414 * 172.43 * 12 * 35.625) / 2*183,976
= 0.083 psi (0.57 MPa)

(iv) Total Stress

Total stress = Stress due to shear + stress due to bending
= 0.205 + 0.083
= 0.288 ksi (1.99 MPa)
(ADAPT-PT 0.288 ksi, B30, C9)

(v) Allowable Stress

Column cross section is closer to a discontinuous edge than 4 times the slab thickness. Therefore, according to ACI318(2014):

∴ Allowable stress is the least of

ϕv_c = $\phi *(2 + 4/ \beta_c)* \sqrt{f'_c}$
ϕ = 0.75
β_c = long side of column/ short side of column
= 28/28 =1
$\therefore \phi v_c$ = $0.75 *(2 + 4/1)* \sqrt{4000}/1000$
= 0.285 ksi (1.96 MPa)
ϕv_c = $\phi*((\alpha_s* d/ b_0)+ 2)* \sqrt{f'_c}$
α_s = 30 for edge column
d = 7.625 in (194 mm)
b_0 = Perimeter of the critical section
= 2 * 31.813 +35.625
= 99.251 in (2521 mm)

ϕv_c = 0.75 *((30 * 7.625/ 99.251)+ 2)* √4000/1000
= 0.204 ksi (1.41 MPa)

ϕv_c = ϕ *4* $\sqrt{f'_c}$
= 0.75 * 4 * √4000/1000
= 0.190 ksi (1.31 MPa) ----------------- Controls

∴ Allowable Stress = 0.190 ksi (1.31 MPa)
(ADAPT-PT 0.190 ksi, B30, C10)

(v) Stress Ratio

Stress ratio = Actual / Allowable
= 0.288 / 0.190
= 1.52 > 1 N.G (ADAPT-PT 1.52, B30, C11)

Per ACI318, if the actual stress exceeds the code allowable maximum stress, enlarge the section resisting the punching shear. The program continues with the calculation of shear stress for the successive layers to give an idea to the users.

5.10.3.4 Support #4 – Interior Column (Refer Fig. 5.10-2)

Actions at the joint are:

V_u = 198.19 kips (881.59 kN) (B 13.2, C4)
M_u = 29.03 kip-ft (39.41 kN-m) (B 13.2, C5)

Layer-1- d/2 from the face of support:

(i) Section Properties for Shear Stress Computations

Column width, c_1 = 24 in (610 mm)
Column depth, c_2 = 24 in (610 mm)
Slab depth, h = 9 in (229 mm)
Rebar used #5, diameter = 0.625 in (16 mm)
Top Cover to rebar = 0.75 in (19 mm)
d = 9 - 0.75 - 0.625
= 7.625 in (194 mm)

Since top bars in one direction are placed above the top bars in the other direction, the d value in this case is measured from the bottom of the slab to the bottom of the top layer of rebar.

$c_1 + d$ = 24 + 7.625 = 31.63 in (803 mm)
$c_2 + d$ = 24 + 7.625 = 31.63 in (803 mm)
A_c = $2d(c_1 + c_2 + 2d))$ = 2*7.625 * (24+ 24+ 2*7.625)
= 964.56 in^2 (6.223e+5 mm^2)
J_c = $(c_1+ d)*d^3/6+(c_1 + d)^3*d/6 +d*(c_2 + d)*(c_1+ d)^2/2$
= $31.625*7.625^3/6 +31.625^3*7.625/6+7.625 *31.625* 31.625^2/2$
= 163,120 in^4 (6.790e+10 mm^4)
γ_V = $1- \{1/[1+ (2/3) * ((c_1 +d) / (c2 +d))^{1/2}]\}$
= $1- \{1/[1+ (2/3) * (31.625 / 31.625)^{1/2}]\}$
= 0.40

(ii) Stress Due to Direct Shear

V_u / A_c = 198.19 / 964.56
= 0.205 ksi (1.42 MPa)

(iii) Stress Due to Bending

M_{stress} = $(\gamma_V*M_u*(c_1+ d))/(2* J_c)$
= (0.40 * 29.03 * 12 * 31.625)/2*163,120
= 0.014 ksi (0.09 MPa)

(iv) Total Stress

Total stress = Stress due to shear + stress due to bending
= 0.205 + 0.014
= 0.219 psi (1.51 MPa)
(ADAPT-PT 0.219 ksi, B30, C9)

(v) Allowable Stress

From ACI318(2014):

Allowable Stress is

ϕv_c = $\phi *[(\beta_P*\sqrt{f'_c}+0.3*f_{pc})+V_p]$

where,

ϕ = 0.75
β_P is the smaller of 3.5 or $((\alpha_s*d/b_0)+ 1.5)$

α_s = 40 for interior column
b_0 = Perimeter of the critical section
= 4 * 31.625
= 126.50 in (3213 mm)
d = 7.625 in (194 mm)
β_P = $((\alpha_s*d/b_0)+1.5)$ = ((40* 7.625 / 126.50)+ 1.5)
= 3.91 >3.50, ∴ use 3.50
f_{pc} = P/A = 125.03 psi (0.86 MPa) (ADAPT-PT B 7.2)

ϕv_c = 0.75 *(3.5*√4000 + 0.3 *125.03)/1000
= 0.194 ksi (1.34 MPa)]

∴ Allowable Stress = 0.194 ksi (1.34 MPa)
(ADAPT-PT 0.194 ksi, B30, C10)

Note that in the evaluation of allowable stresses, the term corresponding to the vertical component of tendon force (V_p) is conservatively disregarded.

(vi) Stress Ratio

Stress ratio = Actual / Allowable
= 0.219 / 0.194
= 1.13 > 1 (ADAPT-PT 1.13, B30, C11)

Punching Shear Stress exceeds the permissible value. Provide shear reinforcement.

(vii) Check Maximum Shear stress

$\varphi v_n \leq \varphi 6*\sqrt{f'_c}$
$\varphi 6*\sqrt{f'_c}$ = 0.75*6*√4000/1000
= 0.285 ksi > 0.219 ksi **OK**

(viii) Shear Reinforcement Design

$$A_v = \frac{(v_u - \varphi v_c) b_0 s}{\varphi \ f_y \sin\alpha}$$

$\varphi v_c = \varphi 2\sqrt{f'_c}$ = 0.75* 2√4000 /1000 = 0.095 ksi

$$Av = \frac{(0.219 - 0.095)126.50 \times 7.625/2}{0.75 \times 60}$$ = 1.33 in^2

(ADAPT 1.33, B30, C12)

Assume #5 stirrups, area of 1 leg = 0.31 in^2

Number of legs, N_{legs}	= 1.33 / 0.31 = 4.3
Distance between the legs	= b_0 / N_{legs} = 126.50/5
	= 25.30 in
	> s_{max} =2d = 15.25 in
∴ Distance between the legs	= 15.25 in (ADAPT 15.25, B30, C14)
∴ Number of legs, N_{legs}	= 126.50 / 15.25
	= 8.30 ≈ 9 (ADAPT 9, B30, C13)

Since the stress exceeded at this location, check the next critical location at d from the face of support.

Layer-2- d from the face of support:

(i) Section Properties for Shear Stress Computations

Column width, c_1	= 24 in (610 mm)
Column depth, c_2	= 24 in (610 mm)
Slab depth, h	= 9 in (229 mm)
Rebar used #5, diameter	= 0.625 in (16 mm)
Top Cover to rebar	= 0.75 in (19 mm)
d	= 9 - 0.75 - 0.625
	= 7.625 in (194 mm)

Since top bars in one direction are placed above the top bars in the other direction, the d value in this case is measured from the bottom of the slab to the bottom of the top layer of rebar.

c_1+ 2d = 24 + 2*7.625 = 39.25 in (997 mm)
c_2 +2d = 24 + 2* 7.625 = 39.25 in (997 mm)
A_c = 2d(c_1 + c_2 + 4d)) = 2*7.625 * (24+ 24+ 4*7.625)
= 1197.13 in^2 (7.723e+5 mm^2)
J_c = (c_1+ 2d)*d^3/6+ (c_1 + 2d)^3*d/6 +d* (c_2 + 2d)*(c_1+ 2d)^2 /2
= 39.25*7.625 3/6 +39.25 3*7.625 /6+7.625 *39.25* 39.25 2 /2
= 310274 in^4 (12.91+10 mm^4)
γ_V = 1- {1/[1+ (2/3) * ((c_1 +2d) / (c_2 +2d))$^{1/2}$]}
= 1- {1/[1+ (2/3) * (39.25 / 39.25)$^{1/2}$]}
= 0.40

(ii) Stress Due to Direct Shear

V_u / A_c = 198.19 / 1197.13
= 0.166 ksi (1.14 MPa)

(iii) Stress Due to Bending

M_{stress} = $(\gamma_V * M_u * (c_1+2d))/ (2*J_c)$
= (0.40 * 29.03 * 12 * 39.25)/ 2*310274
= 0.009 ksi (0.06 MPa)

(iv) Total Stress

Total stress = Stress due to shear + stress due to bending
= 0.166 + 0.009
= 0.175 psi (1.21 MPa)
(ADAPT-PT 0.174 ksi, B30, C9)

(v) Allowable Stress

From ACI318(2014):
Allowable Stress is

ϕv_c = $\phi *[(\beta_P * \sqrt{f'_c} + 0.3 * f_{pc}) + V_p]$

where,

ϕ = 0.75
β_P is the smaller of 3.5 or $((\alpha_s * d/ b_0) + 1.5)$
α_s = 40 for interior column
b_0 = Perimeter of the critical section
= 4 * 39.25
= 157 in (3988 mm)
d = 7.625 in (194 mm)
β_P = $((\alpha_s * d/ b_0) + 1.5) = ((40 * 7.625 / 157) + 1.5)$
= 3.44 <3.50,
f_{pc} = P/A = 125.03 psi (0.86 MPa) (ADAPT-PT B 7.2)

ϕv_c = $0.75 *(3.44 * \sqrt{4000} + 0.3 * 125.03)/1000$
= 0.191 ksi (1.32 MPa)

∴ Allowable Stress = 0.191 ksi (1.32 MPa)
(ADAPT-PT 0.191 ksi, B30, C10)

Note that in the evaluation of allowable stresses, the term corresponding to the vertical component of tendon force (Vp) is conservatively disregarded.

ACI -318 requires to check the shear stress at the section d/2 outside the outermost line shear reinforcement against $\phi * 2 * \sqrt{f'_c}$

Therefore program considers this limit with the allowable stress if any layer needed shear reinforcement by calculation.

ϕv_c = ϕ *2*√f'$_c$ = 0.75 *2* √4000/1000 = 0.095 ksi

(vi) Stress Ratio

Stress ratio = Actual / Allowable
= 0.175 / 0.191
= 0.92 < 1 & > 0.095 ksi (ADAPT-PT 0.91, B30, C11)

Punching Shear Stress exceeds the permissible value. Provide shear reinforcement.

(vii) Check Maximum Shear stress

$\phi v_n \leq \phi 6*\sqrt{f'_c}$
$\phi 6*\sqrt{f'_c}$ = 0.75*6*√4000/1000
= 0.285 ksi > 0.175 ksi **OK**

(viii) Shear Reinforcement Design

A_v = [(v_u- ϕv_c) b_0*s/(ϕ*fy*sinα)]
ϕv_c = ϕ*2*√f'$_c$ = 0.75*2√4000/1000 = 0.095 ksi
A_v = [(0.175- 0.095) 157*7.625/2]/(0.75*60)
= 1.06 in2 (ADAPT 1.06, B30, C12)

Assume #5 stirrups, area of 1 leg = 0.31 in^2
Number of legs, N_{legs} = 1.06/0.31 = 3.4
Distance between the legs = b_0/N_{legs}
= 157/4
= 39.25 in
> s_{max} =2d = 15.25 in

∴ Distance between the legs = 15.25 in
(ADAPT 15.25, B30, C14)
∴ Number of legs, N_{legs} = 157 / 15.25
= 10.30 ≈ 11
(ADAPT 11, B30, C13)

Since the stress exceeded at this location, check the next layer at d/2 from this layer.

The total stress shall not exceed ϕ*2*√f'$_c$ at the critical section located d/2 outside the outermost layer of the shear reinforcement.

5.10.3.5 Support #5 – Interior Column with Drop Cap (Refer Fig. 5.10-8)

Actions at the joint are:

V_u = 212.75 kips (946.35 kN) (B 13.2, ADAPT PT)
M_u = 36.01 kip-ft (48.82 kN-m)

Check whether the critical section lies within the cap or slab.

Section #1 (d/2 from the Column Face)

(i) Section Properties for Shear Stress Computations

Column width, c_1 = 18 in (457 mm)
Column depth, c_2 = 18 in (457 mm)
Slab depth, h = 9 +9 = 18 in (457 mm)
Rebar used #5, diameter = 0.625 in (16 mm)
Top Cover to rebar = 0.75 in (19 mm)
d1 = 18- 0.75- 0.625
= 16.625 in (422 mm)

Since top bars in one direction are placed above the top bars in the other direction, the d_1 value in this case is measured from the bottom of the drop panel to the bottom of the top layer of rebar.

$c_1 + d_1$ = 18 + 16.625 = 34.63 in (880 mm)
$c_2 + d_1$ = 18 + 16.625 = 34.63 in (880 mm)
A_c = $2d(c_1 + c_2 + 2d)$)= 2*16.625 * (18+ 18+ 2*16.625)
= 2302.56 in^2 (1.486e+6 mm^2)
J_c = $(c_1+ d)*d^3/6+ (c_1 + d)^3*d/6 +d* (c_2 + d)*(c_1+ d)^2 /2$
= $34.625*16.625^3/6 +34.625^3*16.625 /6+16.625 *34.625* 34.625^2 /2$
= 486,604 in^4 (2.025e+11 mm^4)
γ_V = $1- \{1/[1+ (2/3) * ((c_1 +d) / (c_2 +d))^{1/2}]\}$
= $1- \{1/[1+ (2/3) * (34.625 / 34.625)^{1/2}]\}$
= 0.40

(ii) Stress Due to Direct Shear

V_u / A_c = 212.75 / 2302.56
= 0.092 ksi (0.64 MPa)

(iii) Stress Due to Bending

M_{stress} = $(\gamma_V * M_u * (c_1 + d))/ (2* J_c)$
= (0.40 * 36.01 * 12 * 34.625)/ 2*486,604
= 0.006 ksi (0.04 MPa)

(iv) Total Stress

Total Stress = Stress due to shear + stress due to bending
= 0.092 + 0.006
= 0.099 ksi (0.68 MPa)
(ADAPT-PT 0.099 ksi, B30, C9)

(v) Allowable Stress

From ACI318(2014):
Allowable Stress is

ϕv_c = $\phi*[(\beta_P*\sqrt{f'_c} + 0.3*f_{pc})+V_p]$

where,

ϕ = 0.75
β_P is the smaller of 3.5 or $((\alpha_s * d/ b_0) + 1.5)$
α_s = 40 for interior column
b_0 = Perimeter of the critical section
= 4 * 34.625
= 138.50 in (3518 mm)
d = 16.625 in (422 mm)
β_P = $((\alpha_s * d/ b_0) + 1.5)$ = ((40* 16.625 / 138.50)+ 1.5)
= 6.30 >3.50, $\therefore$ use 3.50
f_{pc} = P/A = 125.03 psi (0.86 MPa) (ADAPT-PT B 7.2)

ϕv_c = $0.75 *(3.5* \sqrt{4000} + 0.3 *125.03)/1000$
= 0.194 ksi (1.34 MPa)
(ADAPT-PT 0.190 ksi, B30, C10)

Note that in the evaluation of allowable stresses, the term corresponding to the vertical component of tendon force (Vp) is conservatively disregarded.

(vi) Stress Ratio

Stress Ratio = Actual / Allowable
= 0.099 / 0.194

= 0.51 (ADAPT-PT 0.52, B30, C11)

Section #2 (d/2 from the Drop Cap Face)

(i) Section Properties for Shear Stress Computations

Cap width, c_1 = 45 in (1143 mm)
Cap depth, c_2 = 45 in (1143 mm)
Slab depth, h = 9 in (229 mm)
Rebar used #5, diameter = 0.625 in (16 mm)
Top Cover to rebar = 0.75 in (19 mm)
d_2 = 9- 0.75- 0.625
= 7.625 in (194 mm)

Since top bars in one direction are placed above the top bars in the other direction, the d_2 value in this case is measured from the bottom of the slab to the bottom of the top layer of rebar.

$c_{1\,CAP} + d_2$ = 45 + 7.625 = 52.63 in (1337 mm)
$c_{2\,CAP} + d_2$ = 45 + 7.625 = 52.63 in (1337 mm)
A_c = $2d(c_1 + c_2 + 2d)$ = 2*7.625 * (45+ 45+ 2*7.625)
= 1605.06 in^2 (1.036e+6 mm^2)
Jc = $(c_1+ d)*d^3/6+(c_1 + d)^3*d/6 +d*(c_2 + d)*(c_1+d)^2/2$
= (52.625 *7.625 3)/6 +(52.625 3*7.625) /6+(7.625 *52.625*52.625 2) /2
= 744,729 in^4 (3.100e+11 mm^4)
γ_V = $1- \{1/[1+ (2/3) * ((c_1 +d) / (c_2 +d))^{1/2}]\}$
= $1- \{1/[1+ (2/3) * (52.625 / 52.625)^{1/2}]\}$
= 0.40

(ii) Stress Due to Direct Shear

V_u / A_c = 212.75 / 1605.06
= 0.133 ksi (0.91 MPa)

(iii) Stress Due to Bending

M_{stress} = $(\gamma_V*M_u*(c_1+d))/(2*J_c)$
= (0.40 * 36.01 * 12 * 52.625)/ 2*744,729
= 0.006 ksi (0.04 MPa)

(iv) Total Stress

Total Stress = Stress due to shear + stress due to bending
= 0.133 + 0.006
= 0.139 ksi (0.96 MPa)

(ADAPT-PT 0.139 ksi, B30, C9)

(v) Allowable Stress

From ACI318(2014):

Allowable Stress,

ϕv_c = $\phi*[(\beta_P*\sqrt{f'_c} + 0.3*f_{pc}) + V_p]$

where,

ϕ = 0.75
β_P is the smaller of 3.5 or (α_s* d/ b_0)+ 1.5)
αs = 40 for interior column
b0 = Perimeter of the critical section
= 4 * 52.625
= 210.50 in (5347 mm)
d = 7.625 in (194 mm)
β_P = (α_s* d/ b_0)+ 1.5)
= (40* 7.625 / 210.50)+ 1.5)
= 2.95 < 3.50, ∴ use 2.95
= P/A = 125.03 psi (0.86 MPa) (ADAPT B7.2)

∴ Allowable Stress = 0.168 ksi (1.16 MPa)
(ADAPT-PT 0.164 ksi, B30, C10)

Note that in the evaluation of allowable stresses, the term corresponding to the vertical component of tendon force (Vp) is conservatively disregarded.

(vi) Stress Ratio

Total Stress = Actual / Allowable
= 0.139 / 0.168
= 0.83 < 1, OK (ADAPT-PT 0.85, B30, C11)

5.10.3.6 Support #6 – End Column (Refer Fig. 5.10-3)

Actions at the joint are:

V_u = 100.95 kips (449.05 kN) (B 30.2, ADAPT PT)
M_u = 338.14 kip-ft (458.45 kN-m)

(i) Section Properties for Shear Stress Computations

Column width, c_1 = 28 in (711 mm)
Column depth, c_2 = 28 in (711 mm)
Slab depth, h = 9 in (229 mm)
Rebar used #5, diameter = 0.625 in (16 mm)
Top Cover to rebar = 0.75 in (19 mm)
d = 9 - 0.75 - 0.625
= 7.625 in (194 mm)

Since top bars in one direction are placed above the top bars in the other direction, the d value in this case is measured from the bottom of the slab to the bottom of the top layer of rebar.

$c_1 + d/2 = 28 + 7.625/2 = 31.81$ in (808 mm)
$c_2 + d = 28 + 7.625 = 35.63$ in (905 mm)
$A_c = d\,(2c_1 + c_2 + 2d) = 7.625 * (2*28 + 28 + 2*7.625)$
$= 756.78$ in^2 (4.882e+5 mm^2)
$c_{AB} = (c_1 + d/2)^2 / (2c_1 + c_2 + 2d)$
$= 31.813^2 / (2*28 + 28 + 2*7.625)$
$= 10.200$ in (259 mm)
$c_{CD} = 31.813 - 10.200$
$= 21.613$ in (549 mm)
$J_c = 31.813 * 7.625^3/6 + 2*7.625 * (10.200^3 + 21.613^3)/3 + 7.625 * 35.625 * 10.200^2$
$= 87{,}327$ in^4 (3.635e+10 mm^4)
$\gamma_V = 1 - \{1/[1 + (2/3) * ((c_1 + d/2) / (c_2 + d))^{1/2}]\}$
$= 1 - \{1/[1 + (2/3) * (31.813 / 35.625)^{1/2}]\}$
$= 0.386$

(ii) Stress Due to Direct Shear

$V_u / A_c = 100.97 / 756.78$
$= 0.133$ ksi (0.92 MPa)

(iii) Stress Due to Bending

$M_{ue} = M_u - V_u * e$

For the last support, if the column moment is anticlockwise, the moment due to shear must be deducted.

Eccentricity, $e = (c_1 + d/2) - c_{AB} - c_1/2 = 31.813 - 10.200 - 14$
$= 7.613$ in (193 mm)
$M_{ue} = 338.14 - 100.97 * 7.613 / 12$

	= 274.08 kip-ft (371.60 kN-m)
M_{stress}	= $(\gamma_V * M_{ue} * c_{AB})/ J_c$
	= (0.386 * 274.08 * 12 * 10.200)/ 87,327
	= 0.148 ksi (1.02 MPa)

(iv) Total Stress

Total stress	= Stress due to shear + stress due to bending
	= 0.133 + 0.148
	= 0.282 ksi (1.94 MPa)

(ADAPT-PT 0.282 ksi , B30, C9)

(v) Allowable Stress

Column cross section is closer to a discontinuous edge than 4 times the slab thickness. Therefore, according to ACI318(2014), the allowable stress is:

∴ Allowable stress is the least of

ϕv_c	= $\phi*(2 + 4/\beta_c)*\sqrt{f'_c}$
ϕ	= 0.75
β_c	= long side of column/ short side of column
	= 28/28 =1
ϕv_c	= $0.75 *(2 + 4/1)* \sqrt{4000}/1000$
	= 0.285 ksi (1.96 MPa)

ϕv_c	= $\phi*((\alpha_s* d/ b_0)+ 2)*\sqrt{f'_c}$
α_s	= 30 for end column
d	= 7.625 in (194 mm)
b0	= Perimeter of the critical section
	= 2 * 31.813 +35.625
	= 99.251 in (2521 mm)

ϕv_c	= $0.75 *((30 * 7.625/ 99.251)+ 2)* \sqrt{4000}/1000$
	= 0.204 ksi (1.41 MPa)

ϕv_c	= $\phi *4* \sqrt{f'_c}$
	= $0.75 * 4 * \sqrt{4000}/1000$
	= 0.190 ksi (1.31 MPa) ----------------- Controls

∴ Allowable Stress = 0.190 ksi (1.31 MPa)

(ADAPT-PT 0.190 ksi, B30, C10)

(vi) Stress Ratio

Stress ratio = Actual / Allowable
= 0.282 / 0.190
= 1.48 > 1, N.G (ADAPT-PT 1.49, B30, C11)

Punching Shear Stress exceeds the permissible value. Provide shear reinforcement.

(vii) Check Maximum Shear stress

$\phi v_n \leq \phi 6 * \sqrt{f'_c}$

$\phi 6 * \sqrt{f'_c}$ = 0.75*6*√4000/1000
= 0.285 ksi > 0.282 ksi **OK**

(viii) Shear Reinforcement Design

A_v = $[(v_u - \phi v_c)\ b_0 * s / (\phi * fy * \sin_\alpha)]$

ϕv_c = $\phi * 2 * \sqrt{f'_c}$
= 0.75* 2√4000 /1000 = 0.095 ksi

A_v = [(0.282- 0.095) 99.251*7.625/2]/(0.75*60)
= 1.57 in^2 (ADAPT 1.57, B30, C13)

Assume #5 stirrups, area of 1 leg = 0.31 in^2
Number of legs, N_{legs} = 1.57 / 0.31 = 5.06
Distance between the legs = b_0 / N_{legs}
= 99.251/4
= 24.81 in
> s_{max} =2d = 15.25 in
∴ Distance between the legs = 15.25 in
(ADAPT 15.25, B30, C14)
∴ Number of legs, N_{legs} = 99.251 / 15.25
= 6.51 ≈ 7
(ADAPT 7, B30, C13)

Since the stress exceeded at this location, check the next layer at d/2 from this layer.

5.10.4 Computed Values

5.10.4.1 Computer Report for American Units

Comments:

If a stress ratio exceeds the maximum allowable permitted stress (in this case a ratio of 1.5), the section has to be enlarged, or re-designed such as to bring the ratio to 1.50 or less. In this case, column 3 has been conservatively modeled as an "edge column." Its punching shear capacity is larger than assumed in the program. For this reason, it is acceptable if reinforced.

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		Minimum Cover at BOTTOM	0.75 in
F'c for BEAMS/SLABS	4000.00 psi	Post-tensioning	
For COLUMNS/WALLS	4000.00 psi	SYSTEM	UNBONDED
Ec for BEAMS/SLABS	3605.00 ksi	Fpu	270.00 ksi
For COLUMNS/WALLS	3605.00 ksi	Fse	175.00 ksi
CREEP factor	2.00	Strand area	0.153 in 2
CONCRETE WEIGHT	NORMAL	Min CGS from TOP	1.00 in
UNIT WEIGHT	150.00 pcf	Min CGS from BOT for interior spans	1.00 in
Tension stress limits / (f'c)1/2		Min CGS from BOT for exterior spans	1.00 in
At Top	6.000	Min average precompression	125.00 psi
At Bottom	6.000	Max spacing / slab depth	8.00
Compression stress limits / f'c		Analysis and design options	
At all locations	0.450	Structural system	TWO-WAY
Reinforcement		Moment of Inertia over support is	NOT INCREASED
Fy (Main bars)	60.00 ksi	Moments reduced to face of support	YES
Fy (Shear reinforcement)	60.00 ksi	Moment Redistribution	NO
Minimum Cover at TOP	0.75 in	DESIGN CODE SELECTED	ACI-318 (2014)

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		ft	in	in	in	in	in	in	in		
C	1	1.00	192.00	9.00					9.00	0.06	0.94
1	1	25.00	192.00	9.00					9.00	0.06	0.94
2	1	30.00	192.00	9.00					9.00	0.06	0.94
3	1	30.00	360.00	9.00					9.00	0.50	0.50
4	1	30.00	360.00	9.00					9.00	0.50	0.50
5	1	30.00	360.00	9.00					9.00	0.50	0.50
C	1	1.17	360.00	9.00					9.00	0.50	0.50

2.5 Drop Cap and Drop Panel Data

Joint	Cap T	Cap B	Cap DL	Cap DR	Drop TL	Drop TR	Drop B	Drop L	Drop R
	in	in	in	in	in	in	in	in	in

1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	18.00	45.00	22.50	22.50	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	in	ft	in	in			ft	in	in		
1	24.0	10.0	24.0	24.0	100	(1)	10.0	24.0	24.0	100	(1)
2	24.0	10.0	24.0	24.0	100	(1)	10.0	24.0	24.0	100	(1)
3	28.0	10.0	28.0	28.0	100	(1)	10.0	28.0	28.0	100	(1)
4	24.0	10.0	24.0	24.0	100	(1)	10.0	24.0	24.0	100	(1)
5	18.0	10.0	18.0	18.0	100	(1)	10.0	18.0	18.0	100	(1)
6	28.0	10.0	28.0	28.0	100	(1)	10.0	28.0	28.0	100	(1)

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			k/ft2	k/ft	k/ft	ft	ft	ft	k	k-ft
CANT	LL	U	0.040							
CANT	SDL	U	0.020							
1	LL	U	0.040							
1	SDL	U	0.020							
2	LL	U	0.040							
2	SDL	U	0.020							
3	LL	U	0.040							
3	SDL	U	0.020							
4	LL	U	0.040							
4	SDL	U	0.020							
5	LL	U	0.040							
5	SDL	U	0.020							
CANT	LL	U	0.040							
CANT	SDL	U	0.020							

NOTE: SELFWEIGHT INCLUSION REQUIRED (SW= SELF WEIGHT Computed from geometry input and treated as dead loading. Unit selfweight W = 150.0 pcf

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile
Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
CL	1	---	---	0.000	---
1	2	0.000	0.428	0.000	---
2	2	0.000	0.500	0.000	---
3	2	0.000	0.500	0.000	---
4	2	0.000	0.500	0.000	---
5	2	0.000	0.586	0.000	---
CR	1	0.000	---	---	---

7.2 Selected Post-Tensioning Forces and Tendon Drape
Tendon A

Span	Force	CGS Left	CSG C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	k	in	in	in	in	psi	k	
CL	220.000	4.50	---	---	4.50	127.31	0.000	0
1	220.000	4.50	---	1.00	8.00	127.31	1.198	56
2	220.000	8.00	---	1.00	8.00	127.31	1.141	54
3	405.100	8.00	---	1.00	8.00	125.03	2.101	53
4	405.100	8.00	---	1.00	8.00	125.03	2.101	52
5	405.100	8.00	---	1.00	4.50	125.03	1.530	38
CR	405.100	4.50	---	---	4.50	125.03	0.000	0

Approximate weight of strand: 1056.4 LB

7.4 Required Minimum Post-Tensioning Forces

	Based on Stress Conditions			Based on Minimum P/A		
Type	Left	Center	Right	Left	Center	Right
	k	k	k	k	k	k
CL	-----	-----	0.00	-----	-----	216.00
1	52.39	0.00	101.37	216.00	216.00	216.00
2	166.97	59.38	236.38	216.00	216.00	216.00
3	327.37	137.88	366.11	405.00	405.00	405.00
4	321.09	82.36	110.59	405.00	405.00	455.63
5	135.55	128.95	340.18	455.63	405.00	405.00
CR	0.00	-----	-----	405.00	-----	-----

7.5 Service Stresses (tension shown positive)

Envelope of Service 1

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	psi	psi	psi	psi	psi	psi
CL	-----	-----	-----	-----	-127.31	-127.31
1	60.03	-314.65	-263.77	9.14	88.79	-343.42
2	142.53	-397.16	-294.54	39.91	-30.12	-438.74
3	181.98	-432.04	-337.94	87.88	210.83	-460.89
4	172.09	-422.16	-305.97	55.91	68.04	-518.36
5	97.85	-586.12	-380.71	130.65	228.04	-478.11
CR	-125.03	-125.03	-----	-----	-----	-----

Envelope of Service 2

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	psi	psi	psi	psi	psi	psi
CL	-----	-----	-----	-----	-127.31	-127.31
1	134.08	-388.71	-319.15	64.52	178.29	-432.92
2	263.44	-518.07	-371.87	117.24	95.94	-564.81
3	298.76	-548.82	-417.31	167.25	337.06	-587.12
4	289.49	-539.56	-377.98	127.92	143.94	-690.87
5	175.98	-763.68	-455.50	205.43	330.93	-580.99
CR	-125.03	-125.03	-----	-----	-----	-----

7.6 Post-Tensioning Balance Moments, Shears and Reactions
Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right
	k-ft	k-ft	k-ft	k	k
CL	-----	-----	0.00	-----	0.00
1	42.08	-32.26	53.09	2.06	2.06
2	76.48	-50.09	96.42	1.05	1.05
3	119.75	-79.66	127.83	-0.12	-0.12
4	125.08	-77.24	173.42	-0.25	-0.25
5	158.58	-52.77	72.04	-2.38	-2.38
CR	0.00	-----	-----	0.00	-----

Reactions and Column Moments

Joint	Reaction	Moment Lower Column	Moment Upper Column
	k	k-ft	k-ft
1	-2.055	27.783	27.783
2	0.999	12.858	12.858
3	1.172	19.250	19.250
4	0.136	-1.553	-1.553
5	2.127	-10.033	-10.033
6	-2.378	-47.992	-47.992

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	k-ft	k-ft	k-ft	k-ft	k-ft	k-ft
CL	-----	-----	-----	-----	0.00	-----
1	-73.87	-73.87	125.14	125.14	-147.72	-147.72
2	-179.13	-179.13	147.12	147.12	-217.41	-217.41
3	-339.76	-339.76	294.53	294.53	-367.01	-367.01
4	-341.30	-341.30	273.21	273.21	-448.21	-448.21
5	-480.91	-480.91	301.50	301.50	-238.61	-238.61
CR	0.00	-----	-----	-----	-----	-----

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	k	k	k-ft	k-ft	k-ft	k-ft
1	44.96	44.96	-55.84	-55.84	-55.84	-55.84
2	99.66	99.66	-17.73	-17.73	-17.73	-17.73
3	155.11	155.11	-86.22	-86.22	-86.22	-86.22
4	198.17	198.17	14.53	14.53	14.53	14.53
5	212.78	212.78	-17.98	-17.98	-17.98	-17.98
6	100.96	100.96	169.07	169.07	169.07	169.07

8.3 Secondary Moments

Span	Left	Midspan	Right
	k-ft	k-ft	k-ft
1	53.51	29.88	6.25
2	28.85	14.07	-0.53
3	36.88	38.52	40.17
4	37.43	40.94	44.52
5	26.43	60.32	93.25

Note: Moments are reported at face of support

13 - PUNCHING SHEAR REINFORCEMENT

13.1 Critical Section Geometry

Column	Layer	Cond.	a	d	b1	b2
			in	in	in	in
1	1	3	3.81	7.63	27.81	27.81

2	1	4	3.81	7.63	31.63	27.81
3	1	4	3.81	7.63	35.63	31.81
4	1	1	3.81	7.63	31.63	31.63
5	2	1	3.81	7.63	52.63	52.63
6	1	2	3.81	7.63	31.81	35.63

13.2 Critical Section Stresses

Label	Layer	Cond.	Factored shear	Factored moment	Stress due to shear	Stress due to moment	Total stress	Allowable stress	Stress ratio
			k	k-ft	ksi	ksi	ksi	ksi	
1	1	3	-44.96	+111.67	0.11	0.074	0.180	0.190	0.951
2	1	4	-99.65	+35.45	0.15	0.022	0.172	0.190	0.905
3	1	4	-155.12	+172.43	0.20	0.083	0.288	0.190	1.517
4	1	1	-198.19	-29.03	0.21	0.014	0.219	0.194	1.128
5	2	1	-212.75	+36.01	0.13	0.006	0.139	0.164	0.848
6	1	2	-100.95	-338.14	0.13	0.148	0.282	0.190	1.485

13.3 Punching Shear Reinforcement
Reinforcement option: Stirrups
Bar Size: 5

Col.	Dist	N_Legs	Dist	N_Legs	Dist	N_Legs	Dist	N_Legs	Dist	N_Legs
	in		in		in		in		in	
1										
2										
3	***	***								
4	3.8	9	7.6	11	11.4	13	15.3	15	19.1	17
5										
6	3.8	7	7.6	8	11.4	9	15.3	10	19.1	11
6	22.9	12								

Dist. = Distance measured from the face of support
Note: Columns with --- have not been checked for punching shear.
Note: Columns with *** have exceeded the maximum allowable shear stress.

30 - PUNCHING SHEAR REINFORCEMENT

Reinforcement option: Stirrup
Bar Size: 5
Column - 1

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		in	in	in	in	k	k-ft	ksi	ksi		in2		in
1	3	3.81	7.63	27.81	27.81	-44.96	111.67	0.180	0.190	0.95	0.00	0	0.00

Dist. = Distance between the legs

Column - 2

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		in	in	in	in	k	k-ft	ksi	ksi		in2		in
1	4	3.81	7.63	31.63	27.81	-99.65	35.45	0.172	0.190	0.91	0.00	0	0.00

Dist. = Distance between the legs

Column - 3

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		in	in	in	in	k	k-ft	ksi	ksi		in2		in
1	4	3.81	7.63	35.63	31.81	-155.12	172.43	0.288	0.190	1.52	****	****	****
2	4	7.63	7.63	43.25	35.63	-155.12	172.43	0.239	0.190	1.26	1.40	8	15.25
3	4	11.44	7.63	50.87	39.44	-155.12	172.43	0.205	0.179	1.15	1.21	9	15.25
4	4	15.25	7.63	58.50	43.25	-155.12	172.43	0.178	0.170	1.05	1.03	10	15.25
5	4	19.06	7.63	66.13	47.06	-155.12	172.43	0.158	0.163	0.97	0.86	11	15.25

6	4	22.87	7.63	73.75	50.87	-155.12	172.43	0.142	0.157	0.90	0.70	12	15.25
7	4	26.69	7.63	81.37	54.69	-155.12	172.43	0.129	0.152	0.85	0.54	13	15.25
8	4	30.50	7.63	89.00	58.50	-155.12	172.43	0.117	0.148	0.80	0.39	14	15.25
9	4	34.31	7.63	96.63	62.31	-155.12	172.43	0.108	0.144	0.75	0.25	15	15.25
10	4	38.12	7.63	104.25	66.13	-155.12	172.43	0.100	0.141	0.71	0.11	16	15.25
11	4	41.94	7.63	111.87	69.94	-155.12	172.43	0.093	0.138	0.68	0.00	0	0.00

Dist. = Distance between the legs

Column - 4

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		in	in	in	in	k	k-ft	ksi	ksi		in2		in
1	1	3.81	7.63	31.63	31.63	-198.19	-29.03	0.219	0.194	1.13	1.33	9	15.25
2	1	7.63	7.63	39.25	39.25	-198.19	-29.03	0.174	0.191	0.91	1.06	11	15.25
3	1	11.44	7.63	46.87	46.87	-198.19	-29.03	0.145	0.176	0.82	0.79	13	15.25
4	1	15.25	7.63	54.50	54.50	-198.19	-29.03	0.124	0.166	0.75	0.53	15	15.25
5	1	19.06	7.63	62.13	62.13	-198.19	-29.03	0.108	0.158	0.69	0.28	17	15.25
6	1	22.87	7.63	69.75	69.75	-198.19	-29.03	0.096	0.151	0.63	0.00	0	0.00

Dist. = Distance between the legs

Column - 5

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		in	in	in	in	k	k-ft	ksi	ksi		in2		in
1	1	8.31	16.62	34.62	34.62	-212.75	36.01	0.099	0.190	0.52	0.00	0	0.00
2	1	3.81*	7.63	52.63	52.63	-212.75	36.01	0.139	0.164	0.85	0.00	0	0.00

Dist. = Distance between the legs

Column - 6

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		in	in	in	in	k	k-ft	ksi	ksi		in2		in
1	2	3.81	7.63	31.81	35.63	-100.95	-338.14	0.282	0.190	1.49	1.57	7	15.25
2	2	7.63	7.63	35.63	43.25	-100.95	-338.14	0.216	0.190	1.14	1.17	8	15.25
3	2	11.44	7.63	39.44	50.87	-100.95	-338.14	0.171	0.179	0.96	0.84	9	15.25
4	2	15.25	7.63	43.25	58.50	-100.95	-338.14	0.140	0.170	0.83	0.56	10	15.25
5	2	19.06	7.63	47.06	66.13	-100.95	-338.14	0.118	0.163	0.72	0.31	11	15.25
6	2	22.87	7.63	50.87	73.75	-100.95	-338.14	0.101	0.157	0.64	0.08	12	15.25
7	2	26.69	7.63	54.69	81.37	-100.95	-338.14	0.087	0.152	0.57	0.00	0	0.00

Dist. = Distance between the legs

Note: Columns with --- have not been checked for punching shear.
Note: Columns with *** have exceeded the maximum allowable shear stress.
Note: For the layers with As = 0.00, more reinforcement is provided to satisfy provision 13.3.7.4 of Canadian-04 design code.

Legend (2.1):
Span C = Cantilever
Form 1 = Rectangular, 2 = T or Inverted L, 3 = I, 4 = Extended T or L section
Rh Elevation of top surface
TF Top flange
MF Middle flange
BF Bottom flange

Legend (2.5):

Drop Cap Dimensions:
CAP T = Total depth of cap
CAP B = Transverse Width
CAP DL = Extension left of joint
CAP DR = Extension right of joint

Drop Panel Dimensions:
DROP TL = Total depth left of joint
DROP TR = Total depth right of joint
DROP B = Transverse Width
DROP L = Extension left of joint

--- DROP R = Extension right of joint

Legend (2.7):

The Column Boundary Condition (CBC):

Fixed at both	1
Hinged at near end, fixed at far end	2
Fixed at near end, hinged at far end	3
Fixed at near end, roller with rotational fixity at far end	4

LC Lower Column

UC Upper Column

Legend (3.1):

Class: SW: Selfweight, LL: Live Load, SDL: Superimposed Dead Load, X: Other Loading

Type: U: Uniform, P: Partial Uniform, L: Line Load, M: Applied Moment
C: Concentrated Load, R: Triangle, V: Variable, T: Trapezoidal

Legend (7.1):

Type

1 = reversed parabola
2 = simple parabola with straight portion over support
3 = harped tendon
4 = straight tendon
5 = extended reversed parabola

Legend (7.2):

CGS C1: CGS of left middle point of tendon for type 5 profile

CGS C2: CGS of right middle point of tendon for type 5 profile or middle point of other types

Legend (13):

Cond.	: 1 = Interior, 2 = End, 3 = Corner, 4 = Edge
a	: The distance between the layer and face of column or drop cap(*)
d	: Effective depth
b1	: length of section parallel to span line
b2	: length of section normal to span line
Vu	: Factored shear
Mu	: Factored moment
Stress	: Maximum stress
Allow	: Allowable stress
Ratio	: Ratio of calculated to allowable stress
As	: Required area of reinforcement
Nlegs	: Number of legs for stirrup

Legend (30):

Cond.	: 1 = Interior, 2 = End, 3 = Corner, 4 = Edge
a	: The distance between the layer and face of column or drop cap(*)
d	: Effective depth
b1	: length of section parallel to span line
b2	: length of section normal to span line
Vu	: Factored shear
Mu	: Factored moment
Stress	: Maximum stress
Allow	: Allowable stress
Ratio	: Ratio of calculated to allowable stress
As	: Required area of reinforcement
Nlegs	: Number of legs for stirrup

5.10.4.2 Computer Report for SI Units

Comments:

If a stress ratio exceeds 1.50, the section has to be enlarged, or re-designed such as to bring the ratio to 1.50 or less. In this case, column 3 has been conservatively modeled as an "edge column." Its punching shear capacity is larger than assumed in the program. For this reason, it is acceptable if reinforced.

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		Minimum Cover at BOTTOM	19.05 mm
F'c for BEAMS/SLABS	28.00 N/mm 2	Post-tensioning	
For COLUMNS/WALLS	28.00 N/mm 2	SYSTEM	UNBONDED
Ec for BEAMS/SLABS	24870.00 N/mm 2	Fpu	1863.00 N/mm 2
For COLUMNS/WALLS	24870.00 N/mm 2	Fse	1206.60 N/mm 2
CREEP factor	2.00	Strand area	99.000 mm 2
CONCRETE WEIGHT	NORMAL	Min CGS from TOP	25.00 mm
UNIT WEIGHT	2400.00 Kg/m 3	Min CGS from BOT for interior spans	25.00 mm
Tension stress limits / (f'c)1/2		Min CGS from BOT for exterior spans	25.00 mm
At Top	0.500	Min average precompression	0.86 N/mm 2
At Bottom	0.500	Max spacing / slab depth	8.00
Compression stress limits / f'c		Analysis and design options	
At all locations	0.450	Structural system	TWO-WAY
Reinforcement		Moment of Inertia over support is	NOT INCREASED
Fy (Main bars)	413.69 N/mm 2	Moments reduced to face of support	YES
Fy (Shear reinforcement)	460.00 N/mm 2	Moment Redistribution	NO
Minimum Cover at TOP	19.05 mm	DESIGN CODE SELECTED	ACI-318 (2005)

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		m	mm	mm	mm	mm	mm	mm	mm		
C	1	0.31	4877	229					229	0.06	0.94
1	1	7.62	4877	229					229	0.06	0.94
2	1	9.14	4877	229					229	0.06	0.94
3	1	9.14	9144	229					229	0.50	0.50
4	1	9.14	9144	229					229	0.50	0.50
5	1	9.14	9144	229					229	0.50	0.50
C	1	0.36	9144	229					229	0.50	0.50

2.5 Drop Cap and Drop Panel Data

Joint	Cap T	Cap B	Cap DL	Cap DR	Drop TL	Drop TR	Drop B	Drop L	Drop R
	mm	mm	mm	mm	mm	mm	mm	mm	mm
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0

5	457	1144	572	572	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	mm	m	mm	mm			m	mm	mm		
1	610.0	3.0	610.0	610.0	100	(1)	3.0	610.0	610.0	100	(1)
2	610.0	3.0	610.0	610.0	100	(1)	3.0	610.0	610.0	100	(1)
3	711.0	3.0	711.0	711.0	100	(1)	3.0	711.0	711.0	100	(1)
4	610.0	3.0	610.0	610.0	100	(1)	3.0	610.0	610.0	100	(1)
5	457.0	3.0	457.0	457.0	100	(1)	3.0	457.0	457.0	100	(1)
6	711.0	3.0	711.0	711.0	100	(1)	3.0	711.0	711.0	100	(1)

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			kN/m2	kN/m	kN/m	m	m	m	kN	kN-m
CANT	LL	U	1.915							
CANT	SDL	U	0.958							
1	LL	U	1.915							
1	SDL	U	0.958							
2	LL	U	1.915							
2	SDL	U	0.958							
3	LL	U	1.915							
3	SDL	U	0.958							
4	LL	U	1.915							
4	SDL	U	0.958							
5	LL	U	1.915							
5	SDL	U	0.958							
CANT	LL	U	1.915							
CANT	SDL	U	0.958							

NOTE: SELFWEIGHT INCLUSION REQUIRED (SW= SELF WEIGHT Computed from geometry input and treated as dead loading. Unit selfweight W = 2400.0 Kg/m^3

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile
Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
CL	2	---	---	0.000	---
1	2	0.000	0.428	0.000	---
2	2	0.000	0.500	0.000	---
3	2	0.000	0.500	0.000	---
4	2	0.000	0.500	0.000	---
5	2	0.000	0.586	0.000	---
CR	2	0.000	---	---	---

7.2 Selected Post-Tensioning Forces and Tendon Drape
Tendon A

Span	Force	CGS Left	CSG C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	kN	mm	mm	mm	mm	MPa	kN	
CL	978.600	115.00	---	---	115.00	0.88	0.000	0

1	978.600	115.00	---	25.00	204.00	0.88	17.638	57
2	978.600	204.00	---	25.00	204.00	0.88	16.762	54
3	1800.850	204.00	---	25.00	204.00	0.86	30.845	53
4	1800.850	204.00	---	25.00	204.00	0.86	30.845	53
5	1800.850	204.00	---	25.00	115.00	0.86	22.525	39
CR	1800.850	115.00	---	---	115.00	0.86	0.000	0

Approximate weight of strand: 481.9 Kg

7.4 Required Minimum Post-Tensioning Forces

	Based on Stress Conditions			Based on Minimum P/A		
Type	Left	Center	Right	Left	Center	Right
	kN	kN	kN	kN	kN	kN
CL	-----	-----	0.00	-----	-----	960.45
1	214.64	0.00	434.51	960.45	960.45	960.45
2	728.30	248.46	1032.75	960.45	960.45	960.45
3	1425.72	580.60	1599.06	1800.80	1800.80	1800.80
4	1403.76	341.51	457.19	1800.80	1800.80	2025.10
5	540.94	561.44	1490.62	2025.10	1800.80	1800.80
CR	0.00	-----	-----	1800.80	-----	-----

7.5 Service Stresses (tension shown positive)

Envelope of Service 1

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	MPa	MPa	MPa	MPa	MPa	MPa
CL	-----	-----	-----	-----	-0.89	-0.86
1	0.40	-2.15	-1.81	0.05	0.60	-2.35
2	0.96	-2.72	-2.02	0.26	-0.22	-3.00
3	1.24	-2.96	-2.32	0.60	1.44	-3.16
4	1.17	-2.89	-2.10	0.38	0.46	-3.55
5	0.66	-3.99	-2.62	0.90	1.57	-3.29
CR	-0.87	-0.85	-----	-----	-----	-----

Envelope of Service 2

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	MPa	MPa	MPa	MPa	MPa	MPa
CL	-----	-----	-----	-----	-0.89	-0.86
1	0.91	-2.66	-2.19	0.43	1.21	-2.97
2	1.80	-3.55	-2.55	0.80	0.64	-3.87
3	2.04	-3.76	-2.86	1.14	2.30	-4.02
4	1.98	-3.70	-2.60	0.88	0.98	-4.73
5	1.19	-5.19	-3.14	1.42	2.28	-4.00
CR	-0.87	-0.85	-----	-----	-----	-----

7.6 Post-Tensioning Balance Moments, Shears and Reactions
Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN	kN
CL	-----	-----	0.49	-----	0.00
1	57.62	-44.11	72.53	9.16	9.16
2	104.40	-68.37	131.60	4.72	4.72
3	163.30	-108.70	174.40	-0.54	-0.54
4	171.30	-105.80	234.60	-0.90	-0.90
5	211.80	-73.44	100.20	-11.28	-11.28
CR	0.90	-----	-----	0.00	-----

Reactions and Column Moments

Joint	Reaction	Moment	Moment

		Lower Column	Upper Column
	kN	kN-m	kN-m
1	-9.157	37.800	37.800
2	4.442	17.480	17.480
3	5.259	26.180	26.180
4	0.358	-1.860	-1.860
5	10.380	-15.140	-15.140
6	-11.280	-66.170	-66.170

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
CL	-----	-----	-----	-----	0.00	-----
1	-99.91	-99.91	169.97	169.97	-200.24	-200.24
2	-242.80	-242.80	199.70	199.70	-294.92	-294.92
3	-460.61	-460.61	399.83	399.83	-497.66	-497.66
4	-463.65	-463.65	371.44	371.44	-605.64	-605.64
5	-645.73	-645.73	411.45	411.45	-325.83	-325.83
CR	0.00	-----	-----	-----	-----	-----

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	200.09	200.09	-75.62	-75.62	-75.62	-75.62
2	443.57	443.57	-23.99	-23.99	-23.99	-23.99
3	690.43	690.43	-116.76	-116.76	-116.76	-116.76
4	882.48	882.48	19.24	19.24	19.24	19.24
5	945.50	945.50	-22.16	-22.16	-22.16	-22.16
6	450.40	450.40	230.48	230.48	230.48	230.48

8.3 Secondary Moments

Span	Left	Midspan	Right
	kN-m	kN-m	kN-m
1	72.81	40.71	8.62
2	39.35	19.23	-0.65
3	50.22	52.50	54.80
4	51.52	55.36	59.27
5	31.77	80.77	128.30

Note: Moments are reported at face of support

13 - PUNCHING SHEAR REINFORCEMENT

13.1 Critical Section Geometry

Column	Layer	Cond.	a	d	b1	b2
			mm	mm	mm	mm
1	1	3	96.97	193.95	706.98	706.98
2	1	4	96.97	193.95	803.95	706.98
3	1	4	96.97	193.95	904.95	807.98
4	1	1	96.97	193.95	803.95	803.95

5	2	1	96.97	193.95	1338.00	1338.00
6	1	2	96.97	193.95	807.98	904.95

13.2 Critical Section Stresses

Label	Layer	Cond.	Factored shear	Factored moment	Stress due to shear	Stress due to moment	Total stress	Allowable stress	Stress ratio
			kN	kN-m	MPa	MPa	MPa	MPa	
1	1	3	-200.09	+151.23	0.73	0.510	1.240	1.318	0.941
2	1	4	-443.58	+48.04	1.03	0.151	1.182	1.318	0.897
3	1	4	-690.42	+233.62	1.41	0.570	1.982	1.318	1.504
4	1	1	-882.48	-38.43	1.41	0.091	1.506	1.318	1.143
5	2	1	-945.54	+44.31	0.91	0.038	0.949	1.136	0.835
6	1	2	-450.39	-461.12	0.92	1.028	1.950	1.318	1.480

13.3 Punching Shear Reinforcement
Reinforcement option: Stirrups
Bar Size: 16

Col.	Dist	N_Legs	Dist	N_Legs	Dist	N_Legs	Dist	N_Legs	Dist	N_Legs
	mm		mm		mm		mm		mm	
1										
2										
3	193.9	8	290.9	9	387.9	9	484.9	10	581.9	11
3	678.8	12	775.8	13	872.8	14	969.8	15		
4	97.0	9	193.9	10	290.9	12	387.9	14	484.9	16
5										
6	97.0	7	193.9	8	290.9	9	387.9	9	484.9	10
6	581.9	11								

Dist. = Distance measured from the face of support
Note: Columns with --- have not been checked for punching shear.
Note: Columns with *** have exceeded the maximum allowable shear stress.

30 - PUNCHING SHEAR REINFORCEMENT

Reinforcement option: Stirrup
Bar Size: 16
Column - 1

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		mm	mm	mm	mm	kN	kN-m	MPa	MPa		mm2		mm
1	3	96.97	193.95	706.98	706.98	-200.09	151.23	1.240	1.318	0.94	0.00	0	0.00

Dist. = Distance between the legs

Column - 2

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		mm	mm	mm	mm	kN	kN-m	MPa	MPa		mm2		mm
1	4	96.97	193.95	803.95	706.98	-443.58	48.04	1.182	1.318	0.90	0.00	0	0.00

Dist. = Distance between the legs

Column - 3

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		mm	mm	mm	mm	kN	kN-m	MPa	MPa		mm2		mm
1	4	96.97	193.95	904.95	807.98	-690.42	233.62	1.982	1.318	1.50	0.00	0	-1.11
2	4	193.95	193.95	1098.90	904.95	-690.42	233.62	1.648	1.318	1.25	808.94	8	431.32
3	4	290.92	193.95	1292.80	1001.90	-690.42	233.62	1.408	1.240	1.14	694.55	9	431.32
4	4	387.90	193.95	1486.80	1098.90	-690.42	233.62	1.228	1.179	1.04	589.60	9	431.32
5	4	484.88	193.95	1680.80	1195.90	-690.42	233.62	1.088	1.129	0.96	491.21	10	431.32
6	4	581.85	193.95	1874.70	1292.80	-690.42	233.62	0.976	1.089	0.90	397.68	11	431.32

7	4	678.83	193.95	2068.70	1389.80	-690.42	233.62	0.885	1.054	0.84	307.66	12	431.32
8	4	775.80	193.95	2262.60	1486.80	-690.42	233.62	0.809	1.025	0.79	220.42	13	431.32
9	4	872.78	193.95	2456.60	1583.80	-690.42	233.62	0.744	1.000	0.74	135.35	14	431.32
10	4	969.75	193.95	2650.50	1680.80	-690.42	233.62	0.690	0.978	0.71	52.02	15	431.32
11	4	1066.70	193.95	2844.50	1777.70	-690.42	233.62	0.642	0.958	0.67	0.00	0	0.00

Dist. = Distance between the legs

Column - 4

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		mm	mm	mm	mm	kN	kN-m	MPa	MPa		mm2		mm
1	1	96.97	193.95	803.95	803.95	-882.48	-38.43	1.506	1.318	1.14	765.42	9	431.32
2	1	193.95	193.95	997.90	997.90	-882.48	-38.43	1.199	1.299	0.92	606.15	10	431.32
3	1	290.92	193.95	1191.80	1191.80	-882.48	-38.43	0.996	1.195	0.83	451.82	12	431.32
4	1	387.90	193.95	1385.80	1385.80	-882.48	-38.43	0.852	1.120	0.76	300.46	14	431.32
5	1	484.88	193.95	1579.80	1579.80	-882.48	-38.43	0.744	1.063	0.70	151.00	16	431.32
6	1	581.85	193.95	1773.70	1773.70	-882.48	-38.43	0.660	1.019	0.65	0.00	0	0.00

Dist. = Distance between the legs

Column - 5

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		mm	mm	mm	mm	kN	kN-m	MPa	MPa		mm2		mm
1	1	210.97	421.95	878.95	878.95	-945.54	44.31	0.676	1.318	0.51	0.00	0	0.00
2	1	96.97*	193.95	1338.00	1338.00	-945.54	44.31	0.949	1.136	0.84	0.00	0	0.00

Dist. = Distance between the legs

Column - 6

Layer	Cond.	a	d	b1	b2	Vu	Mu	Stress	Allow.	Ratio	As	NLegs	Dist.
		mm	mm	mm	mm	kN	kN-m	MPa	MPa		mm2		mm
1	2	96.97	193.95	807.98	904.95	-450.39	-461.12	1.950	1.318	1.48	914.61	7	431.32
2	2	193.95	193.95	904.95	1098.90	-450.39	-461.12	1.490	1.318	1.13	679.89	8	431.32
3	2	290.92	193.95	1001.90	1292.80	-450.39	-461.12	1.185	1.240	0.96	487.52	9	431.32
4	2	387.90	193.95	1098.90	1486.80	-450.39	-461.12	0.970	1.179	0.82	322.68	9	431.32
5	2	484.88	193.95	1195.90	1680.80	-450.39	-461.12	0.813	1.129	0.72	176.90	10	431.32
6	2	581.85	193.95	1292.80	1874.70	-450.39	-461.12	0.695	1.089	0.64	44.80	11	431.32
7	2	678.83	193.95	1389.80	2068.70	-450.39	-461.12	0.602	1.054	0.57	0.00	0	0.00

Dist. = Distance between the legs

Note: Columns with --- have not been checked for punching shear.
Note: Columns with *** have exceeded the maximum allowable shear stress.
Note: For the layers with As = 0.00, more reinforcement is provided to satisfy provision 13.3.7.4 of Canadian-04 design code.

Legend (2.1):
Span C = Cantilever
Form 1 = Rectangular, 2 = T or Inverted L, 3 = I, 4 = Extended T or L section
Rh Elevation of top surface
TF Top flange
MF Middle flange
BF Bottom flange

Legend (2.5):

Drop Cap Dimensions:
CAP T = Total depth of cap
CAP B = Transverse Width
CAP DL = Extension left of joint
CAP DR = Extension right of joint

Drop Panel Dimensions:
DROP TL = Total depth left of joint
DROP TR = Total depth right of joint
DROP B = Transverse Width
DROP L = Extension left of joint
DROP R = Extension right of joint

Legend (2.7):
The Column Boundary Condition (CBC):

Fixed at both	1
Hinged at near end, fixed at far end	2
Fixed at near end, hinged at far end	3
Fixed at near end, roller with rotational fixity at far end	4

LC Lower Column
UC Upper Column

Legend (3.1):
Class: SW: Selfweight, LL: Live Load, SDL: Superimposed Dead Load, X: Other Loading
Type: U: Uniform, P: Partial Uniform, L: Line Load, M: Applied Moment
C: Concentrated Load, R: Triangle, V: Variable, T: Trapezoidal

Legend (7.1):
Type
1 = reversed parabola
2 = simple parabola with straight portion over support
3 = harped tendon
4 = straight tendon
5 = extended reversed parabola

Legend (7.2):
CGS C1: CGS of left middle point of tendon for type 5 profile
CGS C2: CGS of right middle point of tendon for type 5 profile or middle point of other types

Legend (13):

Cond.	: 1 = Interior, 2 = End, 3 = Corner, 4 = Edge
a	: The distance between the layer and face of column or drop cap(*)
d	: Effective depth
b1	: length of section parallel to span line
b2	: length of section normal to span line
Vu	: Factored shear
Mu	: Factored moment
Stress	: Maximum stress
Allow	: Allowable stress
Ratio	: Ratio of calculated to allowable stress
As	: Required area of reinforcement
Nlegs	: Number of legs for stirrup

Legend (30):

Cond.	: 1 = Interior, 2 = End, 3 = Corner, 4 = Edge
a	: The distance between the layer and face of column or drop cap(*)
d	: Effective depth
b1	: length of section parallel to span line
b2	: length of section normal to span line
Vu	: Factored shear
Mu	: Factored moment
Stress	: Maximum stress
Allow	: Allowable stress
Ratio	: Ratio of calculated to allowable stress
As	: Required area of reinforcement
Nlegs	: Number of legs for stirrup

5.11 Initial Stress Analysis

The Initial Stress Analysis allows the user to determine if additional mild steel reinforcing is required at force transfer of prestressing to concrete.

Stress checks can be performed for any loading, post-tensioning, or concrete strength conditions. For initial stress check, user enters the initial concrete strength and the initial load combination factors during data input.

This section verifies the results of the Initial Stress Check (Data block 27, detailed stresses) and the Reinforcement Requirements (Data block 29, detailed rebar). The reinforcement should be provided if the tension stress exceeds the allowable values. The two-span T-beam shown in **Fig.-1** will be used for the verification.

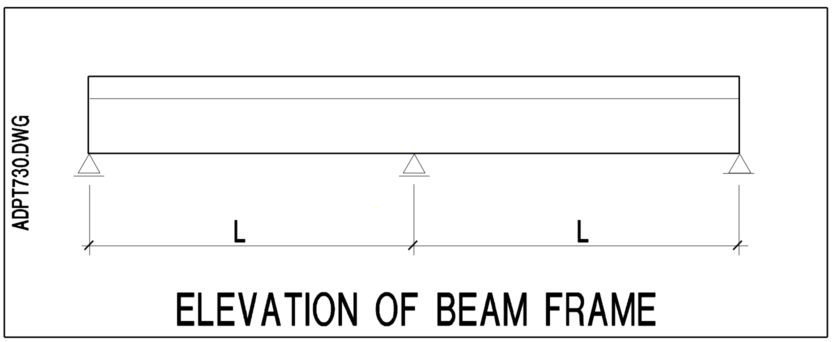


Figure 5.11-1

Geometry and loading:

L = 20 m
Superimposed Dead Load = 23.88 kN/m
Live Load = 22.11 kN/m

Allowable stress at transfer of prestressing (initial stress):

Tension Stress = $0.25(f'_{ci})^{1/2}$
Compression Stress = $0.60(f'_{ci})$

Load Combination: 1.0 SW + 1.15 PT

5.11.1 Computer Report

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		SYSTEM	UNBONDED
F'c for BEAMS/SLABS	28.00 N/mm 2	Fpu	1860.00 N/mm 2
Ec for BEAMS/SLABS	24870.00 N/mm 2	Fse	1200.00 N/mm 2
CREEP factor	2.00	Strand area	99.000 mm 2
CONCRETE WEIGHT	NORMAL	Min CGS from TOP	25.00 mm
UNIT WEIGHT	2400.00 Kg/m 3	Min CGS from BOT for interior spans	25.00 mm
Tension stress limits / (f'c)1/2		Min CGS from BOT for exterior spans	45.00 mm
At Top	0.500	Min average precompression	0.85 N/mm 2
At Bottom	0.500	Max spacing / slab depth	8.00
Compression stress limits / f'c		Analysis and design options	
At all locations	0.450	Structural system	BEAM
Reinforcement		Moment of Inertia over support is	NOT INCREASED
Fy (Main bars)	460.00 N/mm 2	Moments reduced to face of support	YES
Fy (Shear reinforcement)	460.00 N/mm 2	Moment Redistribution	NO
Minimum Cover at TOP	25.00 mm	Effective flange width consideration	NO
Minimum Cover at BOTTOM	25.00 mm	DESIGN CODE SELECTED	ACI-318 (2014)
Post-tensioning			

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		m	mm	mm	mm	mm	mm	mm	mm		
1	2	20.00	460	915	2286	155			915	0.50	0.50
2	2	20.00	460	915	2286	155			915	0.50	0.50

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	mm	m	mm	mm			m	mm	mm		
1	0.0	0.0	0.0	0.0	100	(1)					
2	0.0	0.0	0.0	0.0	100	(1)					
3	0.0	0.0	0.0	0.0	100	(1)					

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			kN/m2	kN/m	kN/m	m	m	m	kN	kN-m
1	LL	L		22.110		0.000	20.000			
1	SDL	L		23.880		0.000	20.000			
2	LL	L		22.110		0.000	20.000			
2	SDL	L		23.880		0.000	20.000			

NOTE: SELFWEIGHT INCLUSION REQUIRED (SW= SELF WEIGHT Computed from geometry input and treated as dead loading. Unit selfweight W = 2400.0 Kg/m^3

3.2 Compiled loads

ADAPT

Span	Class	Type	P1	P2	F	M	A	B	C	Reduction Factor
			kN/m	kN/m	kN	kN-m	m	m	m	%
1	LL	P	22.110				0.000	20.000		0.000
1	SDL	P	23.880				0.000	20.000		
1	SW	U	16.573							
2	LL	P	22.110				0.000	20.000		0.000
2	SDL	P	23.880				0.000	20.000		
2	SW	U	16.573							

4 - CALCULATED SECTION PROPERTIES

4.1 Section Properties of Uniform Spans and Cantilevers

Span	Area	I	Yb	Yt
	mm2	mm4	mm	mm
1	703930.00	0.54E+11	610.29	304.71
2	703930.00	0.54E+11	610.29	304.71

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile

Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
1	1	0.000	0.500	0.100	---
2	1	0.100	0.500	0.000	---

7.2 Selected Post-Tensioning Forces and Tendon Drape

Tendon A

Span	Force	CGS Left	CSG C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	kN	mm	mm	mm	mm	MPa	kN	
1	2391.000	610.00	---	25.00	890.00	3.40	34.669	86
2	2391.000	890.00	---	25.00	610.00	3.40	34.669	86

Approximate weight of strand: 669.2 Kg

10 - MILD STEEL - NO REDISTRIBUTION

10.1 Required Rebar

10.1.1 Total Strip Required Rebar

Span	Location	From	To	As Required	Ultimate	Minimum
		m	m	mm2	mm2	mm2
1	TOP	16.00	20.00	7491.00	7491.00	0.00
2	TOP	0.00	4.00	7491.00	7491.00	0.00
1	BOT	0.00	20.00	3640.00	3640.00	3569.00
2	BOT	0.00	20.00	3640.00	3640.00	3569.00

23 - DETAILED MOMENTS

SPAN 1

XL	X	SW	SDL	XL	LL Min	LL Max	PT	Secondary
	m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.70	0.00
0.05	1.00	116.04	167.20	0.00	154.81	154.81	-219.68	46.56
0.10	2.00	215.51	310.52	0.00	287.51	287.51	-410.95	93.12

0.15	3.00	298.40	429.96	0.00	398.09	398.09	-574.25	139.68
0.20	4.00	364.72	525.52	0.00	486.57	486.57	-709.56	186.24
0.25	5.00	414.47	597.20	0.00	552.93	552.93	-816.89	232.80
0.30	6.00	447.64	644.99	0.00	597.19	597.19	-896.25	279.36
0.35	7.00	464.24	668.91	0.00	619.33	619.33	-947.62	325.92
0.40	8.00	464.27	668.95	0.00	619.37	619.37	-971.01	372.48
0.45	9.00	447.72	645.11	0.00	597.29	597.29	-966.42	419.04
0.50	10.00	414.60	597.38	0.00	553.11	553.11	-933.86	465.60
0.55	11.00	364.91	525.78	0.00	486.81	486.81	-861.44	512.16
0.60	12.00	298.64	430.30	0.00	398.41	398.41	-737.33	558.72
0.65	13.00	215.80	310.94	0.00	287.89	287.89	-561.51	605.28
0.70	14.00	116.38	167.69	0.00	155.27	155.27	-333.98	651.84
0.75	15.00	0.40	0.57	0.00	0.53	0.53	-54.75	698.40
0.80	16.00	-132.16	-190.43	0.00	-176.32	-176.32	276.19	744.96
0.85	17.00	-281.30	-405.31	0.00	-375.27	-375.27	658.83	791.52
0.90	18.00	-447.00	-644.07	0.00	-596.34	-596.34	1093.20	838.08
0.95	19.00	-629.28	-906.72	0.00	-839.51	-839.51	1450.00	884.64
1.00	20.00	-828.14	-1193.20	0.00	-1104.80	-1104.80	1599.90	931.20

SPAN 2

XL	X	SW	SDL	XL	LL Min	LL Max	PT	Secondary
	m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
0.00	0.00	-828.14	-1193.20	0.00	-1104.80	-1104.80	1599.90	931.20
0.05	1.00	-629.28	-906.72	0.00	-839.51	-839.51	1450.00	884.64
0.10	2.00	-447.00	-644.07	0.00	-596.34	-596.34	1093.20	838.08
0.15	3.00	-281.30	-405.31	0.00	-375.27	-375.27	658.83	791.52
0.20	4.00	-132.16	-190.43	0.00	-176.32	-176.32	276.19	744.96
0.25	5.00	0.40	0.57	0.00	0.53	0.53	-54.75	698.40
0.30	6.00	116.38	167.69	0.00	155.27	155.27	-333.98	651.84
0.35	7.00	215.80	310.94	0.00	287.89	287.89	-561.51	605.28
0.40	8.00	298.64	430.30	0.00	398.41	398.41	-737.33	558.72
0.45	9.00	364.91	525.78	0.00	486.81	486.81	-861.44	512.16
0.50	10.00	414.60	597.38	0.00	553.11	553.11	-933.86	465.60
0.55	11.00	447.72	645.11	0.00	597.29	597.29	-966.43	419.04
0.60	12.00	464.27	668.95	0.00	619.37	619.37	-971.02	372.48
0.65	13.00	464.24	668.91	0.00	619.33	619.33	-947.64	325.92
0.70	14.00	447.64	644.99	0.00	597.19	597.19	-896.29	279.36
0.75	15.00	414.47	597.20	0.00	552.93	552.93	-816.96	232.80
0.80	16.00	364.72	525.52	0.00	486.57	486.57	-709.66	186.24
0.85	17.00	298.40	429.96	0.00	398.09	398.09	-574.38	139.68
0.90	18.00	215.51	310.52	0.00	287.51	287.51	-411.13	93.12
0.95	19.00	116.04	167.20	0.00	154.81	154.81	-219.90	46.56
1.00	20.00	0.00	0.00	0.00	0.00	0.00	-0.70	0.00

27 - DETAILED STRESSES

SPAN 1

XL	X	SW Top	SW Bot	SDL Top	SDL Bot	XL Top	XL Bot	LL Top Max-T	LL Top Max-C	LL Bot Max-T	LL Bot Max-C	PT Top	PT Bot
	m	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-3.39	-3.40
0.05	1.00	-0.65	1.30	-0.94	1.88	0.00	0.00	-0.87	-0.87	1.74	1.74	-2.17	-5.86
0.10	2.00	-1.21	2.42	-1.74	3.49	0.00	0.00	-1.61	-1.61	3.23	3.23	-1.09	-8.01
0.15	3.00	-1.67	3.35	-2.41	4.83	0.00	0.00	-2.23	-2.23	4.47	4.47	-0.18	-9.84
0.20	4.00	-2.04	4.09	-2.95	5.90	0.00	0.00	-2.73	-2.73	5.46	5.46	0.58	-11.36
0.25	5.00	-2.32	4.65	-3.35	6.70	0.00	0.00	-3.10	-3.10	6.21	6.21	1.18	-12.57
0.30	6.00	-2.51	5.02	-3.61	7.24	0.00	0.00	-3.35	-3.35	6.70	6.70	1.63	-13.46
0.35	7.00	-2.60	5.21	-3.75	7.51	0.00	0.00	-3.47	-3.47	6.95	6.95	1.91	-14.03

0.40	8.00	-2.60	5.21	-3.75	7.51	0.00	0.00	-3.47	-3.47	6.95	6.95	2.05	-14.30
0.45	9.00	-2.51	5.03	-3.62	7.24	0.00	0.00	-3.35	-3.35	6.70	6.70	2.02	-14.24
0.50	10.00	-2.32	4.65	-3.35	6.71	0.00	0.00	-3.10	-3.10	6.21	6.21	1.84	-13.88
0.55	11.00	-2.05	4.10	-2.95	5.90	0.00	0.00	-2.73	-2.73	5.46	5.46	1.43	-13.07
0.60	12.00	-1.67	3.35	-2.41	4.83	0.00	0.00	-2.23	-2.23	4.47	4.47	0.74	-11.67
0.65	13.00	-1.21	2.42	-1.74	3.49	0.00	0.00	-1.61	-1.61	3.23	3.23	-0.25	-9.70
0.70	14.00	-0.65	1.31	-0.94	1.88	0.00	0.00	-0.87	-0.87	1.74	1.74	-1.52	-7.15
0.75	15.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	-3.09	-4.01
0.80	16.00	0.74	-1.48	1.07	-2.14	0.00	0.00	0.99	0.99	-1.98	-1.98	-4.94	-0.30
0.85	17.00	1.58	-3.16	2.27	-4.55	0.00	0.00	2.10	2.10	-4.21	-4.21	-7.09	4.00
0.90	18.00	2.51	-5.02	3.61	-7.23	0.00	0.00	3.34	3.34	-6.69	-6.69	-9.52	8.87
0.95	19.00	3.53	-7.06	5.08	-10.18	0.00	0.00	4.71	4.71	-9.42	-9.42	-11.52	12.88
1.00	20.00	4.64	-9.30	6.69	-13.39	0.00	0.00	6.19	6.19	-12.40	-12.40	-12.36	14.56

XL	X	Initial Top Max-T	Initial Top Max-C	Initial Bot Max-T	Initial Bot Max-C	Env-1 Top Max-T	Env-1 Top Max-C	Env-1 Bot Max-T	Env-1 Bot Max-C	Env-2 Top Max-T	Env-2 Top Max-C	Env-2 Bot Max-T	Env-2 Bot Max-C
	m	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
0.00	0.00	-----	-3.90	-----	-3.92	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.05	1.00	-----	-3.14	-----	-5.44	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.10	2.00	-----	-2.47	-----	-6.79	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.15	3.00	-----	-1.88	-----	-7.97	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.20	4.00	-----	-1.38	-----	-8.97	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.25	5.00	-----	-0.96	-----	-9.80	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.30	6.00	-----	-0.64	-----	-10.45	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.35	7.00	-----	-0.40	-----	-10.93	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.40	8.00	-----	-0.25	-----	-11.23	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.45	9.00	-----	-0.19	-----	-11.36	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.50	10.00	-----	-0.21	-----	-11.31	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.55	11.00	-----	-0.40	-----	-10.93	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.60	12.00	-----	-0.83	-----	-10.07	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.65	13.00	-----	-1.50	-----	-8.73	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.70	14.00	-----	-2.41	-----	-6.91	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.75	15.00	-----	-3.56	-----	-4.61	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.80	16.00	-----	-4.95	-----	-1.82	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.85	17.00	-----	-6.58	1.44	-----	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.90	18.00	-----	-8.45	5.19	-----	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.95	19.00	-----	-9.72	7.75	-----	0.00	-----	0.00	-----	0.00	-----	0.00	-----
1.00	20.00	-----	-9.58	7.45	-----	0.00	-----	0.00	-----	0.00	-----	0.00	-----

SPAN 2

XL	X	SW Top	SW Bot	SDL Top	SDL Bot	XL Top	XL Bot	LL Top Max-T	LL Top Max-C	LL Bot Max-T	LL Bot Max-C	PT Top	PT Bot
	m	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
0.00	0.00	4.64	-9.30	6.69	-13.39	0.00	0.00	6.19	6.19	-12.40	-12.40	-12.36	14.56
0.05	1.00	3.53	-7.06	5.08	-10.18	0.00	0.00	4.71	4.71	-9.42	-9.42	-11.52	12.88
0.10	2.00	2.51	-5.02	3.61	-7.23	0.00	0.00	3.34	3.34	-6.69	-6.69	-9.52	8.87
0.15	3.00	1.58	-3.16	2.27	-4.55	0.00	0.00	2.10	2.10	-4.21	-4.21	-7.09	4.00
0.20	4.00	0.74	-1.48	1.07	-2.14	0.00	0.00	0.99	0.99	-1.98	-1.98	-4.94	-0.30
0.25	5.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	-3.09	-4.01
0.30	6.00	-0.65	1.31	-0.94	1.88	0.00	0.00	-0.87	-0.87	1.74	1.74	-1.52	-7.15
0.35	7.00	-1.21	2.42	-1.74	3.49	0.00	0.00	-1.61	-1.61	3.23	3.23	-0.25	-9.70
0.40	8.00	-1.67	3.35	-2.41	4.83	0.00	0.00	-2.23	-2.23	4.47	4.47	0.74	-11.67
0.45	9.00	-2.05	4.10	-2.95	5.90	0.00	0.00	-2.73	-2.73	5.46	5.46	1.43	-13.07
0.50	10.00	-2.32	4.65	-3.35	6.71	0.00	0.00	-3.10	-3.10	6.21	6.21	1.84	-13.88
0.55	11.00	-2.51	5.03	-3.62	7.24	0.00	0.00	-3.35	-3.35	6.70	6.70	2.02	-14.24
0.60	12.00	-2.60	5.21	-3.75	7.51	0.00	0.00	-3.47	-3.47	6.95	6.95	2.05	-14.30
0.65	13.00	-2.60	5.21	-3.75	7.51	0.00	0.00	-3.47	-3.47	6.95	6.95	1.91	-14.03
0.70	14.00	-2.51	5.02	-3.61	7.24	0.00	0.00	-3.35	-3.35	6.70	6.70	1.63	-13.46

0.75	15.00	-2.32	4.65	-3.35	6.70	0.00	0.00	-3.10	-3.10	6.21	6.21	1.18	-12.57
0.80	16.00	-2.04	4.09	-2.95	5.90	0.00	0.00	-2.73	-2.73	5.46	5.46	0.58	-11.36
0.85	17.00	-1.67	3.35	-2.41	4.83	0.00	0.00	-2.23	-2.23	4.47	4.47	-0.18	-9.84
0.90	18.00	-1.21	2.42	-1.74	3.49	0.00	0.00	-1.61	-1.61	3.23	3.23	-1.09	-8.01
0.95	19.00	-0.65	1.30	-0.94	1.88	0.00	0.00	-0.87	-0.87	1.74	1.74	-2.16	-5.87
1.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-3.39	-3.40

XL	X	Initial Top Max-T	Initial Top Max-C	Initial Bot Max-T	Initial Bot Max-C	Env-1 Top Max-T	Env-1 Top Max-C	Env-1 Bot Max-T	Env-1 Bot Max-C	Env-2 Top Max-T	Env-2 Top Max-C	Env-2 Bot Max-T	Env-2 Bot Max-C
	m	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
0.00	0.00	-----	-9.58	7.45	-----	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.05	1.00	-----	-9.72	7.75	-----	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.10	2.00	-----	-8.45	5.19	-----	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.15	3.00	-----	-6.58	1.44	-----	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.20	4.00	-----	-4.95	-----	-1.82	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.25	5.00	-----	-3.56	-----	-4.61	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.30	6.00	-----	-2.41	-----	-6.91	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.35	7.00	-----	-1.50	-----	-8.73	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.40	8.00	-----	-0.83	-----	-10.07	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.45	9.00	-----	-0.40	-----	-10.93	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.50	10.00	-----	-0.21	-----	-11.31	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.55	11.00	-----	-0.19	-----	-11.36	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.60	12.00	-----	-0.25	-----	-11.23	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.65	13.00	-----	-0.40	-----	-10.93	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.70	14.00	-----	-0.64	-----	-10.45	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.75	15.00	-----	-0.96	-----	-9.80	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.80	16.00	-----	-1.38	-----	-8.97	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.85	17.00	-----	-1.88	-----	-7.97	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.90	18.00	-----	-2.46	-----	-6.79	0.00	-----	0.00	-----	0.00	-----	0.00	-----
0.95	19.00	-----	-3.14	-----	-5.44	0.00	-----	0.00	-----	0.00	-----	0.00	-----
1.00	20.00	-----	-3.90	-----	-3.92	0.00	-----	0.00	-----	0.00	-----	0.00	-----

29 - DETAILED REBAR

SPAN 1

XL	X	Analysis Top	Analysis Bot	Minimum Top	Minimum Bot	Selected Top	Selected Bot
	m	mm2	mm2	mm2	mm2	mm2	mm2
0.00	0.00	0.00	76.08	0.00	0.00	0.00	76.08
0.05	1.00	0.00	897.90	0.00	0.00	0.00	897.90
0.10	2.00	0.00	1671.00	0.00	0.00	0.00	1671.00
0.15	3.00	0.00	2352.00	0.00	0.00	0.00	2352.00
0.20	4.00	0.00	2834.00	0.00	0.00	0.00	2834.00
0.25	5.00	0.00	3261.00	0.00	0.00	0.00	3261.00
0.30	6.00	0.00	3518.00	0.00	0.00	0.00	3518.00
0.35	7.00	0.00	3640.00	0.00	0.00	0.00	3640.00
0.40	8.00	0.00	3640.00	0.00	0.00	0.00	3640.00
0.45	9.00	0.00	3617.00	0.00	0.00	0.00	3617.00
0.50	10.00	0.00	3361.00	0.00	0.00	0.00	3361.00
0.55	11.00	0.00	2913.00	0.00	0.00	0.00	2913.00
0.60	12.00	0.00	2353.00	0.00	0.00	0.00	2353.00
0.65	13.00	0.00	1671.00	0.00	0.00	0.00	1671.00
0.70	14.00	0.00	897.90	0.00	0.00	0.00	897.90
0.75	15.00	0.00	3.04	0.00	0.00	0.00	3.04
0.80	16.00	1043.00	189.00	0.00	0.00	1043.00	189.00
0.85	17.00	2288.00	0.00	0.00	280.70	2288.00	280.70
0.90	18.00	3733.00	0.00	0.00	2059.00	3733.00	2059.00
0.95	19.00	5612.00	806.40	0.00	3569.00	5612.00	3569.00
1.00	20.00	7491.00	3300.00	0.00	3389.00	7491.00	3389.00

SPAN 2

XL	X	Analysis Top	Analysis Bot	Minimum Top	Minimum Bot	Selected Top	Selected Bot
	m	mm2	mm2	mm2	mm2	mm2	mm2
0.00	0.00	7491.00	3300.00	0.00	3389.00	7491.00	3389.00
0.05	1.00	5612.00	806.40	0.00	3569.00	5612.00	3569.00
0.10	2.00	3733.00	0.00	0.00	2059.00	3733.00	2059.00
0.15	3.00	2288.00	0.00	0.00	280.70	2288.00	280.70
0.20	4.00	1043.00	189.00	0.00	0.00	1043.00	189.00
0.25	5.00	0.00	3.04	0.00	0.00	0.00	3.04
0.30	6.00	0.00	897.90	0.00	0.00	0.00	897.90
0.35	7.00	0.00	1671.00	0.00	0.00	0.00	1671.00
0.40	8.00	0.00	2353.00	0.00	0.00	0.00	2353.00
0.45	9.00	0.00	2913.00	0.00	0.00	0.00	2913.00
0.50	10.00	0.00	3361.00	0.00	0.00	0.00	3361.00
0.55	11.00	0.00	3617.00	0.00	0.00	0.00	3617.00
0.60	12.00	0.00	3640.00	0.00	0.00	0.00	3640.00
0.65	13.00	0.00	3640.00	0.00	0.00	0.00	3640.00
0.70	14.00	0.00	3518.00	0.00	0.00	0.00	3518.00
0.75	15.00	0.00	3261.00	0.00	0.00	0.00	3261.00
0.80	16.00	0.00	2834.00	0.00	0.00	0.00	2834.00
0.85	17.00	0.00	2352.00	0.00	0.00	0.00	2352.00
0.90	18.00	0.00	1671.00	0.00	0.00	0.00	1671.00
0.95	19.00	0.00	897.90	0.00	0.00	0.00	897.90
1.00	20.00	0.00	76.08	0.00	0.00	0.00	76.08

Legend (2.1):
Span C = Cantilever
Form 1 = Rectangular, 2 = T or Inverted L, 3 = I, 4 = Extended T or L section
Rh Elevation of top surface
TF Top flange
MF Middle flange
BF Bottom flange

Legend (2.7):
The Column Boundary Condition (CBC):
Fixed at both 1
Hinged at near end, fixed at far end 2
Fixed at near end, hinged at far end 3
Fixed at near end, roller with rotational fixity at far end 4
LC Lower Column
UC Upper Column

Legend (3.1):
Class: SW: Selfweight, LL: Live Load, SDL: Superimposed Dead Load, X: Other Loading
Type: U: Uniform, P: Partial Uniform, L: Line Load, M: Applied Moment
C: Concentrated Load, R: Triangle, V: Variable, T: Trapezoidal

Legend (4.1, 4.2):
Yb: distance from centroid to bottom fiber
Yt: distance from centroid to top fiber
I: gross moment of inertia

Legend (7.1):
Type
1 = reversed parabola
2 = simple parabola with straight portion over support
3 = harped tendon
4 = straight tendon
5 = extended reversed parabola

Legend (7.2):
CGS C1: CGS of left middle point of tendon for type 5 profile
CGS C2: CGS of right middle point of tendon for type 5 profile or middle point of other types

Legend (10.1, 11.1):
From: Beginning of rebar measured from left support of the span
To: End of rebar measured from left support of the span
As Required: Envelope of minimum and ultimate rebar
Ultimate: Required rebar for ultimate load combinations
Minimum: Required minimum rebar

Legend (10.2, 11_2):
ID: ID number of the bar as shown on graph
From: Beginning of rebar measured from left support of the span
Quantity: Number of bars
Size: Bar number
Length: Total length of the bar
Area: Area of reinforcement

5.11.2 Verification

In this example, steel for initial condition is only required at the bottom of the second support. The following computations verify that the calculated stress and the area are correct. The results are referenced to the Results Report, i.e. the notation ADAPT B4.2, C3 refers to column 3 of block/section 4.2.

Stresses due to initial conditions are reported in the section 27-Detailed Stress of the detailed report. The maximum tensile stress at X/L = 0.95 in span 1 and X/L = 0.05 in span 2. Stresses are calculated as:

Stress:

$f = (\pm M_{(combined)}/S) - P/A$
Where,

$S_b = I/Y_b$
$= 5.437 \times 10^{10}\ mm^4 / 610.29\ mm$
$= 8.908 \times 10^7\ mm^3$ (ADAPT B4.1, C3, C4)
$S_t = I/Y_t$
$= 5.437 \times 10^{10}\ mm^4 / 304.71\ mm$
$= 1.7843 \times 10^8\ mm^3$ (ADAPT B4.1, C3, C5)

$P/A = 1.15 * 3.40\ N/mm^2 = 3.91\ N/mm^2$ (ADAPT B7.2, C7)

Moments are reported under block/section 23-Detailed Moments of the detailed report. Evaluating the combination of 1.00 SW + 1.15 PT at X/L=0.05 gives:

$M_{(combined,\ X/L=0.05)} = 1.00*(-629.28) + 1.15*(1450)$

= 1038.22 kN-m

Conservatively program considers 1% increment for moment for the design.

$M_{(combined, X/L=0.05)}$ = 1.01 * 1038.22
= 1048.60 kN-m

f_b = $(1038.22 \times 10^6)/(8.908 \times 10^7) - 3.91$
= 7.74 N/mm^2 (T) (ADAPT 7.75,B27, C5)

Considering 1% increase,
f_b = 7.86 N/mm^2 (T)

f_t = $(-1038.22 \times 10^6)/(1.784 \times 10^8) - 3.91$
= -9.73 N/mm^2 (C) (ADAPT -9.72,B27, C4)

Considering 1% increase,
f_t = -9.79 N/mm^2 (C)

The allowable tensile stresses are calculated as:

f'_{ci} = 21 N/mm^2
$f_{allowable}$, (T) = $0.25(f'_{ci})^{1/2}$
= $0.25 * 21^{1/2}$
= 1.15 N/mm^2 (tension)

Since the tensile stress f_b (7.86 N/mm^2) is greater than the allowable value (1.15 N/mm^2), nonprestressed reinforcement needs to be provided. Mild reinforcement is provided for the tension force (T) on the concrete section using the following relationship from ACI-318:

A_s = $T/(0.5*f_y)$
T = tension force
f_y = 460 N/mm^2 (ADAPT B1)
> 413.69 MPa , so use f_y = 413.69 MPa

The tensile force is found by assuming a linear stress distribution as shown in **Fig. 5.11-2**:

h = 915 mm
b_w = 460 mm
X = [7.86/(7.86 + 9.79)]*915
= 407.47 mm

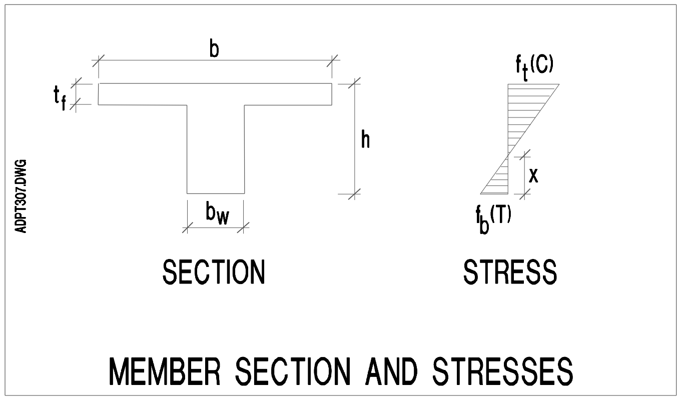


Figure 5.11-2

T = (407.47*460/2)*7.86
= 736624 N

Steel required for the initial conditions is reported in block/section 29-Detailed Rebar under minimum rebar column.

A_s = 736624/(0.5*413.69)
= 3562 mm^2 (ADAPT 3569 mm^2, B29, C6)

Data Block 27 - Compressive Stresses

The initial compressive strength, f'_{ci}, is the strength entered in the Material/Concrete input screen. In this example:

f'_{ci} = 21 N/mm^2

Allowable stresses were as 0.60*f'_{ci}. Therefore, the maximum allowable stress is:

0.60*21 = 12.6 N/mm^2

The maximum compressive stress, as shown in the Data Block 27, is 11.36 N/mm^2 at X/L = 0.45 in span 1 and X/L = 0.55 in span 2.

11.36/21 = 0.54
The maximum stress is 0.54 *f'_{ci} < 0.60 f'_{ci} OK

5.12 Deflection

5.12.1 Background

The background theory for computation of deflection profile of concrete members, with due allowance to cracking of the section, is given in chapter 3-Analysis and Design Background, of Volume 2. The following is an example of longhand deflection calculation and its comparison with the solutions obtained from ADAPT-PT. It serves two purposes. First, it demonstrates that the software correctly computes deflections. Second, the detailed description of deflection calculation may be used as a guide for verification of users' problems.

The longhand computation is broken into two parts. The first assumes, as its entry value, the equivalent moment of inertia, I_e, computed by the software. The second illustrates how the software computes I_e.

5.12.2 Deflection Computation

Consider the two-span beam shown in **Fig 5.12-1**. The particulars of the beam are:

f'_c	= 28 MPa
E_c	= 24870 MPa
Concrete; normal weight	= 2400 kg/m^3
Creep/shrinkage factor	= 2.0
Steel yield strength	= 460 MPa

Distance from tension fiber to centroid of tension steel	= 71 mm
Distance from compression fiber to centroid of compression rebar	= 71 mm

Cover = 60 mm top and bottom

Loading: applied dead load of 10 kN/m; concentrated dead load,

P	= 25 kN at center of first span;
Live loading	= 12 kN/m of beam.

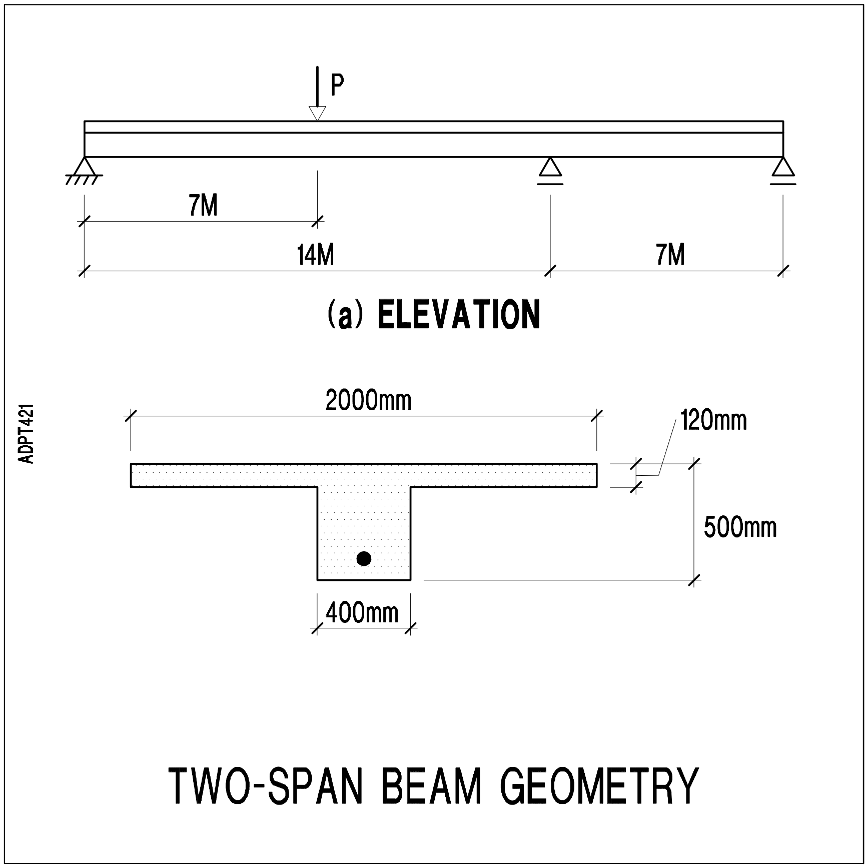


Figure 5.12-1

The computed deflections by ADAPT-PT are given in **Fig 5.12-2** graphically. The graphs are a representation of the deflection computations at 1/20th points. The 1/20th point deflections for the dead loading are listed in file CDF_D.INT and the combined deflections for dead and live loading are given in file CDF_DPSL.INT. The values for the current problem are extracted from these files and divided by modulus of elasticity of concrete (Ec) to get deflection and listed in **Table 5.12-1**. In the regular output of ADAPT-PT, only the summary of maximum deflections of each span is given (data block 14). For the current problem, this summary is reproduced in **Table 5.12-2**. In the following, the deflection values of span 1 from this table are a summary of the longhand computations.

TABLE 5.12-1 ADAPT-PT COMPUTED DEFLECTIONS OF SPAN 1

X/L	X	Deflections, δ			
	(m)	SW*	SW+PT** (mm)	SW+PT+SDL*** (mm)	SW+PT+SDL+LL**** (mm)
0.00	0.00	0.00	0.00	0.00	0.00
0.05	0.70	2.33	-6.18	1.76	4.79
0.10	1.40	4.58	-12.40	3.36	9.31
0.15	2.10	6.67	-18.64	4.74	13.41
0.20	2.80	8.53	-24.82	5.90	17.00
0.25	3.50	10.12	-30.82	6.84	20.01
0.30	4.20	11.40	-36.41	7.56	22.39
0.35	4.90	12.33	-40.90	8.07	24.11
0.40	5.60	12.90	-43.81	8.36	25.14
0.45	6.30	13.10	-45.18	8.45	25.49
0.50	7.00	12.93	-45.05	8.33	25.15
0.55	7.70	12.41	-43.46	8.01	24.16
0.60	8.40	11.57	-40.43	7.54	22.58
0.65	9.10	10.44	-35.96	6.93	20.50
0.70	9.80	9.07	-30.54	6.21	18.00
0.75	10.50	7.52	-24.81	5.41	15.19
0.80	11.20	5.87	-19.02	4.51	12.14
0.85	11.90	4.19	-13.28	3.53	8.98
0.90	12.60	2.58	-7.80	2.44	5.80
0.95	13.30	1.14	-3.08	1.25	2.73
1.00	14.00	0.00	0.00	0.00	0.00

Note: E_c= Modulus elasticity of concrete = 24870.00 N/mm^2

* = Reproduced from file CDF_D.INT

** = Reproduced from file CDF_DP.INT

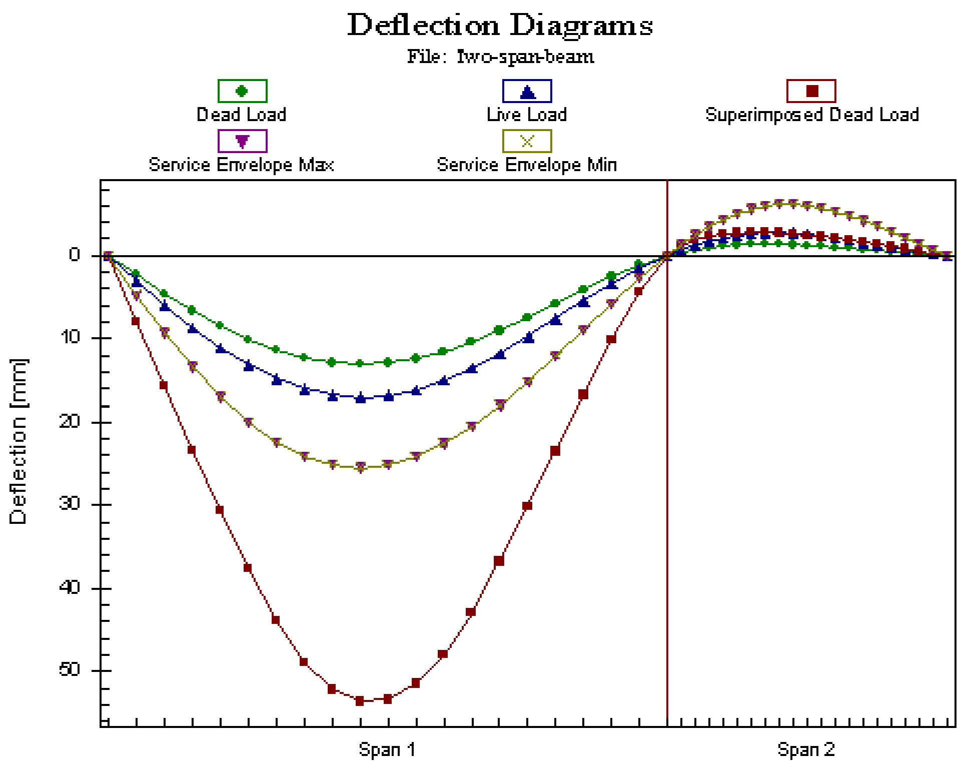
*** = Reproduced from file CDF_DPS.INT

**** = Reproduced from file CDF_DPSL.INT

TABLE 5.12-2: SUMMARY OF MAXIMUM DEFLECTIONS

14.1 Maximum Span Deflections

Span	SW	SW+PT	SW+PT+ SDL	SW+PT+SDL +Creep	LL	X	Total
	mm	mm	mm	mm	mm	mm	mm
1	13.1	-45.2	8.4	25.3(552)	17.0(821)	0.0(****)	42.4(330)
2	-1.4	-1.1	-3.5	-10.5(667)	-2.8(2510)	0.0(****)	-13.2(530)



Service Combination: 1SW + 1PT + 1SDL + 1LL

Figure 5.12-2

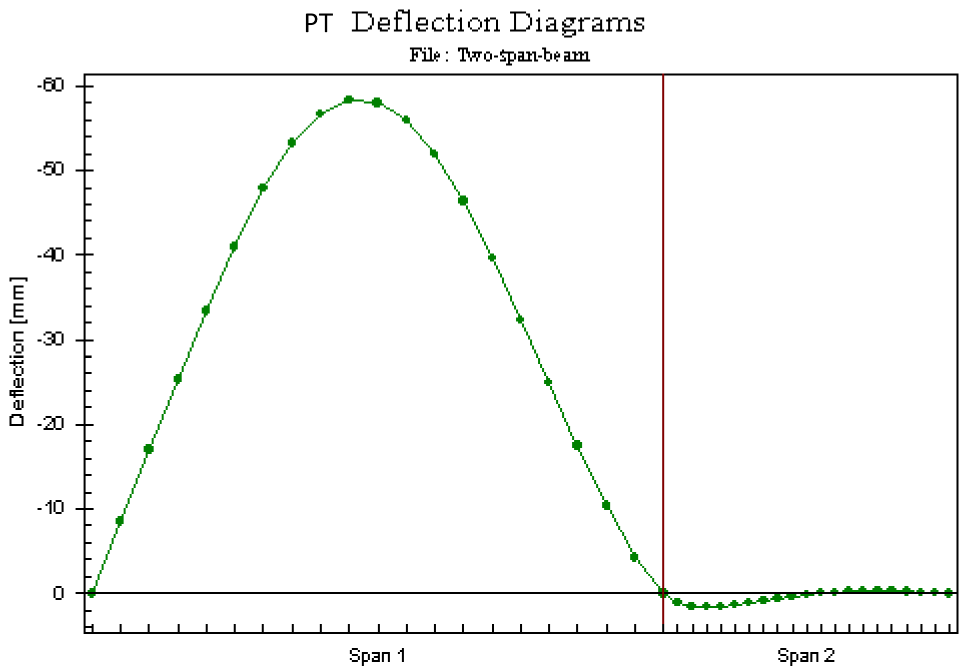


Figure 5.12-3

The procedure adopted for deflection calculation is described next. Refer to **Fig 5.12-3**. The distance, t, offset to the tangent at A, from point B, is given by the second equation of the *moment-area* method.

t = (moment of the bending moment diagram about B)/(E_c*I_e)

θ_a = t /AB

(w_{max} + t') = θ_a * a

where, a, is the distance from support, A, the location at which the maximum deflection occurs (w_{max}). The distance, a, is read from the **Table 5.12-1**. For the current problem, this distance is 6300 mm. The user may verify that 6300 mm is the maximum deflection by opening the deflection graph and clicking on the maximum point. The X and Y coordinates of the point will display.

Likewise, the offset, t', at location of maximum deflection is given by:

t' = (moment of the bending moment diagram between A, and D, about, D)/(E_c* I_e)

w_{max} = θ_a * a - t'

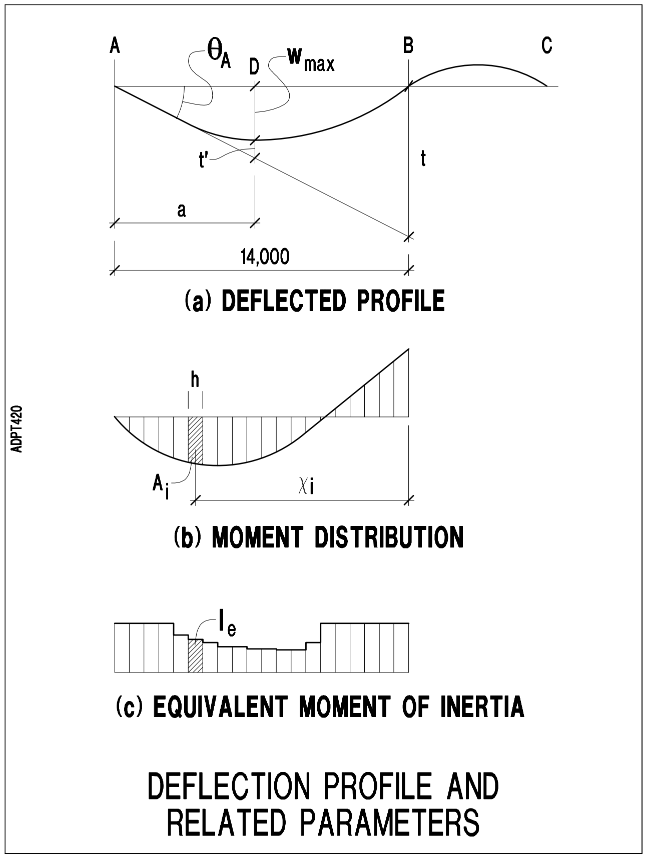


Figure 5.12-4

5.12.2.1 Deflection due to Selfweight

The computation is summarized in **Table 5.12-3**. The values of the equivalent moment of inertia and the applied moment are extracted from the file, D_IE.INT, generated by ADAPT-PT. A printout of this file for the current problem is given **Table 5.12-3** and **Table 5.12-4**. Refer to **Table 5.12-3** and **Table 5.12-4** again:

$t = \sum A_i * X_i / (E_c * I_e) = 46.90$ mm

$\theta_a = 46.90$ mm /14,000 mm = 3.350E-03

$(w_{max} + t') = 3.350E\text{-}03 * 6{,}300$ mm = 21.11 mm

$t' = \sum A'_i * X'_i / (E_c * I_e) = 8.01$ mm

$w_{max} = 21.11 - 8.01$

= 13.10 mm (ADAPT-PT 13.1 mm, data block 14, column 2)

TABLE 5.12-3 MOMENT-AREA INTERIM COMPUTATIONS

X	Moment*	I_e*	A_i	C_i	X_i	X_i'	A_iX_i/E_cI_e	A_iX_i'/E_cI_e
(mm)	(N.mm)	(mm4)	(N.mm2)	(mm)	(mm)	(mm)	(mm)	(mm)
0	1.00E-02	7.93E+09	n/a	n/a	n/a	n/a	n/a	n/a
700	3.46E+07	7.93E+09	1.210E+10	233.333	13533.333	5833.333	0.830	3.58E-01
1400	6.46E+07	7.93E+09	3.472E+10	314.655	12914.655	5214.655	2.272	9.18E-01
2100	9.02E+07	7.93E+09	5.417E+10	330.755	12230.755	4530.755	3.358	1.24E+00
2800	1.11E+08	7.93E+09	7.047E+10	337.803	11537.803	3837.803	4.121	1.37E+00
3500	1.28E+08	7.93E+09	8.358E+10	341.988	10841.988	3141.988	4.593	1.33E+00
4200	1.40E+08	7.93E+09	9.352E+10	344.760	10144.760	2444.760	4.809	1.16E+00
4900	1.47E+08	7.93E+09	1.003E+11	346.988	9446.988	1746.988	4.803	8.88E-01
5600	1.50E+08	7.93E+09	1.040E+11	348.822	8748.822	1048.822	4.609	5.53E-01
6300	1.48E+08	7.93E+09	1.044E+11	350.665	8050.665	350.665	4.260	1.86E-01
7000	1.42E+08	7.93E+09	1.017E+11	352.450	7352.450	-347.550	3.789	0.00E+00
7700	1.32E+08	7.93E+09	9.583E+10	354.517	6654.517	-1045.483	3.232	0.00E+00
8400	1.16E+08	7.93E+09	8.680E+10	357.151	5957.151	-1742.849	2.621	0.00E+00
9100	9.67E+07	7.93E+09	7.458E+10	360.791	5260.791	-2439.209	1.989	0.00E+00
9800	7.25E+07	7.93E+09	5.921E+10	366.704	4566.704	-3133.296	1.370	0.00E+00
10500	4.37E+07	7.93E+09	4.067E+10	378.855	3878.855	-3821.145	0.800	0.00E+00
11200	1.05E+07	7.93E+09	1.897E+10	421.593	3221.593	-4478.407	0.310	0.00E+00
11900	-2.73E+07	7.93E+09	-5.897E+09	88.348	2188.348	-5511.652	-0.065	0.00E+00
12600	-6.96E+07	7.93E+09	-3.393E+10	299.092	1699.092	-6000.908	-0.292	0.00E+00
13300	-1.17E+08	7.93E+09	-6.514E+10	320.614	1020.614	-6679.386	-0.337	0.00E+00
14000	-1.68E+08	7.93E+09	-9.950E+10	328.948	328.948	-7371.052	-0.166	0.00E+00
						Σ =	46.904	8.01E+00

Note: * Copied from file D_IE.INT

E_c = Modulus elasticity of concrete = 24870.00 N/mm^2.

A_i = Moment area each 1/20th subdivision (assumed as a trapezoid) (see **Fig 5.12-3**)

C = Centroid of each 1/20th subdivision (assumed as a trapezoid)

X_i = Moment arm of each 1/20th subdivision about point, B (see **Fig 5.12-3**)

X_i' = Moment arm of each 1/20th subdivision about point, D (see **Fig 5.12-3**)

TABLE 5.12-4 ADAPT-PT MOMENTS AND MOMENT OF INERTIAS DUE TO Selfweight

ADAPT STRUCTURAL CONCRETE SOFTWARE SYSTEM DATE: Dec 11,2019 TIME: 15:46

Data ID: Two-span Output File ID: D_IE.INT

Applied moment (Ma), Cracked moment (Mcr), Gross Moment of Inertia (Ig)

Cracked I (Icr) and Effective I (Ie)

S	pts	Ma	Mcr	Ig	Icr	Ie
1	0	0.1000000E-01	0.1494389E+09	0.79334001E+10	0.26295739E+09	0.79334001E+10
1	1	0.3457000E+08	0.1683360E+09	0.79334001E+10	0.28783990E+09	0.79334001E+10
1	2	0.6462000E+08	0.2250274E+09	0.79334001E+10	0.92564435E+09	0.79334001E+10
1	3	0.9015000E+08	0.2958915E+09	0.79334001E+10	0.15239332E+10	0.79334001E+10
1	4	0.1112000E+09	0.3573071E+09	0.79334001E+10	0.20948934E+10	0.79334001E+10
1	5	0.1276000E+09	0.4092741E+09	0.79334001E+10	0.26153687E+10	0.79334001E+10
1	6	0.1396000E+09	0.4517926E+09	0.79334001E+10	0.31121011E+10	0.79334001E+10
1	7	0.1470000E+09	0.4848626E+09	0.79334001E+10	0.34617347E+10	0.79334001E+10
1	8	0.1500000E+09	0.5084840E+09	0.79334001E+10	0.38910047E+10	0.79334001E+10
1	9	0.1483000E+09	0.5226568E+09	0.79334001E+10	0.38890550E+10	0.79334001E+10
1	10	0.1422000E+09	0.5273811E+09	0.79334001E+10	0.39134597E+10	0.79334001E+10
1	11	0.1316000E+09	0.5208339E+09	0.79334001E+10	0.35922557E+10	0.79334001E+10
1	12	0.1164000E+09	0.5011923E+09	0.79334001E+10	0.31386931E+10	0.79334001E+10
1	13	0.9669000E+08	0.4684562E+09	0.79334001E+10	0.24867569E+10	0.79334001E+10
1	14	0.7247000E+08	0.4226258E+09	0.79334001E+10	0.15213101E+10	0.79334001E+10
1	15	0.4373000E+08	0.3637009E+09	0.79334001E+10	0.11537068E+10	0.79334001E+10
1	16	0.1047000E+08	0.2916817E+09	0.79334001E+10	0.69595206E+09	0.79334001E+10
1	17	-.2732000E+08	0.2695331E+09	0.79334001E+10	0.13632786E+10	0.79334001E+10
1	18	-.6962000E+08	0.3677412E+09	0.79334001E+10	0.16359140E+10	0.79334001E+10
1	19	-.1165000E+09	0.4463076E+09	0.79334001E+10	0.19882194E+10	0.79334001E+10
1	20	-.1678000E+09	0.4724964E+09	0.79334001E+10	0.21374641E+10	0.79334001E+10

5.12.2.2 Deflection due to Live Loading

Deflection calculation for live load is followed in a similar manner, in which the applied moment and the associated equivalent moment of inertia are due to the simultaneous application of selfweight, post-tensioning, superimposed dead load and live load. The values of the parameters involved are given in **Tables 5.12-5** through **5.12-8**.

(i) Deflection due to SW + PT + SDL:

t = $\sum A_i * X_i / (E_c * I_e)$ = 35.68 mm

θ_a = 35.68 mm/14,000 mm = 2.549E-03

(w_{max} + t') = 2.549E-03*6,300 mm = 16.06 mm

t' = $\sum A'_i * X'_i / (E_c * I_e)$ = 7.61 mm

w_{max} due to SW+PT+SDL= 16.06 mm – 7.61 mm

= 8.45 mm

(ADAPT-PT 8.4 mm, data block 14, column 4)

TABLE 5.12-5 MOMENT-AREA INTERIM COMPUTATIONS

X	Moment*	I_e*	A_i	C_i	X_i	X_i'	A_iX_i/E_cI_e	A_iX_i'/E_cI_e
(mm)	(N.mm)	(mm4)	(N.mm2)	(mm)	(mm)	(mm)	(mm)	(mm)
0	-1.61E+03	7.93E+09	n/a	n/a	n/a	n/a	n/a	n/a
700	6.95E+07	7.93E+09	2.431E+10	233.33	13533.33	5833.33	1.67	0.72
1400	9.17E+07	7.93E+09	5.641E+10	333.89	12933.89	5233.89	3.70	1.50
2100	9.04E+07	7.93E+09	6.372E+10	350.87	12250.87	4550.87	3.96	1.47
2800	8.90E+07	7.93E+09	6.278E+10	350.86	11550.86	3850.86	3.68	1.23
3500	8.77E+07	7.93E+09	6.187E+10	350.86	10850.86	3150.86	3.40	0.99
4200	8.65E+07	7.93E+09	6.096E+10	350.86	10150.86	2450.86	3.14	0.76
4900	8.52E+07	7.93E+09	6.008E+10	350.84	9450.84	1750.84	2.88	0.53
5600	8.40E+07	7.93E+09	5.922E+10	350.84	8750.84	1050.84	2.63	0.32
6300	8.28E+07	7.93E+09	5.837E+10	350.84	8050.84	350.84	2.38	0.10
7000	8.16E+07	7.93E+09	5.754E+10	350.83	7350.83	-349.17	2.14	0.00
7700	6.48E+07	7.93E+09	5.125E+10	363.40	6663.40	-1036.60	1.73	0.00
8400	5.17E+07	7.93E+09	4.076E+10	363.16	5963.16	-1736.84	1.23	0.00
9100	4.22E+07	7.93E+09	3.284E+10	361.79	5261.79	-2438.21	0.88	0.00
9800	3.64E+07	7.93E+09	2.749E+10	358.63	4558.63	-3141.37	0.64	0.00
10500	3.43E+07	7.93E+09	2.472E+10	353.50	3853.50	-3846.50	0.48	0.00
11200	3.58E+07	7.93E+09	2.451E+10	347.43	3147.43	-4552.57	0.39	0.00
11900	4.10E+07	7.93E+09	2.688E+10	342.07	2442.07	-5257.93	0.33	0.00
12600	4.99E+07	7.93E+09	3.182E+10	338.59	1738.59	-5961.41	0.28	0.00
13300	2.97E+07	7.93E+09	2.786E+10	379.59	1079.59	-6620.41	0.15	0.00
14000	-5.23E+07	7.93E+09	-7.896E+09	-73.95	-73.95	-7773.95	0.00	0.00
						Σ =	35.68	7.61

Note: ** Copied from file DPS_IE.INT

E_c = Modulus elasticity of concrete = 24870.00 N/mm^2.

A_i = Moment area each 1/20th subdivision (assumed as a trapezoid) (see **Fig 5.12-3**)

C_i = Centroid of each 1/20th subdivision (assumed as a trapezoid)

X_i = Moment arm of each 1/20th subdivision about point B (see **Fig 5.12-3**)

X_i' = Moment arm of each 1/20th subdivision about point D (see **Fig 5.12-3**)

TABLE 5.12-6 ADAPT-PT MOMENTS AND MOMENT OF INERTIAS DUE TO SW+PT+SDL

ADAPT STRUCTURAL CONCRETE SOFTWARE SYSTEM DATE: Dec 11,2019 TIME: 15:46

Data ID: Two-span Output File ID: DPS_IE.INT

Applied moment (Ma), Cracked moment (Mcr), Gross Moment of Inertia (Ig)

Cracked I (Icr) and Effective I (Ie)

S	pts	Ma	Mcr	Ig	Icr	Ie
1	0	-.1605000E+04	0.3266621E+09	0.79334001E+10	0.14842995E+10	0.79334001E+10
1	1	0.6946000E+08	0.1683360E+09	0.79334001E+10	0.28783990E+09	0.79334001E+10
1	2	0.9171000E+08	0.2250274E+09	0.79334001E+10	0.92564435E+09	0.79334001E+10
1	3	0.9035000E+08	0.2958915E+09	0.79334001E+10	0.15239332E+10	0.79334001E+10
1	4	0.8903000E+08	0.3573071E+09	0.79334001E+10	0.20948934E+10	0.79334001E+10
1	5	0.8773000E+08	0.4092741E+09	0.79334001E+10	0.26153687E+10	0.79334001E+10
1	6	0.8645000E+08	0.4517926E+09	0.79334001E+10	0.31121011E+10	0.79334001E+10
1	7	0.8521000E+08	0.4848626E+09	0.79334001E+10	0.34617347E+10	0.79334001E+10
1	8	0.8399000E+08	0.5084840E+09	0.79334001E+10	0.38910047E+10	0.79334001E+10
1	9	0.8279000E+08	0.5226568E+09	0.79334001E+10	0.38890550E+10	0.79334001E+10
1	10	0.8162000E+08	0.5273811E+09	0.79334001E+10	0.39134597E+10	0.79334001E+10
1	11	0.6480000E+08	0.5208339E+09	0.79334001E+10	0.35922557E+10	0.79334001E+10
1	12	0.5166000E+08	0.5011923E+09	0.79334001E+10	0.31386931E+10	0.79334001E+10
1	13	0.4218000E+08	0.4684562E+09	0.79334001E+10	0.24867569E+10	0.79334001E+10
1	14	0.3637000E+08	0.4226258E+09	0.79334001E+10	0.15213101E+10	0.79334001E+10
1	15	0.3425000E+08	0.3637009E+09	0.79334001E+10	0.11537068E+10	0.79334001E+10
1	16	0.3579000E+08	0.2916817E+09	0.79334001E+10	0.69595206E+09	0.79334001E+10
1	17	0.4101000E+08	0.2065680E+09	0.79334001E+10	0.41647779E+09	0.79334001E+10
1	18	0.4990000E+08	0.1083599E+09	0.79334001E+10	0.10570386E+10	0.79334001E+10
1	19	0.2971000E+08	0.2979342E+08	0.79334001E+10	0.17868195E+10	0.79334001E+10
1	20	-.5227000E+08	0.4724964E+09	0.79334001E+10	0.21374641E+10	0.79334001E+10

(ii) **Deflection due to SW + PT + SDL + LL:**

t = $\sum A_i * X_i/(E_c * I_e)$ = 96.67 mm
θ_a = 96.67/14,000 = 6.905E-03
(w_{max} + t') = 6.905E-03*6,300 mm = 43.50 mm

t' = $\sum A'_i * X'_i/(E_c * I_e)$ = 18.02 mm
w_{max} due to SW+PT+SDL+LL
= 43.50 mm – 18.02 mm = 25.48 mm

w_{max} due to live load = w_{max} due to SW+PT+SDL+LL –
w_{max} due to SW+PT+SDL
= 25.48 – 8.45 = 17.03 mm
(ADAPT-PT 17.0 mm, data block 14, column 6)

TABLE 5.12-7 MOMENT-AREA INTERIM COMPUTATIONS

X	Moment*	I_e*	A_i	C_i	X_i	X_i'	A_iX_i/E_cI_e	A_iX_i'/E_cI_e
(mm)	(N.mm)	(mm4)	(N.mm2)	(mm)	(mm)	(mm)	(mm)	(mm)
0	-1.61E+03	7.93E+09	n/a	n/a	n/a	n/a	n/a	n/a
700	1.14E+08	7.93E+09	4.004E+10	233.33	13533.33	5833.33	2.75	1.18
1400	1.76E+08	7.93E+09	1.015E+11	325.35	12925.35	5225.35	6.65	2.69
2100	2.08E+08	7.93E+09	1.342E+11	340.29	12240.29	4540.29	8.32	3.09
2800	2.34E+08	7.93E+09	1.544E+11	343.12	11543.12	3843.12	9.03	3.01
3500	2.54E+08	7.93E+09	1.706E+11	345.19	10845.19	3145.19	9.37	2.72
4200	2.68E+08	7.93E+09	1.826E+11	346.80	10146.80	2446.80	9.39	2.26
4900	2.76E+08	7.93E+09	1.905E+11	348.20	9448.20	1748.20	9.12	1.69
5600	2.79E+08	7.93E+09	1.944E+11	349.45	8749.45	1049.45	8.62	1.03
6300	2.76E+08	7.93E+09	1.941E+11	350.69	8050.69	350.69	7.92	0.35
7000	2.67E+08	7.93E+09	1.898E+11	351.98	7351.98	-348.02	7.07	0.00
7700	2.36E+08	7.93E+09	1.758E+11	357.11	6657.11	-1042.89	5.93	0.00
8400	2.03E+08	7.93E+09	1.536E+11	358.75	5958.75	-1741.25	4.64	0.00
9100	1.68E+08	7.93E+09	1.298E+11	361.04	5261.04	-2438.96	3.46	0.00
9800	1.31E+08	7.93E+09	1.045E+11	364.58	4564.58	-3135.42	2.42	0.00
10500	9.11E+07	7.93E+09	7.760E+10	370.78	3870.78	-3829.22	1.52	0.00
11200	4.94E+07	7.93E+09	4.918E+10	384.63	3184.63	-4515.37	0.79	0.00
11900	5.49E+06	7.93E+09	1.921E+10	443.32	2543.32	-5156.68	0.25	0.00
12600	-4.06E+07	7.93E+09	-1.230E+10	196.86	1596.86	-6103.14	-0.10	0.00
13300	-1.22E+08	7.93E+09	-5.682E+10	291.73	991.73	-6708.27	-0.29	0.00
14000	-2.71E+08	7.93E+09	-1.373E+11	305.74	305.74	-7394.26	-0.21	0.00
						Σ =	96.674	18.02

Note: ** Copied from file DPSL_IE.INT

E_c = Modulus elasticity of concrete = 24870.00 N/mm^2.

A_i = Moment area each 1/20th subdivision (assumed as a trapezoid) (see **Fig 5.12-3**)

C_i = Centroid of each 1/20th subdivision (assumed as a trapezoid)

X_i = Moment arm of each 1/20th subdivision about point B (see **Fig 5.12-3**)

X_i' = Moment arm of each 1/20th subdivision about point D (see **Fig 5.12-3**)

TABLE 5.12-8 ADAPT-PT MOMENTS AND MOMENT OF INERTIAS DUE TO SW+PT+SDL+LL

ADAPT STRUCTURAL CONCRETE SOFTWARE SYSTEM DATE: Dec 11,2019 TIME: 15:46

Data ID: Two-span Output File ID: DPSL_IE.INT

==

Applied moment (Ma), Cracked moment (Mcr), Gross Moment of Inertia (Ig)

Cracked I (Icr) and Effective I (Ie)

S	pts	Ma	Mcr	Ig	Icr	Ie
1	0	-.1605000E+04	0.3266621E+09	0.79334001E+10	0.14842995E+10	0.79334001E+10
1	1	0.1144000E+09	0.1683360E+09	0.79334001E+10	0.28783990E+09	0.79334001E+10
1	2	0.1757000E+09	0.2250274E+09	0.79334001E+10	0.92564435E+09	0.79334001E+10
1	3	0.2076000E+09	0.2958915E+09	0.79334001E+10	0.15239332E+10	0.79334001E+10
1	4	0.2336000E+09	0.3573071E+09	0.79334001E+10	0.20948934E+10	0.79334001E+10
1	5	0.2537000E+09	0.4092741E+09	0.79334001E+10	0.26153687E+10	0.79334001E+10
1	6	0.2680000E+09	0.4517926E+09	0.79334001E+10	0.31121011E+10	0.79334001E+10
1	7	0.2764000E+09	0.4848626E+09	0.79334001E+10	0.34617347E+10	0.79334001E+10
1	8	0.2790000E+09	0.5084840E+09	0.79334001E+10	0.38910047E+10	0.79334001E+10
1	9	0.2757000E+09	0.5226568E+09	0.79334001E+10	0.38890550E+10	0.79334001E+10
1	10	0.2665000E+09	0.5273811E+09	0.79334001E+10	0.39134597E+10	0.79334001E+10
1	11	0.2359000E+09	0.5208339E+09	0.79334001E+10	0.35922557E+10	0.79334001E+10
1	12	0.2030000E+09	0.5011923E+09	0.79334001E+10	0.31386931E+10	0.79334001E+10
1	13	0.1679000E+09	0.4684562E+09	0.79334001E+10	0.24867569E+10	0.79334001E+10
1	14	0.1306000E+09	0.4226258E+09	0.79334001E+10	0.15213101E+10	0.79334001E+10
1	15	0.9111000E+08	0.3637009E+09	0.79334001E+10	0.11537068E+10	0.79334001E+10
1	16	0.4940000E+08	0.2916817E+09	0.79334001E+10	0.69595206E+09	0.79334001E+10
1	17	0.5493000E+07	0.2065680E+09	0.79334001E+10	0.41647779E+09	0.79334001E+10
1	18	-.4063000E+08	0.3677412E+09	0.79334001E+10	0.16359140E+10	0.79334001E+10
1	19	-.1217000E+09	0.4463076E+09	0.79334001E+10	0.19882194E+10	0.79334001E+10
1	20	-.2705000E+09	0.4724964E+09	0.79334001E+10	0.21374641E+10	0.79334001E+10

In cases in which the live loading is skipped, an envelope for the live load is calculated, and hence, the combined dead and live loading is determined. In the computation of the equivalent moment of inertia, the following conservative procedure is adopted. At a location where the combined dead and skipped live load moment does not change sign, the maximum value of the combined moment is used as M_a, since this produces maximum deflection. At locations where the combined moment changes sign, two values are computed for the equivalent moment of inertia, I_e: one value uses the maximum positive moment, and the other uses the maximum negative moment. Of the two values of computed I_e, the smaller is used for deflection computation.

5.12.2.3 Dead Load, Post-Tensioning and Creep/Shrinkage

Creep/shrinkage factor = 2.0
w_{max} due to SW+PT+SDL = 8.45 mm
w_{max} due to creep/shrinkage,
dead load and PT = (2.0*8.45) + (8.45)
= 25.35 mm
(ADAPT-PT 25.3 mm, data block 14, column 5)

5.12.2.4 Dead Load, Post-Tensioning, Live Load and Creep/Shrinkage

Creep/Shrinkage factor = 2.0
w_{max} due to LL = 17.03 mm
w_{max} due to creep/shrinkage,
dead load, PT and live load = 25.35 + 17.03 = 42.38 mm
(ADAPT-PT 42.4 mm, data block 14, column 8)

5.12.3 Computation of Equivalent Moment of Inertia, I_e

In addition to the geometry of the section, the location and amount of both the tension and the compression reinforcement are necessary to compute I_{cr}. Herein, I_{cr} at the section next to the second support(18th pint in Table 5.12-10) is hand calculated for SW+PT combination. This section contains both negative and positive reinforcement. Refer to **Table 5.12-9**.

For this combination since tension occurs at the bottom fiber of the section, indicated by the positive moment in **Table 5.12-10**, the following are the primary equations used in determining the cracking moment of inertia, I_{cr}.

$$I_{cr} = b(c)^3/3 + n_s A_s (d-c)^2 + n_p A_{ps} (d_p-c)^2 + A_s'(n-1)(c-d')^2$$

For the current problem,

A_s = 736.20mm^2 (**Table 5.12-9**)
A_s' = 1019 mm^2 (**Table 5.12-9**)
A_p = 1247.09*10^3/1200 = 1039.24 mm^2
b = 2000 mm
d = 429 mm
d_p = 500- 376 =124 mm
d' = 71 mm
E_c = 24,870 N/mm^2
E_s =E_s' = 200,000 N/mm^2
E_p = 200,000 N/mm^2
n_s = E_s/E_c = 8.04
n_p = E_p/E_c = 8.04
c = 500-422.88 = 77.12 mm (Extracted from Icr_p.dat file)

Solving for I_{cr},

I_{cr} = 2000*(77.12)^3/3 + 8.04*736.20*(429 – 77.12)^2 + 8.04*1039.24*
(124 – 77.12)^2 + 1019*(8.40-1)(77.12-71)^2
= 0.1057E+10mm^4 (ADAPT-PT 0.1057E+10 mm^4, DP_IE.INT file)

$$I_e = (M_{cr} / M_a)^3 I_g + [1-(M_{cr} / M_a)^3]I_{cr} \le I_g \qquad (5.10.2\text{-}1)$$

Where for the current problem,

M_{cr} = 0.1083599E+09 N.mm (Extracted from DP_IE.INT file)
M_a = 0.1466000E+09 N.mm (Extracted from DP_IE.INT file)
I_g = 0.7933400E+10 mm^4 (Extracted from DL_IE.INT file)

After substitution,

I_e = (0.1083599E+09 / 0.1466000E+09)^3 *0.7933400E+10 + [1-
(0.1083599E+09 / 0.1466000E+09)^3]* 0.1057E+10
= 0.3834E+10 mm^4 < I_g = 0.79334E+10 mm^4
(ADAPT-PT 0.3834E+10 mm^4, DP_IE.INT file)

TABLE 5.12-9 ADAPT-RC 1/20TH POINT REINFORCEMENT OUTPUTS

29 - DETAILED REBAR

SPAN 1

XL	X	Analysis Top	Analysis Bot	Minimum Top	Minimum Bot	Selected Top	Selected Bot
	m	mm2	mm2	mm2	mm2	mm2	mm2
0.00	0.00	0.00	0.00	1019.00	0.00	1019.00	0.00
0.05	0.70	0.00	0.00	1019.00	0.00	1019.00	0.00
0.10	1.40	0.00	440.90	1019.00	0.00	1019.00	440.90
0.15	2.10	0.00	757.80	1019.00	0.00	1019.00	757.80
0.20	2.80	0.00	1023.00	0.00	0.00	0.00	1023.00
0.25	3.50	0.00	1199.00	0.00	0.00	0.00	1199.00
0.30	4.20	0.00	1394.00	0.00	0.00	0.00	1394.00
0.35	4.90	0.00	1414.00	0.00	548.90	0.00	1414.00
0.40	5.60	0.00	1618.00	0.00	548.90	0.00	1618.00
0.45	6.30	0.00	1508.00	0.00	548.90	0.00	1508.00
0.50	7.00	0.00	1433.00	0.00	548.90	0.00	1433.00
0.55	7.70	0.00	1117.00	0.00	548.90	0.00	1117.00
0.60	8.40	0.00	868.70	0.00	548.90	0.00	868.70
0.65	9.10	0.00	391.60	0.00	548.90	0.00	548.90
0.70	9.80	0.00	0.00	0.00	0.00	0.00	0.00
0.75	10.50	0.00	47.55	0.00	0.00	0.00	47.55
0.80	11.20	0.00	0.00	0.00	0.00	0.00	0.00
0.85	11.90	0.00	34.75	1019.00	0.00	1019.00	34.75
0.90	12.60	422.50	614.40	1019.00	736.20	1019.00	736.20
0.95	13.30	506.00	640.30	1019.00	1396.00	1019.00	1396.00
1.00	14.00	974.10	1277.00	1019.00	1270.00	1019.00	1277.00

TABLE 5.12-10 ADAPT-PT MOMENTS AND MOMENT OF INERTIAS DUE TO SW+PT

```
ADAPT STRUCTURAL CONCRETE SOFTWARE SYSTEM   DATE: Dec 12,2019      TIME: 16:51
 Data ID: Two-span                           Output File ID:       DP_IE.INT


=============================================================================
   Applied moment (Ma), Cracked moment (Mcr),  Gross Moment of Inertia (Ig)
                    Cracked I (Icr) and Effective I (Ie)


 S  pts          Ma           Mcr            Ig             Icr            Ie
------------------------------------------------------------------------------
1   0 -.1605000E+04 0.3266621E+09 0.79334001E+10 0.14842995E+10 0.79334001E+10
1   1 0.2541000E+08 0.1683360E+09 0.79334001E+10 0.28783990E+09 0.79334001E+10
1   2 0.8496000E+07 0.2250274E+09 0.79334001E+10 0.92564435E+09 0.79334001E+10
1   3 -.2711000E+08 0.1802096E+09 0.79334001E+10 0.13329687E+10 0.79334001E+10
1   4 -.5779000E+08 0.1187939E+09 0.79334001E+10 0.72090675E+09 0.79334001E+10
1   5 -.8354000E+08 0.6682694E+08 0.79334001E+10 0.95024198E+09 0.45248072E+10
1   6 -.1044000E+09 0.2430839E+08 0.79334001E+10 0.12433130E+10 0.13277628E+10
1   7 -.1203000E+09 0.0000000E+00 0.79334001E+10 0.14880417E+10 0.14880417E+10
1   8 -.1312000E+09 0.0000000E+00 0.79334001E+10 0.16752808E+10 0.16752808E+10
1   9 -.1373000E+09 0.0000000E+00 0.79334001E+10 0.18173078E+10 0.18173078E+10
1  10 -.1384000E+09 0.0000000E+00 0.79334001E+10 0.18823898E+10 0.18823898E+10
1  11 -.1328000E+09 0.0000000E+00 0.79334001E+10 0.18194551E+10 0.18194551E+10
1  12 -.1186000E+09 0.0000000E+00 0.79334001E+10 0.16375526E+10 0.16375526E+10
1  13 -.9582000E+08 0.7644817E+07 0.79334001E+10 0.13518359E+10 0.13551784E+10
1  14 -.6448000E+08 0.5347526E+08 0.79334001E+10 0.10773665E+10 0.49880852E+10
1  15 -.2456000E+08 0.1124001E+09 0.79334001E+10 0.75743814E+09 0.79334001E+10
1  16 0.2393000E+08 0.2916817E+09 0.79334001E+10 0.69595206E+09 0.79334001E+10
1  17 0.8099000E+08 0.2065680E+09 0.79334001E+10 0.41647779E+09 0.79334001E+10
1  18 0.1466000E+09 0.1083599E+09 0.79334001E+10 0.10570386E+10 0.38339530E+10
1  19 0.1881000E+09 0.2979342E+08 0.79334001E+10 0.17868195E+10 0.18112442E+10
1  20 0.1727000E+09 0.3604598E+07 0.79334001E+10 0.17141897E+10 0.17142463E+10
```

5.13 One-Way Shear Verification for British Version

The following describes the general method of verification for each of the datum columns of ADAPT-PT report for one-way shear calculation (Data Block 12). Following the description, a specific section of the three span T-beam given at the end of this section is verified.

ADAPT-PT reports moments, shears and stresses at 1/20th points along each span in MOMENTS.DAT, SHEARS.DAT and STRESSES.DAT files. These files are reproduced and attached at the end of this section for ease of reference.

Shear calculations are carried out for sections which fall outside the face-of-support. Sections which are adjacent to the supports (up to two times the member depth from the face-of-support) exhibit a stronger shear resistance compared to sections away from supports. This added strength, referred to in BS8110 3.4.5.8 as *enhanced shear strength* is conservatively disregarded in the shear evaluations by ADAPT-PT. Hence, sections near the supports and concentrated loading are treated the same as regular sections.

Column 4. Vu

This is the factored shear. The factors are read from the A.2 block of the concise report in the Report Generator; the shears from SHEARS.DAT. User can enter up to four strength load combinations in the input screen. In such a case, program evaluates the shear stress ratio for all the combinations and the factored shear associated with the highest stress ratio is selected and reported in data block 12. STRUPRC_det.dat file gives the shear reinforcement calculation for each strength load combination.

$$V_u = 1.4*V_d + 1.60*V_l + V_{sec}$$

Consider a section in the second span distanced 1.7 meters from the second-support line. Refer to SHEARS.DAT printout, second span, X/L=0.10; the following values are read off and combined into V:

$$V_u = 1.4*(-225.30) + 1.6*(-64.37) + 15.78 = -402.63 \text{ kN}$$

(Block 12, Column 4, -402.60 kN)

Column 5. Mu

Factored moments are calculated at 1/20th points from the MOMENTS.DAT file using the following relationship. The numerical factors are given in A.2 block of the concise report in Report Generator.

$$M_u = 1.4*M_d + 1.6*M_l + M_{sec}$$

Observe that due to the patterned nature of live load, it is possible that at a given section there will be both a positive and a negative live load moment due to different arrangements of loads. Also, the user can enter up to four strength load combinations in the input screen.

In such a case, program evaluates the shear stress ratio for all the combinations and the factored moment associated with the highest stress ratio is selected and reported in data block 12.

For the section being used as an example:

$$M_u = 1.4*(-591.32) + 1.6*(-168.95) + 284.32 = -813.85 \text{ kNm}$$

Conservatively program multiplies this value with 1.01 factor,

$M_u = 1.01 * 813.85 = 821.99$ kNm (Block 12, Column 5, -821.90)

Column 6. V_C

v^c is the design concrete shear 3.9 of BS8110 as follows:

$$v_c = (0.79*[100*(A_{ps}+A_s)/(b_v*d_r)]^{1/3} *(400/d_r)^{1/4}* (f_{cu}/25)^{1/3})/\gamma_m$$

where,

A_{ps} = Area of prestressing steel
A_s = area of nonprestressed reinforcement on tension side
b_v = width of section (stem width for T sections)
d_r = distance of tension rebar to compression fiber
γ_m = material constant stipulated as 1.25

The following adjustments are observed when calculating v_C:

if $[100*(A_{ps}+A_s)/(b_v*d_r)] > 3$, set it equal to 3;
if $(400/d_r) < 1$, set it equal to 1;

The enhancement in concrete shear stress v_c is considered due to higher concrete strength f_{cu}. The enhancement states that for concrete strengths up to f_{cu} = 40 N/mm^2, v_c may be multiplied by $(f_{cu}/25)^{1/3}$.

For the particular section of the example:

$$A_{ps} = 1660*1000/1060 = 1566 \text{ mm}^2;$$

Where, 1660 kN is the specified post-tensioning force for span 1 from (B7.2, C2). Observe that the same force is used for the section under consideration in the second span, since it is assumed that terminated tendons extend over the support from first span into the second span and are anchored at one-fifth point of second span; 1060 N/mm^2 is the average stress in tendon specified by user as part of input and given in B1.

b_v = 460 mm from (B2.1, C4);

d_r = 900 - 25 - 16/2 = 867 mm;

Where 25 mm is cover to rebar from B1 and 16 mm is the diameter of top bar specified by user and read from B10.2, C6. Note that the top bar parameters are used, since M is negative, otherwise bottom bar values apply.

A_s = 0 mm (B29, C3)

Note that the rebar area chosen is for the tension side, and that it is used if it falls within the rebar cut-off length stipulated by the user during data input.

Substituting the values:

v_c = (0.79*[l00*(1566+0)/(460*867)]1/3*(1)l/4* (35/25)1/3)
= 0.65 N/mm2
V_c = 0.65 *460*867 = 258.10 kN (B12,C6; 258.60 kN, OK)

In the preceding (400/867) is set as 1, since it shall not be taken less than 1.

Column 7. V_{co}

From Equation 54 of BS8110 4.3.8.4

$$V_{co} = 0.67*b_v*h*(f_t^2 + 0.8*f_{cp}*f_t)^{1/2}$$

where,

f_t = maximum design principal tensile stress
f_t = 0.24*(f_{cu})1/2 (BS8110 4.3.8.4); and
f_{cp} = design compressive stress at the centroidal axis due to prestress, taken as positive; for T sections and when the centroidal axis falls within the flange the stress at the interface of stem and flange is used

For the particular case:

$$f_t = 0.24*(35)^{1/2} = 1.42 \text{ N/mm}^2$$

Strictly speaking, the centroidal axis used for shear should be based on the cross-sectional geometry that is defined by the effective width of the section. However, in the example under consideration, the effective width concept was not used. Hence the properties of the entire section are used.

Since centroidal axis (305.08 mm from the flanged side, B4.1, C5) falls within the stem (flange thickness 120 mm, B2.1, C7) the stresses at centroid are used. The stress at the centroidal axis is interpolated between the stresses at the extreme fibers given in the section 27-Detailed Stresses of the detailed report. Also provided in STRESS.DAT file under PT. Refer the report and read the extreme fiber stresses for span 2, X/L = 0.1 as follows:

Stress at top, f_{top} = 5.70 N/mm^2 (compression)
stress at bottom, f_{bot} = 3.68 N/mm^2
total depth = 900 mm
depth from bottom to centroidal axis = 594.92 mm

Hence,

f_{cp} = 3.68 + (594.92/900)*(5.70 3.68)
= 2.52 N/mm^2
V_{co} = 0.67*460*900*(1.422 + 0.80*2.52*1.42)1/2
= 612.70 kN (B12, C7; 612.60 kN)

Note that in the preceding relationship compression is substituted as positive.

Column 8. V_{cr}

The design ultimate resistance of a section cracked in flexure is given by Equation 55 of BS8110,:

V_{cr} = (1 - 0.55*f_{pea}/f_{pu})*v_c *b_v*d + (M_o/M)*V

But, V_{cr} need not be less than 0.1*b_v*d*$(f_{cu})^{1/2}$.

The parameters are:

f_{pea} = adjusted f_{pe}
f_{pea} = PTF/(A_{ps} + (f_y/f_{pu})*A_s);
PTF is the prestressing force (B7.2, C2);
but if f_{pe} = PTF/A_{ps} > 0.6*f_{pu} set f_{pe} = 0.6*f_{pu};
f_{pe} is user input, see B1

f_{pu} = tendon's ultimate strength; user input, see B1;
v_c = design concrete shear stress given under column 6;
M_o = defined under column 9; and
V = given under column 5.

For the section under consideration

PTF = 1660 kN (B7.2, C2);
f_{pe} = 1060 N/mm^2 (B1)
A_{ps} = PTF/f_{pe} = 1660*1000/1060 = 1566 N/mm^2;
A_s = 0 mm^2 (B29, C3);
M/M_o = 1.06
V = 402.60 kN

Substitute;

f_{pea} = (1660*1000)/(1566 + (460/1770)*0)
= 1060 N/mm^2

V_{cr} = (1 0.55*1060/1770)*0.65*460*867+ 402.63*1000/1.67
= 414.94 kN (B12, C8, 414.10 kN, OK)

Column 9. Ratio M/M_o

Herein;

M = applied factor moment (B12, C5)
M_o = moment necessary to produce zero stress in the concrete at the extreme tension fiber (decompression moment); in this calculation only 0.80 of the stress due to prestress is considered

M_o is calculated from the prestressing stresses and the section moduli. The following two conditions are differentiated:

One, if applied moment due to dead and live loading alone is positive, then

$M_o = 0.80(P*e + f_{cp}*S_b)$; and,

Two, when the sum of dead and live loading is negative.

$M_o = 0.80(P*e + f_{cp}*S_t)$;
Strictly speaking M_{bal} should be used instead of P*e in the above equations for M_0.

where,

f_{cp} = design compressive stress at the centroidal axis due to prestress, taken as positive; for T sections and when the centroidal axis falls within the flange the stress at the interface of stem and flange is used.
S_b and S_t = bottom and top section moduli derived from B4.1.
e = eccentricity of the tendon from N.A

For the particular example and from MOMENTS.DAT file it is noted that (DL + LL) moments add up to a negative number, hence relationship (ii) is used.

Stress at top, f_{top} = 5.70 N/mm^2 (compression)
stress at bottom, f_{bot} = 3.68 N/mm^2
total depth = 900 mm
depth from bottom to centroidal axis

CGS of tendon = 594.92 mm
= 708 mm (B21, C7)

Hence,

f_{cp} = 3.68 + (594.92/900)*(5.70   3.68)
= 2.52 N/mm^2
S_t = I/Y_t = (0.5164*1011)/305.08 = 169.3*106 mm^3
e = 708 – 594.92 = 113.08 mm

M_o = 0.80(1660*1000*113.08 +2.52*169.3*106)/106 = 491.48 kNm;
M = 821.99 kNm (from column 5);

Hence,

M/M_o = 821.99/491.48 = 1.67

Columns 10 and 11: A_{sv} and Spacing of Links (Stirrups)

The **Fig. 5.13-1** for shear in prestressed concrete is used to calculate the area of links and spacing between them. It is assumed that the links are two legged. The bar size used is user defined and is printed at top of column 10.

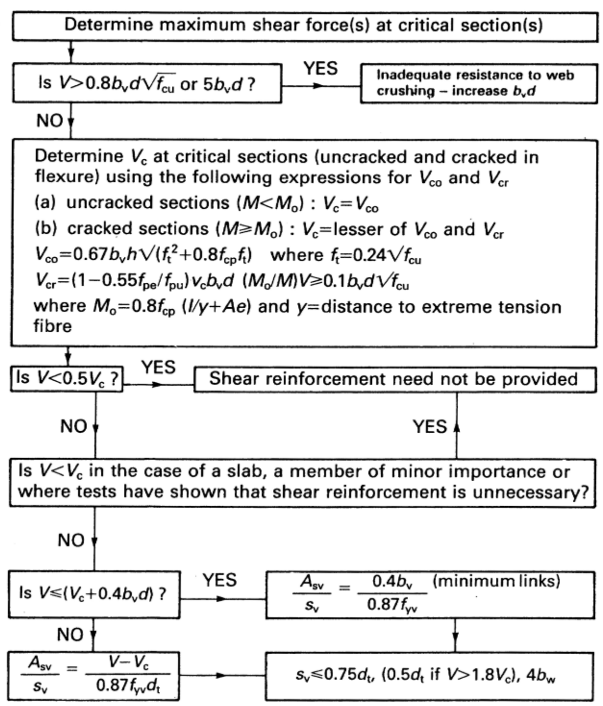


Figure 5.13-1 FLOW CHART FOR SHEAR IN PRESTRESSED CONCRETE

In the preceding, the values of **Fig. 5.13-1** are normalized with respect to (b*h).

For the particular example since M/M_o = 1.06, the section is cracked. Hence, select the lesser of V_{co} and V_{cr} as the average design shear resistance (V_{ca}).

V_{ca}	= lesser of 612.70 and 414.94, select 414.94 kN
V	= 414.94 kN
$V > 0.5*V_{ca}$	= 0.5*414.94 = 207.47 kN, hence links required
$V < V_{ca} + 0.4b_v*d$	= 574.47 kN, hence Equation 56 applied (CASE 2)
A_{sv}	= $0.4*b_v*1000/0.95f_{yv}$
	= 0.4*460*1000/0.95*460 = 420 mm^2/m (B12, C10, 420 mm2,OK)

Area for each two-legged 8mm bar used is 2*50 = 100 mm^2; hence, the required spacing s_v is given by:

s_v	= 1000*100/420 = 238 mm (B12,C11, 239.4 mm, OK)

5.13.1 Beam Example (MNL5-3B)

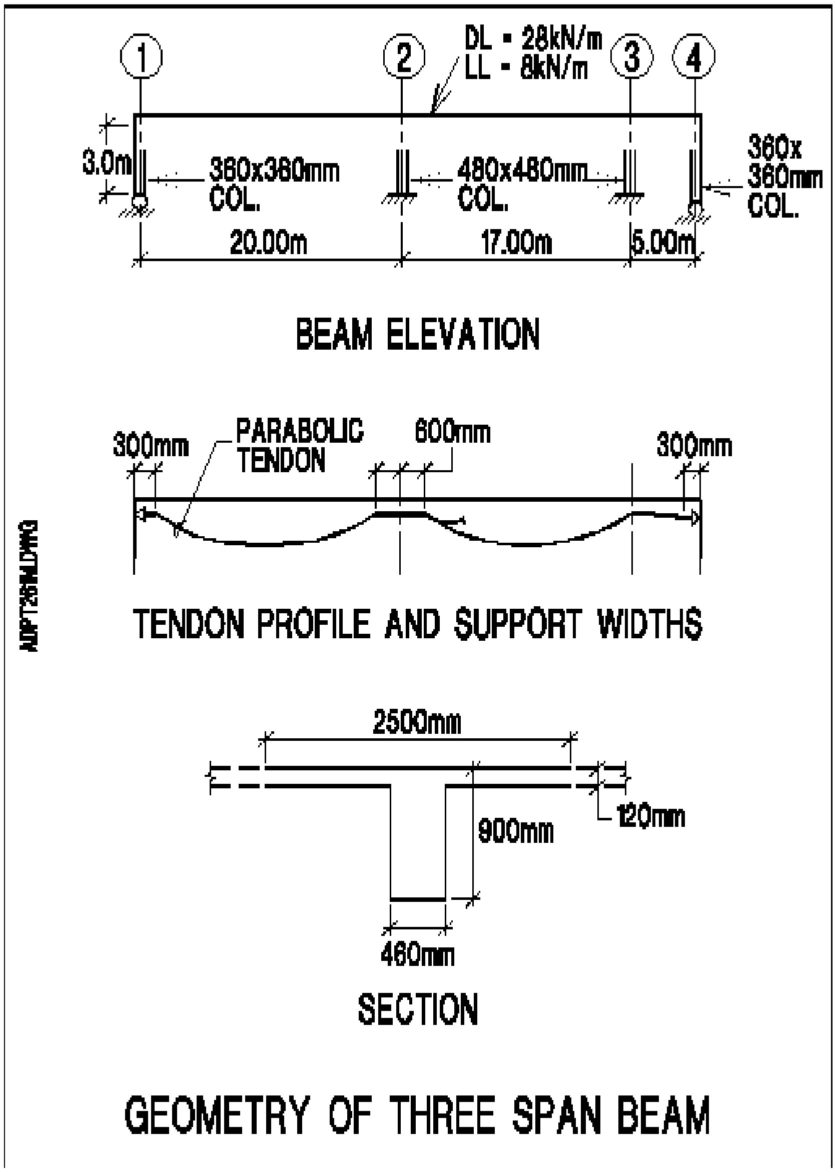


Figure 5.13-2

1 - USER SPECIFIED GENERAL ANALYSIS AND DESIGN PARAMETERS

Parameter	Value	Parameter	Value
Concrete		Post-tensioning	
Fcu for BEAMS/SLABS	35.00 N/mm 2	SYSTEM	UNBONDED
For COLUMNS/WALLS	35.00 N/mm 2	Fpu	1770.00 N/mm 2
Ec for BEAMS/SLABS	26568.00 N/mm 2	Fse	1060.00 N/mm 2
For COLUMNS/WALLS	26568.00 N/mm 2	Strand area	150.000 mm 2
CREEP factor	2.00	Min CGS from TOP	35.00 mm
CONCRETE WEIGHT	NORMAL	Min CGS from BOT for interior spans	80.00 mm
Tension stress limits / (f'c)1/2		Min CGS from BOT for exterior spans	80.00 mm
At Top	0.450	Min average precompression	1.00 N/mm 2
At Bottom	0.450	Max spacing / slab depth	8.00
Compression stress limits / f'c		Analysis and design options	
At all locations	0.330	Structural system	BEAM
Reinforcement		Moment of Inertia over support is	NOT INCREASED
Fy (Main bars)	460.00 N/mm 2	Moments reduced to face of support	YES
Fy (Shear reinforcement)	460.00 N/mm 2	Moment Redistribution	NO
Minimum Cover at TOP	25.00 mm	Effective flange width consideration	NO
Minimum Cover at BOTTOM	25.00 mm	DESIGN CODE SELECTED	British-BS8110 (1997)

2 - INPUT GEOMETRY

2.1 Principal Span Data of Uniform Spans

Span	Form	Length	Width	Depth	TF Width	TF Thick.	BF/MF Width	BF/MF Thick.	Rh	Right Mult.	Left Mult.
		m	mm	mm	mm	mm	mm	mm	mm		
1	2	20.00	460	900	2500	120			900	0.50	0.50
2	2	17.00	460	900	2500	120			900	0.50	0.50
3	2	5.00	460	900	2500	120			900	0.50	0.50

2.7 Support Width and Column Data

Joint	Support Width	Length LC	B(DIA.) LC	D LC	% LC	CBC LC	Length UC	B(DIA.) UC	D UC	% UC	CBC UC
	mm	m	mm	mm			m	mm	mm		
1	360.0	3.0	360.0	360.0	100	(3)					
2	480.0	3.0	480.0	480.0	100	(1)					
3	480.0	3.0	480.0	480.0	100	(1)					
4	360.0	3.0	360.0	360.0	100	(3)					

3 - INPUT APPLIED LOADING

3.1 Loading As Appears in User's Input Screen

Span	Class	Type	W	P1	P2	A	B	C	F	M
			kN/m2	kN/m	kN/m	m	m	m	kN	kN-m
1	LL	L		8.000		0.000	20.000			
1	SDL	L		28.000		0.000	20.000			
2	LL	L		8.000		0.000	17.000			
2	SDL	L		28.000		0.000	17.000			
3	LL	L		8.000		0.000	5.000			
3	SDL	L		28.000		0.000	5.000			

3.2 Compiled loads

Span	Class	Type	P1	P2	F	M	A	B	C	Reduction Factor
			kN/m	kN/m	kN	kN-m	m	m	m	%
1	LL	P	8.000				0.000	20.000		0.000
1	SDL	P	28.000				0.000	20.000		
2	LL	P	8.000				0.000	17.000		0.000
2	SDL	P	28.000				0.000	17.000		
3	LL	P	8.000				0.000	5.000		0.000
3	SDL	P	28.000				0.000	5.000		

4 - CALCULATED SECTION PROPERTIES

4.1 Section Properties of Uniform Spans and Cantilevers

Span	Area	I	Yb	Yt
	mm2	mm4	mm	mm
1	658800.00	0.52E+11	594.92	305.08
2	658800.00	0.52E+11	594.92	305.08
3	658800.00	0.52E+11	594.92	305.08

5 - MOMENTS, SHEARS AND REACTIONS

5.1 Span Moments and Shears (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right	Shear Left	Shear Right
		kN-m	kN-m	kN-m	kN	kN
1	SW	0.00	0.00	0.00	0.00	0.00
2	SW	0.00	0.00	0.00	0.00	0.00
3	SW	0.00	0.00	0.00	0.00	0.00
1	SDL	-125.89	760.18	-1153.75	-228.61	331.39
2	SDL	-1014.79	293.37	-421.47	-272.90	203.10
3	SDL	-368.38	-94.60	4.18	-144.51	-4.51
1	XL	0.00	0.00	0.00	0.00	0.00
2	XL	0.00	0.00	0.00	0.00	0.00
3	XL	0.00	0.00	0.00	0.00	0.00

5.2 Reactions and Column Moments (Excluding Live Load)

Joint	Load Case	Reaction	Moment Lower Column	Moment Upper Column
		kN	kN-m	kN-m
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
4	SW	0.00	0.00	0.00
1	SDL	228.61	-125.85	0.00
2	SDL	604.29	138.94	0.00
3	SDL	347.61	53.08	0.00
4	SDL	-4.51	-4.18	0.00
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00
4	XL	0.00	0.00	0.00

5.3 Span Moments and Shears (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN	kN

1	-35.97	-35.97	217.20	217.20	-329.64	-329.64	-65.32	94.68
2	-289.94	-289.94	83.82	83.82	-120.42	-120.42	-77.97	58.03
3	-105.25	-105.25	-27.03	-27.03	1.19	1.19	-41.29	-1.29

5.4 Reactions and Column Moments (Live Load)

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	65.32	65.32	-35.96	-35.96	0.00	0.00
2	172.66	172.66	39.70	39.70	0.00	0.00
3	99.32	99.32	15.17	15.17	0.00	0.00
4	-1.29	-1.29	-1.19	-1.19	0.00	0.00

6 - MOMENTS REDUCED TO FACE OF SUPPORT

6.1 Reduced Moments at Face of Support (Excluding Live Load)

Span	Load Case	Moment Left	Moment Midspan	Moment Right
		kN-m	kN-m	kN-m
1	SW	0.00	0.00	0.00
2	SW	0.00	0.00	0.00
3	SW	0.00	0.00	0.00
1	SDL	-85.19	760.20	-1075.00
2	SDL	-950.10	293.40	-373.50
3	SDL	-334.50	-94.60	2.92
1	XL	0.00	0.00	0.00
2	XL	0.00	0.00	0.00
3	XL	0.00	0.00	0.00

6.2 Reduced Moments at Face of Support (Live Load)

Span	Moment Left Max	Moment Left Min	Moment Midspan Max	Moment Midspan Min	Moment Right Max	Moment Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	-24.34	-24.34	217.20	217.20	-307.10	-307.10
2	-271.50	-271.50	83.82	83.82	-106.70	-106.70
3	-95.57	-95.57	-27.03	-27.03	0.83	0.83

7 - SELECTED POST-TENSIONING FORCES AND TENDON PROFILES

7.1 Tendon Profile
Tendon A

Span	Type	X1/L	X2/L	X3/L	A/L
1	1	0.000	0.500	0.100	---
2	1	0.100	0.500	0.100	---
3	1	0.100	0.500	0.000	---

7.2 Selected Post-Tensioning Forces and Tendon Drape
Tendon A

Span	Force	CGS Left	CGS C1	CGS C2	CGS Right	P/A	Wbal	WBal (%DL)
	kN	mm	mm	mm	mm	MPa	kN/-	
1	1660.000	595.00	---	80.00	865.00	2.52	21.580	77
2	925.000	865.00	---	80.00	865.00	1.40	20.100	72
3	925.000	865.00	---	750.00	595.00	1.40	-5.920	-21

Approximate weight of strand: 425.5 Kg

7.4 Required Minimum Post-Tensioning Forces

Type	Based on Stress Conditions Left	Center	Right	Based on Minimum P/A Left	Center	Right
	kN	kN	kN	kN	kN	kN
1	0.00	435.74	0.00	658.80	658.80	658.80
2	0.00	0.00	0.00	658.80	658.80	658.80
3	0.00	0.00	0.00	658.80	658.80	658.80

7.5 Service Stresses (tension shown positive)

Span	Left Top	Left Bottom	Center Top	Center Bottom	Right Top	Right Bottom
	MPa	MPa	MPa	MPa	MPa	MPa
1	-2.26	-3.02	-4.68	1.70	0.72	-8.83
2	0.26	-7.93	-1.86	-0.51	-0.30	-3.55
3	-0.28	-3.60	-1.50	-1.22	-1.50	-1.21

7.6 Post-Tensioning Balance Moments, Shears and Reactions

Span Moments and Shears

Span	Moment Left	Moment Center	Moment Right	Shear Left	Shear Right
	kN-m	kN-m	kN-m	kN	kN
1	65.86	-611.40	834.30	-15.00	-15.00
2	751.80	-299.30	293.60	15.78	15.78
3	239.50	137.40	13.20	0.31	0.31

Reactions and Column Moments

Joint	Reaction	Moment Lower Column	Moment Upper Column
	kN	kN-m	kN-m
1	15.000	93.330	0.000
2	-30.780	-82.180	0.000
3	15.480	-48.170	0.000
4	0.305	6.829	0.000

Note: Moments are reported at face of support

8 - FACTORED MOMENTS AND REACTIONS ENVELOPE

8.1 Factored Design Moments (Not Redistributed)

Span	Left Max	Left Min	Middle Max	Middle Min	Right Max	Right Min
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1	-62.18	-62.18	1655.10	1655.10	-1606.66	-1606.66
2	-1457.14	-1457.14	721.87	721.87	-646.96	-646.96
3	-626.59	-626.59	-181.75	-181.75	-1.36	-1.36

8.2 Reactions and Column Moments

Joint	Reaction Max	Reaction Min	Moment Lower Column Max	Moment Lower Column Min	Moment Upper Column Max	Moment Upper Column Min
	kN	kN	kN-m	kN-m	kN-m	kN-m
1	439.55	439.55	-140.33	-140.33	0.00	0.00
2	1091.56	1091.56	175.80	175.80	0.00	0.00
3	661.03	661.03	50.41	50.41	0.00	0.00
4	-8.08	-8.08	-0.94	-0.94	0.00	0.00

8.3 Secondary Moments

Span	Left	Midspan	Right
	kN-m	kN-m	kN-m
1	96.03	243.30	389.70

2	307.40	177.00	46.66
3	-5.38	-6.07	-6.77

Note: Moments are reported at face of support

10 - MILD STEEL - NO REDISTRIBUTION

10.1 Required Rebar

10.1.1 Total Strip Required Rebar

Span	Location	From	To	As Required	Ultimate	Minimum
		m	m	mm2	mm2	mm2
1	TOP	0.00	3.00	1493.00	0.00	1493.00
1	TOP	17.00	20.00	1493.00	914.70	1493.00
2	TOP	0.00	2.55	1493.00	333.00	1493.00
2	TOP	14.45	17.00	1493.00	0.00	1493.00
3	TOP	0.00	0.75	1073.00	0.00	1073.00
3	TOP	1.75	2.25	1073.00	0.00	1073.00
3	TOP	4.25	5.00	1073.00	0.00	1073.00
1	BOT	5.00	13.00	1085.00	685.50	1085.00
2	BOT	6.80	11.05	1085.00	0.00	1085.00
3	BOT	2.50	3.25	961.70	0.00	961.70

12 - SHEAR REINFORCEMENT

12.1 Shear Calculation Envelope

SPAN 1

XL	X	d	Vu	Mu	Vc	Vco	vcr	Ratio	Req.	Spacing
	m	mm	kN	kNm	kN	kN	kN		mm2	mm
0.01	0.18	867.00	-430.20	-62.81	258.60	612.60	2670.00	0.70	420.00	239.40
0.05	1.00	862.50	-387.60	275.80	257.70	612.60	601.00	0.63	420.00	239.40
0.10	2.00	862.50	-335.60	640.90	257.70	612.60	393.20	0.85	420.00	239.40
0.15	3.00	862.50	-283.60	953.60	257.70	612.60	328.50	0.86	420.00	239.40
0.20	4.00	862.50	-231.60	1214.00	268.10	612.60	299.50	0.77	420.00	239.40
0.25	5.00	862.50	-179.60	1421.00	276.30	612.60	277.50	0.65	420.00	239.40
0.30	6.00	862.50	-127.60	1576.00	285.00	612.60	259.80	0.49	0.00	0.00
0.35	7.00	862.50	-75.57	1679.00	290.50	612.60	240.50	0.31	0.00	0.00
0.40	8.00	862.50	-23.57	1729.00	290.50	612.60	234.70	0.10	0.00	0.00
0.45	9.00	862.50	28.43	1727.00	285.00	612.60	234.70	0.12	0.00	0.00
0.50	10.00	862.50	80.43	1672.00	276.30	612.60	234.70	0.34	0.00	0.00
0.55	11.00	862.50	132.40	1564.00	268.10	612.60	254.20	0.52	420.00	239.40
0.60	12.00	862.50	184.40	1404.00	257.70	612.60	278.80	0.66	420.00	239.40
0.65	13.00	862.50	236.40	1191.00	257.70	612.60	320.00	0.74	420.00	239.40
0.70	14.00	862.50	288.40	926.40	257.70	612.60	375.30	0.77	420.00	239.40
0.75	15.00	862.50	340.40	608.90	257.70	612.60	470.80	0.72	420.00	239.40
0.80	16.00	862.50	392.40	238.80	257.70	612.60	813.30	0.64	420.00	239.40
0.85	17.00	867.00	444.40	-183.90	258.60	612.60	1107.00	0.73	420.00	239.40
0.90	18.00	867.00	496.40	-659.10	258.60	612.60	543.50	0.91	420.00	239.40
0.95	19.00	867.00	548.40	-1187.00	258.60	612.60	472.80	1.16	420.00	239.40
0.99	19.76	867.00	588.00	-1623.00	301.00	612.60	464.00	1.27	420.00	239.40

SPAN 2

XL	X	d	Vu	Mu	Vc	Vco	vcr	Ratio	Req.	Spacing
	m	mm	kN	kNm	kN	kN	kN		mm2	mm
0.01	0.24	867.00	-478.60	-1472.00	275.60	612.60	412.40	1.16	420.00	239.40
0.05	0.85	867.00	-446.80	-1187.00	258.60	612.60	417.30	1.07	420.00	239.40
0.10	1.70	867.00	-402.60	-821.90	258.60	612.60	414.10	0.97	420.00	239.40
0.15	2.55	867.00	-358.40	-495.20	258.60	612.60	453.20	0.79	420.00	239.40

0.20	3.40	867.00	-314.20	-206.60	258.60	612.60	1019.00	0.51	420.00	239.40
0.25	4.25	862.50	-270.00	44.32	212.50	527.10	1952.00	0.51	420.00	239.40
0.30	5.10	862.50	-225.80	257.10	212.50	527.10	460.70	0.43	0.00	0.00
0.35	5.95	862.50	-181.60	432.00	212.50	527.10	316.20	0.57	420.00	239.40
0.40	6.80	862.50	-137.40	569.00	212.50	527.10	251.10	0.55	420.00	239.40
0.45	7.65	862.50	-93.23	668.00	212.50	527.10	234.70	0.40	0.00	0.00
0.50	8.50	862.50	-49.03	729.10	212.50	527.10	234.70	0.21	0.00	0.00
0.55	9.35	862.50	-4.83	752.20	212.50	527.10	234.70	0.02	0.00	0.00
0.60	10.20	862.50	39.37	737.30	212.50	527.10	234.70	0.17	0.00	0.00
0.65	11.05	862.50	83.57	684.60	212.50	527.10	234.70	0.36	0.00	0.00
0.70	11.90	862.50	127.80	593.80	212.50	527.10	234.70	0.54	420.00	239.40
0.75	12.75	862.50	172.00	465.10	212.50	527.10	252.30	0.68	420.00	239.40
0.80	13.60	862.50	216.20	298.60	212.50	527.10	299.70	0.72	420.00	239.40
0.85	14.45	862.50	260.40	94.07	212.50	527.10	482.20	0.49	0.00	0.00
0.90	15.30	867.00	304.60	-148.50	213.20	527.10	704.60	0.58	420.00	239.40
0.95	16.15	867.00	348.80	-429.00	213.20	527.10	436.50	0.80	420.00	239.40
0.99	16.76	867.00	380.50	-653.40	213.20	527.10	365.30	1.04	420.00	239.40

SPAN 3

XL	X	d	Vu	Mu	Vc	Vco	vcr	Ratio	Req.	Spacing
	m	mm	kN	kNm	kN	kN	kN		mm2	mm
0.05	0.24	867.00	-255.60	-632.90	213.20	527.10	298.90	0.86	420.00	239.40
0.05	0.25	867.00	-255.10	-630.20	213.20	527.10	299.10	0.85	420.00	239.40
0.10	0.50	867.00	-242.10	-567.50	213.20	527.10	302.10	0.80	420.00	239.40
0.15	0.75	867.00	-229.10	-508.10	213.20	527.10	303.90	0.75	420.00	239.40
0.20	1.00	867.00	-216.10	-451.90	213.20	527.10	307.10	0.70	420.00	239.40
0.25	1.25	867.00	-203.10	-398.90	213.20	527.10	311.70	0.65	420.00	239.40
0.30	1.50	867.00	-190.10	-349.30	213.20	527.10	318.20	0.60	420.00	239.40
0.35	1.75	867.00	-177.10	-303.00	213.20	527.10	326.80	0.34	0.00	0.00
0.40	2.00	867.00	-164.10	-259.90	213.20	527.10	338.10	0.31	0.00	0.00
0.45	2.25	867.00	-151.10	-220.10	213.20	527.10	353.00	0.29	0.00	0.00
0.50	2.50	867.00	-138.10	-183.60	213.20	527.10	372.30	0.26	0.00	0.00
0.55	2.75	867.00	-125.10	-150.40	213.20	527.10	395.60	0.24	0.00	0.00
0.60	3.00	867.00	-112.10	-120.40	213.20	527.10	422.50	0.21	0.00	0.00
0.65	3.25	867.00	-99.07	-93.75	213.20	527.10	454.30	0.19	0.00	0.00
0.70	3.50	867.00	-86.07	-70.38	213.20	527.10	493.40	0.16	0.00	0.00
0.75	3.75	867.00	-73.07	-50.27	213.20	527.10	544.40	0.14	0.00	0.00
0.80	4.00	867.00	-60.07	-33.47	213.20	527.10	616.10	0.11	0.00	0.00
0.85	4.25	867.00	-47.07	-19.94	213.20	527.10	729.90	0.09	0.00	0.00
0.90	4.50	867.00	-34.07	-9.70	213.20	527.10	956.20	0.06	0.00	0.00
0.95	4.75	867.00	-21.07	-2.73	213.20	527.10	1776.00	0.04	0.00	0.00
0.96	4.82	867.00	-17.43	-1.37	213.20	527.10	2758.00	0.03	0.00	0.00

Note: "Vu" is related to the load combination which produces the maximum "Ratio"
Note: Sections with **** have exceeded the maximum allowable shear stress.

21 - TENDON HEIGHTS

XL	X	CGS A	CGS B	CGS C	X	CGS A	CGS B	CGS C
	m	mm	mm	mm	m	mm	mm	mm
	SPAN 1				SPAN 2			
0.00	0.00	595.00	595.00	595.00	0.00	865.00	865.00	865.00
0.05	1.00	497.23	497.15	497.15	0.85	825.75	825.75	825.75
0.10	2.00	409.67	409.60	409.60	1.70	708.00	708.00	708.00
0.15	3.00	332.40	332.35	332.35	2.55	560.81	560.81	560.81
0.20	4.00	265.44	265.40	265.40	3.40	433.25	433.25	433.25
0.25	5.00	208.78	208.75	208.75	4.25	325.31	325.31	325.31
0.30	6.00	162.42	162.40	162.40	5.10	237.00	237.00	237.00

0.35	7.00	126.36	126.35	126.35	5.95	168.31	168.31	168.31
0.40	8.00	100.60	100.60	100.60	6.80	119.25	119.25	119.25
0.45	9.00	85.15	85.15	85.15	7.65	89.81	89.81	89.81
0.50	10.00	80.00	80.00	80.00	8.50	80.00	80.00	80.00
0.55	11.00	89.81	89.81	89.81	9.35	89.81	89.81	89.81
0.60	12.00	119.25	119.25	119.25	10.20	119.25	119.25	119.25
0.65	13.00	168.31	168.31	168.31	11.05	168.31	168.31	168.31
0.70	14.00	237.00	237.00	237.00	11.90	237.00	237.00	237.00
0.75	15.00	325.31	325.31	325.31	12.75	325.31	325.31	325.31
0.80	16.00	433.25	433.25	433.25	13.60	433.25	433.25	433.25
0.85	17.00	560.81	560.81	560.81	14.45	560.81	560.81	560.81
0.90	18.00	708.00	708.00	708.00	15.30	708.00	708.00	708.00
0.95	19.00	825.75	825.75	825.75	16.15	825.75	825.75	825.75
1.00	20.00	865.00	865.00	865.00	17.00	865.00	865.00	865.00

XL	X	CGS A	CGS B	CGS C
	m	mm	mm	mm
	SPAN 3			
0.00	0.00	865.00	865.00	865.00
0.05	0.25	859.25	859.25	859.25
0.10	0.50	842.00	842.00	842.00
0.15	0.75	820.44	820.44	820.44
0.20	1.00	801.75	801.75	801.75
0.25	1.25	785.94	785.94	785.94
0.30	1.50	773.00	773.00	773.00
0.35	1.75	762.94	762.94	762.94
0.40	2.00	755.75	755.75	755.75
0.45	2.25	751.44	751.44	751.44
0.50	2.50	750.00	750.00	750.00
0.55	2.75	748.45	748.45	748.45
0.60	3.00	743.80	743.80	743.80
0.65	3.25	736.05	736.05	736.05
0.70	3.50	725.20	725.20	725.20
0.75	3.75	711.25	711.25	711.25
0.80	4.00	694.20	694.20	694.20
0.85	4.25	674.05	674.05	674.05
0.90	4.50	650.80	650.80	650.80
0.95	4.75	624.45	624.45	624.45
1.00	5.00	595.00	595.00	595.00

23 - DETAILED MOMENTS

SPAN 1

XL	X	SW	SDL	XL	LL Min	LL Max	PT	Secondary
	m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
0.00	0.00	0.00	-125.89	0.00	-35.97	-35.97	93.49	93.33
0.05	1.00	0.00	88.72	0.00	25.35	25.35	-53.80	108.33
0.10	2.00	0.00	275.33	0.00	78.67	78.67	-184.16	123.33
0.15	3.00	0.00	433.93	0.00	123.98	123.98	-297.43	138.33
0.20	4.00	0.00	564.54	0.00	161.30	161.30	-393.59	153.33
0.25	5.00	0.00	667.15	0.00	190.61	190.61	-472.65	168.33
0.30	6.00	0.00	741.76	0.00	211.93	211.93	-534.61	183.33
0.35	7.00	0.00	788.36	0.00	225.25	225.25	-579.46	198.33
0.40	8.00	0.00	806.97	0.00	230.56	230.56	-607.22	213.33
0.45	9.00	0.00	797.58	0.00	227.88	227.88	-617.87	228.33
0.50	10.00	0.00	760.18	0.00	217.20	217.20	-611.43	243.33
0.55	11.00	0.00	694.79	0.00	198.51	198.51	-580.14	258.33
0.60	12.00	0.00	601.40	0.00	171.83	171.83	-516.27	273.33

0.65	13.00	0.00	480.01	0.00	137.14	137.14	-419.83	288.33
0.70	14.00	0.00	330.61	0.00	94.46	94.46	-290.81	303.33
0.75	15.00	0.00	153.22	0.00	43.78	43.78	-129.22	318.33
0.80	16.00	0.00	-52.17	0.00	-14.91	-14.91	64.96	333.33
0.85	17.00	0.00	-285.57	0.00	-81.59	-81.59	291.71	348.33
0.90	18.00	0.00	-546.96	0.00	-156.27	-156.27	551.04	363.33
0.95	19.00	0.00	-836.35	0.00	-238.96	-238.96	761.50	378.33
1.00	20.00	0.00	-1153.70	0.00	-329.64	-329.64	841.66	393.33

SPAN 2

XL	X	SW	SDL	XL	LL Min	LL Max	PT	Secondary
	m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
0.00	0.00	0.00	-1014.80	0.00	-289.94	-289.94	759.47	311.15
0.05	0.85	0.00	-792.94	0.00	-226.55	-226.55	697.34	297.74
0.10	1.70	0.00	-591.32	0.00	-168.95	-168.95	537.79	284.32
0.15	2.55	0.00	-409.93	0.00	-117.12	-117.12	326.19	270.91
0.20	3.40	0.00	-248.77	0.00	-71.08	-71.08	107.94	257.49
0.25	4.25	0.00	-107.84	0.00	-30.81	-30.81	-5.32	244.08
0.30	5.10	0.00	12.86	0.00	3.68	3.68	-100.42	230.67
0.35	5.95	0.00	113.34	0.00	32.38	32.38	-177.37	217.25
0.40	6.80	0.00	193.58	0.00	55.31	55.31	-236.16	203.84
0.45	7.65	0.00	253.59	0.00	72.45	72.45	-276.81	190.42
0.50	8.50	0.00	293.37	0.00	83.82	83.82	-299.30	177.01
0.55	9.35	0.00	312.92	0.00	89.41	89.41	-303.63	163.59
0.60	10.20	0.00	312.24	0.00	89.21	89.21	-289.82	150.18
0.65	11.05	0.00	291.33	0.00	83.24	83.24	-257.85	136.77
0.70	11.90	0.00	250.19	0.00	71.48	71.48	-207.73	123.35
0.75	12.75	0.00	188.83	0.00	53.95	53.95	-139.45	109.94
0.80	13.60	0.00	107.23	0.00	30.64	30.64	-53.02	96.52
0.85	14.45	0.00	5.40	0.00	1.54	1.54	51.56	83.11
0.90	15.30	0.00	-116.66	0.00	-33.33	-33.33	174.30	69.70
0.95	16.15	0.00	-258.95	0.00	-73.99	-73.99	269.80	56.28
1.00	17.00	0.00	-421.47	0.00	-120.42	-120.42	292.69	42.87

SPAN 3

XL	X	SW	SDL	XL	LL Min	LL Max	PT	Secondary
	m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
0.00	0.00	0.00	-368.38	0.00	-105.25	-105.25	244.52	-5.30
0.05	0.25	0.00	-333.13	0.00	-95.18	-95.18	239.13	-5.38
0.10	0.50	0.00	-299.63	0.00	-85.61	-85.61	223.09	-5.46
0.15	0.75	0.00	-267.87	0.00	-76.54	-76.54	203.07	-5.53
0.20	1.00	0.00	-237.87	0.00	-67.96	-67.96	185.71	-5.61
0.25	1.25	0.00	-209.62	0.00	-59.89	-59.89	171.01	-5.68
0.30	1.50	0.00	-183.11	0.00	-52.32	-52.32	158.96	-5.76
0.35	1.75	0.00	-158.36	0.00	-45.25	-45.25	149.58	-5.84
0.40	2.00	0.00	-135.36	0.00	-38.67	-38.67	142.85	-5.91
0.45	2.25	0.00	-114.10	0.00	-32.60	-32.60	138.79	-5.99
0.50	2.50	0.00	-94.60	0.00	-27.03	-27.03	137.38	-6.07
0.55	2.75	0.00	-76.85	0.00	-21.96	-21.96	135.87	-6.14
0.60	3.00	0.00	-60.85	0.00	-17.38	-17.38	131.50	-6.22
0.65	3.25	0.00	-46.59	0.00	-13.31	-13.31	124.25	-6.29
0.70	3.50	0.00	-34.09	0.00	-9.74	-9.74	114.14	-6.37
0.75	3.75	0.00	-23.33	0.00	-6.67	-6.67	101.16	-6.45
0.80	4.00	0.00	-14.33	0.00	-4.09	-4.09	85.31	-6.52
0.85	4.25	0.00	-7.08	0.00	-2.02	-2.02	66.60	-6.60
0.90	4.50	0.00	-1.57	0.00	-0.45	-0.45	45.01	-6.68
0.95	4.75	0.00	2.18	0.00	0.62	0.62	20.56	-6.75
1.00	5.00	0.00	4.18	0.00	1.19	1.19	-6.75	-6.83

ADAPT

24 - DETAILED SHEARS

SPAN 1

XL	X	SW	SDL	XL	LL Min	LL Max	PT	Secondary
	m	kN	kN	kN	kN	kN	kN	kN
0.00	0.00	0.00	-228.61	0.00	0.00	-65.32	-14.99	-15.00
0.05	1.00	0.00	-200.61	0.00	0.00	-57.32	138.92	-15.00
0.10	2.00	0.00	-172.61	0.00	0.00	-49.32	121.82	-15.00
0.15	3.00	0.00	-144.61	0.00	0.00	-41.32	104.72	-15.00
0.20	4.00	0.00	-116.61	0.00	0.00	-33.32	87.62	-15.00
0.25	5.00	0.00	-88.61	0.00	0.00	-25.32	70.52	-15.00
0.30	6.00	0.00	-60.61	0.00	0.00	-17.32	53.41	-15.00
0.35	7.00	0.00	-32.61	0.00	0.00	-9.32	36.31	-15.00
0.40	8.00	0.00	-4.61	0.00	0.00	-1.32	19.21	-15.00
0.45	9.00	0.00	23.39	0.00	6.68	0.00	2.11	-15.00
0.50	10.00	0.00	51.39	0.00	14.68	0.00	-14.99	-15.00
0.55	11.00	0.00	79.39	0.00	22.68	0.00	-47.57	-15.00
0.60	12.00	0.00	107.39	0.00	30.68	0.00	-80.15	-15.00
0.65	13.00	0.00	135.39	0.00	38.68	0.00	-112.72	-15.00
0.70	14.00	0.00	163.39	0.00	46.68	0.00	-145.30	-15.00
0.75	15.00	0.00	191.39	0.00	54.68	0.00	-177.88	-15.00
0.80	16.00	0.00	219.39	0.00	62.68	0.00	-210.46	-15.00
0.85	17.00	0.00	247.39	0.00	70.68	0.00	-243.03	-15.00
0.90	18.00	0.00	275.39	0.00	78.68	0.00	-275.61	-15.00
0.95	19.00	0.00	303.39	0.00	86.68	0.00	-145.30	-15.00
1.00	20.00	0.00	331.39	0.00	94.68	0.00	-14.99	-15.00

SPAN 2

XL	X	SW	SDL	XL	LL Min	LL Max	PT	Secondary
	m	kN	kN	kN	kN	kN	kN	kN
0.00	0.00	0.00	-272.90	0.00	0.00	-77.97	15.78	15.78
0.05	0.85	0.00	-249.10	0.00	0.00	-71.17	130.40	15.78
0.10	1.70	0.00	-225.30	0.00	0.00	-64.37	245.02	15.78
0.15	2.55	0.00	-201.50	0.00	0.00	-57.57	252.85	15.78
0.20	3.40	0.00	-177.70	0.00	0.00	-50.77	143.92	15.78
0.25	4.25	0.00	-153.90	0.00	0.00	-43.97	122.56	15.78
0.30	5.10	0.00	-130.10	0.00	0.00	-37.17	101.21	15.78
0.35	5.95	0.00	-106.30	0.00	0.00	-30.37	79.85	15.78
0.40	6.80	0.00	-82.50	0.00	0.00	-23.57	58.49	15.78
0.45	7.65	0.00	-58.70	0.00	0.00	-16.77	37.14	15.78
0.50	8.50	0.00	-34.90	0.00	0.00	-9.97	15.78	15.78
0.55	9.35	0.00	-11.10	0.00	0.00	-3.17	-5.58	15.78
0.60	10.20	0.00	12.70	0.00	3.63	0.00	-26.93	15.78
0.65	11.05	0.00	36.50	0.00	10.43	0.00	-48.29	15.78
0.70	11.90	0.00	60.30	0.00	17.23	0.00	-69.65	15.78
0.75	12.75	0.00	84.10	0.00	24.03	0.00	-91.00	15.78
0.80	13.60	0.00	107.90	0.00	30.83	0.00	-112.36	15.78
0.85	14.45	0.00	131.70	0.00	37.63	0.00	-133.72	15.78
0.90	15.30	0.00	155.50	0.00	44.43	0.00	-155.07	15.78
0.95	16.15	0.00	179.30	0.00	51.23	0.00	-69.65	15.78
1.00	17.00	0.00	203.10	0.00	58.03	0.00	15.78	15.78

SPAN 3

XL	X	SW	SDL	XL	LL Min	LL Max	PT	Secondary
	m	kN	kN	kN	kN	kN	kN	kN
0.00	0.00	0.00	-144.51	0.00	0.00	-41.29	0.29	0.31
0.05	0.25	0.00	-137.51	0.00	0.00	-39.29	42.84	0.31
0.10	0.50	0.00	-130.51	0.00	0.00	-37.29	85.39	0.31

0.15	0.75	0.00	-123.51	0.00	0.00	-35.29	74.75	0.31
0.20	1.00	0.00	-116.51	0.00	0.00	-33.29	64.12	0.31
0.25	1.25	0.00	-109.51	0.00	0.00	-31.29	53.48	0.31
0.30	1.50	0.00	-102.51	0.00	0.00	-29.29	42.84	0.31
0.35	1.75	0.00	-95.51	0.00	0.00	-27.29	32.20	0.31
0.40	2.00	0.00	-88.51	0.00	0.00	-25.29	21.57	0.31
0.45	2.25	0.00	-81.51	0.00	0.00	-23.29	10.93	0.31
0.50	2.50	0.00	-74.51	0.00	0.00	-21.29	0.29	0.31
0.55	2.75	0.00	-67.51	0.00	0.00	-19.29	11.76	0.31
0.60	3.00	0.00	-60.51	0.00	0.00	-17.29	23.23	0.31
0.65	3.25	0.00	-53.51	0.00	0.00	-15.29	34.70	0.31
0.70	3.50	0.00	-46.51	0.00	0.00	-13.29	46.17	0.31
0.75	3.75	0.00	-39.51	0.00	0.00	-11.29	57.64	0.31
0.80	4.00	0.00	-32.51	0.00	0.00	-9.29	69.11	0.31
0.85	4.25	0.00	-25.51	0.00	0.00	-7.29	80.58	0.31
0.90	4.50	0.00	-18.51	0.00	0.00	-5.29	92.05	0.31
0.95	4.75	0.00	-11.51	0.00	0.00	-3.29	103.52	0.31
1.00	5.00	0.00	-4.51	0.00	0.00	-1.29	114.99	0.31

27 - DETAILED STRESSES

SPAN 1

XL	X	SW Top	SW Bot	SDL Top	SDL Bot	XL Top	XL Bot	LL Top Max-T	LL Top Max-C	LL Bot Max-T	LL Bot Max-C	PT Top	PT Bot
	m	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
0.00	0.00												
0.05	1.00	0.00	0.00	-0.52	1.02	0.00	0.00	-0.15	-0.15	0.29	0.29	-2.20	-3.14
0.10	2.00	0.00	0.00	-1.63	3.17	0.00	0.00	-0.46	-0.46	0.91	0.91	-1.43	-4.64
0.15	3.00	0.00	0.00	-2.56	5.00	0.00	0.00	-0.73	-0.73	1.43	1.43	-0.76	-5.95
0.20	4.00	0.00	0.00	-3.34	6.50	0.00	0.00	-0.95	-0.95	1.86	1.86	-0.19	-7.05
0.25	5.00	0.00	0.00	-3.94	7.69	0.00	0.00	-1.13	-1.13	2.20	2.20	0.27	-7.97
0.30	6.00	0.00	0.00	-4.38	8.55	0.00	0.00	-1.25	-1.25	2.44	2.44	0.64	-8.68
0.35	7.00	0.00	0.00	-4.66	9.08	0.00	0.00	-1.33	-1.33	2.60	2.60	0.90	-9.20
0.40	8.00	0.00	0.00	-4.77	9.30	0.00	0.00	-1.36	-1.36	2.66	2.66	1.07	-9.52
0.45	9.00	0.00	0.00	-4.71	9.19	0.00	0.00	-1.35	-1.35	2.63	2.63	1.13	-9.64
0.50	10.00	0.00	0.00	-4.49	8.76	0.00	0.00	-1.28	-1.28	2.50	2.50	1.09	-9.56
0.55	11.00	0.00	0.00	-4.10	8.00	0.00	0.00	-1.17	-1.17	2.29	2.29	0.91	-9.20
0.60	12.00	0.00	0.00	-3.55	6.93	0.00	0.00	-1.02	-1.02	1.98	1.98	0.53	-8.47
0.65	13.00	0.00	0.00	-2.84	5.53	0.00	0.00	-0.81	-0.81	1.58	1.58	-0.04	-7.36
0.70	14.00	0.00	0.00	-1.95	3.81	0.00	0.00	-0.56	-0.56	1.09	1.09	-0.80	-5.87
0.75	15.00	0.00	0.00	-0.91	1.77	0.00	0.00	-0.26	-0.26	0.50	0.50	-1.76	-4.01
0.80	16.00	0.00	0.00	0.31	-0.60	0.00	0.00	0.09	0.09	-0.17	-0.17	-2.90	-1.77
0.85	17.00	0.00	0.00	1.69	-3.29	0.00	0.00	0.48	0.48	-0.94	-0.94	-4.24	0.84
0.90	18.00	0.00	0.00	3.23	-6.30	0.00	0.00	0.92	0.92	-1.80	-1.80	-5.78	3.83
0.95	19.00	0.00	0.00	4.94	-9.64	0.00	0.00	1.41	1.41	-2.75	-2.75	-7.02	6.25
1.00	20.00												

XL	X	Env-1 Top Max-T	Env-1 Top Max-C	Env-1 Bot Max-T	Env-1 Bot Max-C
	m	MPa	MPa	MPa	MPa
0.00	0.00				
0.05	1.00	-----	-2.88	-----	-1.83
0.10	2.00	-----	-3.52	-----	-0.56
0.15	3.00	-----	-4.06	0.48	-----
0.20	4.00	-----	-4.48	1.31	-----
0.25	5.00	-----	-4.80	1.92	-----
0.30	6.00	-----	-5.00	2.31	-----

ADAPT

0.35	7.00	-----	-5.08	2.48	-----
0.40	8.00	-----	-5.06	2.44	-----
0.45	9.00	-----	-4.93	2.18	-----
0.50	10.00	-----	-4.68	1.70	-----
0.55	11.00	-----	-4.37	1.09	-----
0.60	12.00	-----	-4.04	0.44	-----
0.65	13.00	-----	-3.69	-----	-0.25
0.70	14.00	-----	-3.31	-----	-0.97
0.75	15.00	-----	-2.92	-----	-1.74
0.80	16.00	-----	-2.51	-----	-2.54
0.85	17.00	-----	-2.07	-----	-3.39
0.90	18.00	-----	-1.62	-----	-4.27
0.95	19.00	-----	-0.67	-----	-6.14
1.00	20.00				

SPAN 2

XL	X	SW Top	SW Bot	SDL Top	SDL Bot	XL Top	XL Bot	LL Top Max-T	LL Top Max-C	LL Bot Max-T	LL Bot Max-C	PT Top	PT Bot
	m	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
0.00	0.00												
0.05	0.85	0.00	0.00	4.68	-9.14	0.00	0.00	1.34	1.34	-2.61	-2.61	-6.64	5.51
0.10	1.70	0.00	0.00	3.49	-6.81	0.00	0.00	1.00	1.00	-1.95	-1.95	-5.70	3.68
0.15	2.55	0.00	0.00	2.42	-4.72	0.00	0.00	0.69	0.69	-1.35	-1.35	-4.45	1.24
0.20	3.40	0.00	0.00	1.47	-2.87	0.00	0.00	0.42	0.42	-0.82	-0.82	-3.16	-1.28
0.25	4.25	0.00	0.00	0.64	-1.24	0.00	0.00	0.18	0.18	-0.35	-0.35	-1.37	-1.47
0.30	5.10	0.00	0.00	-0.08	0.15	0.00	0.00	-0.02	-0.02	0.04	0.04	-0.81	-2.56
0.35	5.95	0.00	0.00	-0.67	1.31	0.00	0.00	-0.19	-0.19	0.37	0.37	-0.36	-3.45
0.40	6.80	0.00	0.00	-1.14	2.23	0.00	0.00	-0.33	-0.33	0.64	0.64	-0.01	-4.12
0.45	7.65	0.00	0.00	-1.50	2.92	0.00	0.00	-0.43	-0.43	0.83	0.83	0.23	-4.59
0.50	8.50	0.00	0.00	-1.73	3.38	0.00	0.00	-0.50	-0.50	0.97	0.97	0.36	-4.85
0.55	9.35	0.00	0.00	-1.85	3.61	0.00	0.00	-0.53	-0.53	1.03	1.03	0.39	-4.90
0.60	10.20	0.00	0.00	-1.84	3.60	0.00	0.00	-0.53	-0.53	1.03	1.03	0.31	-4.74
0.65	11.05	0.00	0.00	-1.72	3.36	0.00	0.00	-0.49	-0.49	0.96	0.96	0.12	-4.37
0.70	11.90	0.00	0.00	-1.48	2.88	0.00	0.00	-0.42	-0.42	0.82	0.82	-0.18	-3.80
0.75	12.75	0.00	0.00	-1.12	2.18	0.00	0.00	-0.32	-0.32	0.62	0.62	-0.58	-3.01
0.80	13.60	0.00	0.00	-0.63	1.24	0.00	0.00	-0.18	-0.18	0.35	0.35	-1.09	-2.01
0.85	14.45	0.00	0.00	-0.03	0.06	0.00	0.00	-0.01	-0.01	0.02	0.02	-1.71	-0.81
0.90	15.30	0.00	0.00	0.69	-1.34	0.00	0.00	0.20	0.20	-0.38	-0.38	-2.43	0.60
0.95	16.15	0.00	0.00	1.53	-2.98	0.00	0.00	0.44	0.44	-0.85	-0.85	-3.00	1.70
1.00	17.00												

XL	X	Env-1 Top Max-T	Env-1 Top Max-C	Env-1 Bot Max-T	Env-1 Bot Max-C
	m	MPa	MPa	MPa	MPa
0.00	0.00				
0.05	0.85	-----	-0.62	-----	-6.23
0.10	1.70	-----	-1.21	-----	-5.08
0.15	2.55	-----	-1.33	-----	-4.83
0.20	3.40	-----	-1.27	-----	-4.96
0.25	4.25	-----	-0.55	-----	-3.06
0.30	5.10	-----	-0.91	-----	-2.37
0.35	5.95	-----	-1.22	-----	-1.77
0.40	6.80	-----	-1.48	-----	-1.26
0.45	7.65	-----	-1.69	-----	-0.84
0.50	8.50	-----	-1.86	-----	-0.51
0.55	9.35	-----	-1.99	-----	-0.27
0.60	10.20	-----	-2.06	-----	-0.12
0.65	11.05	-----	-2.09	-----	-0.06

0.70	11.90	-----	-2.08	-----	-0.09
0.75	12.75	-----	-2.01	-----	-0.21
0.80	13.60	-----	-1.91	-----	-0.43
0.85	14.45	-----	-1.75	-----	-0.73
0.90	15.30	-----	-1.55	-----	-1.12
0.95	16.15	-----	-1.03	-----	-2.13
1.00	17.00				

SPAN 3

XL	X	SW Top	SW Bot	SDL Top	SDL Bot	XL Top	XL Bot	LL Top Max-T	LL Top Max-C	LL Bot Max-T	LL Bot Max-C	PT Top	PT Bot
	m	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
0.00	0.00												
0.05	0.25	0.00	0.00	1.97	-3.84	0.00	0.00	0.56	0.56	-1.10	-1.10	-2.82	1.35
0.10	0.50	0.00	0.00	1.77	-3.45	0.00	0.00	0.51	0.51	-0.99	-0.99	-2.72	1.17
0.15	0.75	0.00	0.00	1.58	-3.09	0.00	0.00	0.45	0.45	-0.88	-0.88	-2.60	0.94
0.20	1.00	0.00	0.00	1.41	-2.74	0.00	0.00	0.40	0.40	-0.78	-0.78	-2.50	0.74
0.25	1.25	0.00	0.00	1.24	-2.42	0.00	0.00	0.35	0.35	-0.69	-0.69	-2.41	0.57
0.30	1.50	0.00	0.00	1.08	-2.11	0.00	0.00	0.31	0.31	-0.60	-0.60	-2.34	0.43
0.35	1.75	0.00	0.00	0.94	-1.82	0.00	0.00	0.27	0.27	-0.52	-0.52	-2.29	0.32
0.40	2.00	0.00	0.00	0.80	-1.56	0.00	0.00	0.23	0.23	-0.45	-0.45	-2.25	0.24
0.45	2.25	0.00	0.00	0.67	-1.31	0.00	0.00	0.19	0.19	-0.38	-0.38	-2.22	0.19
0.50	2.50	0.00	0.00	0.56	-1.09	0.00	0.00	0.16	0.16	-0.31	-0.31	-2.22	0.18
0.55	2.75	0.00	0.00	0.45	-0.89	0.00	0.00	0.13	0.13	-0.25	-0.25	-2.21	0.16
0.60	3.00	0.00	0.00	0.36	-0.70	0.00	0.00	0.10	0.10	-0.20	-0.20	-2.18	0.11
0.65	3.25	0.00	0.00	0.28	-0.54	0.00	0.00	0.08	0.08	-0.15	-0.15	-2.14	0.03
0.70	3.50	0.00	0.00	0.20	-0.39	0.00	0.00	0.06	0.06	-0.11	-0.11	-2.08	-0.09
0.75	3.75	0.00	0.00	0.14	-0.27	0.00	0.00	0.04	0.04	-0.08	-0.08	-2.00	-0.24
0.80	4.00	0.00	0.00	0.08	-0.17	0.00	0.00	0.02	0.02	-0.05	-0.05	-1.91	-0.42
0.85	4.25	0.00	0.00	0.04	-0.08	0.00	0.00	0.01	0.01	-0.02	-0.02	-1.80	-0.64
0.90	4.50	0.00	0.00	0.01	-0.02	0.00	0.00	0.00	0.00	-0.01	-0.01	-1.67	-0.89
0.95	4.75	0.00	0.00	-0.01	0.03	0.00	0.00	0.00	0.00	0.01	0.01	-1.53	-1.17
1.00	5.00												

XL	X	Env-1 Top Max-T	Env-1 Top Max-C	Env-1 Bot Max-T	Env-1 Bot Max-C
	m	MPa	MPa	MPa	MPa
0.00	0.00				
0.05	0.25	-----	-0.29	-----	-3.58
0.10	0.50	-----	-0.45	-----	-3.27
0.15	0.75	-----	-0.57	-----	-3.03
0.20	1.00	-----	-0.69	-----	-2.79
0.25	1.25	-----	-0.82	-----	-2.54
0.30	1.50	-----	-0.95	-----	-2.29
0.35	1.75	-----	-1.08	-----	-2.03
0.40	2.00	-----	-1.22	-----	-1.76
0.45	2.25	-----	-1.36	-----	-1.50
0.50	2.50	-----	-1.50	-----	-1.22
0.55	2.75	-----	-1.62	-----	-0.98
0.60	3.00	-----	-1.72	-----	-0.79
0.65	3.25	-----	-1.78	-----	-0.66
0.70	3.50	-----	-1.82	-----	-0.59
0.75	3.75	-----	-1.82	-----	-0.58
0.80	4.00	-----	-1.80	-----	-0.63
0.85	4.25	-----	-1.74	-----	-0.74
0.90	4.50	-----	-1.66	-----	-0.91
0.95	4.75	-----	-1.54	-----	-1.13
1.00	5.00				

29 - DETAILED REBAR

SPAN 1

XL	X	Analysis Top	Analysis Bot	Minimum Top	Minimum Bot	Selected Top	Selected Bot
	m	mm2	mm2	mm2	mm2	mm2	mm2
0.00	0.00	0.00	0.00	1493.00	0.00	1493.00	0.00
0.05	1.00	0.00	0.00	1493.00	0.00	1493.00	0.00
0.10	2.00	0.00	0.00	1493.00	0.00	1493.00	0.00
0.15	3.00	0.00	0.00	1493.00	0.00	1493.00	0.00
0.20	4.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	5.00	0.00	368.80	0.00	0.00	0.00	368.80
0.30	6.00	0.00	559.50	0.00	0.00	0.00	559.50
0.35	7.00	0.00	685.50	0.00	1085.00	0.00	1085.00
0.40	8.00	0.00	685.50	0.00	1085.00	0.00	1085.00
0.45	9.00	0.00	559.50	0.00	1085.00	0.00	1085.00
0.50	10.00	0.00	368.80	0.00	1085.00	0.00	1085.00
0.55	11.00	0.00	0.00	0.00	1085.00	0.00	1085.00
0.60	12.00	0.00	0.00	0.00	1085.00	0.00	1085.00
0.65	13.00	0.00	0.00	0.00	1085.00	0.00	1085.00
0.70	14.00	0.00	0.00	0.00	0.00	0.00	0.00
0.75	15.00	0.00	0.00	0.00	0.00	0.00	0.00
0.80	16.00	0.00	0.00	0.00	0.00	0.00	0.00
0.85	17.00	0.00	0.00	1493.00	0.00	1493.00	0.00
0.90	18.00	0.00	0.00	1493.00	0.00	1493.00	0.00
0.95	19.00	0.00	0.00	1493.00	0.00	1493.00	0.00
1.00	20.00	847.50	0.00	1493.00	0.00	1493.00	0.00

SPAN 2

XL	X	Analysis Top	Analysis Bot	Minimum Top	Minimum Bot	Selected Top	Selected Bot
	m	mm2	mm2	mm2	mm2	mm2	mm2
0.00	0.00	222.00	0.00	1493.00	0.00	1493.00	0.00
0.05	0.85	0.00	0.00	1493.00	0.00	1493.00	0.00
0.10	1.70	0.00	0.00	1493.00	0.00	1493.00	0.00
0.15	2.55	0.00	0.00	1493.00	0.00	1493.00	0.00
0.20	3.40	0.00	0.00	0.00	0.00	0.00	0.00
0.25	4.25	0.00	0.00	0.00	0.00	0.00	0.00
0.30	5.10	0.00	0.00	0.00	0.00	0.00	0.00
0.35	5.95	0.00	0.00	1493.00	0.00	1493.00	0.00
0.40	6.80	0.00	0.00	0.00	1085.00	0.00	1085.00
0.45	7.65	0.00	0.00	0.00	1085.00	0.00	1085.00
0.50	8.50	0.00	0.00	0.00	1085.00	0.00	1085.00
0.55	9.35	0.00	0.00	0.00	1085.00	0.00	1085.00
0.60	10.20	0.00	0.00	0.00	1085.00	0.00	1085.00
0.65	11.05	0.00	0.00	0.00	1085.00	0.00	1085.00
0.70	11.90	0.00	0.00	0.00	0.00	0.00	0.00
0.75	12.75	0.00	0.00	0.00	0.00	0.00	0.00
0.80	13.60	0.00	0.00	0.00	0.00	0.00	0.00
0.85	14.45	0.00	0.00	1493.00	0.00	1493.00	0.00
0.90	15.30	0.00	0.00	1493.00	0.00	1493.00	0.00
0.95	16.15	0.00	0.00	1493.00	0.00	1493.00	0.00
1.00	17.00	0.00	0.00	1493.00	0.00	1493.00	0.00

SPAN 3

XL	X	Analysis Top	Analysis Bot	Minimum Top	Minimum Bot	Selected Top	Selected Bot

	m	mm2	mm2	mm2	mm2	mm2	mm2
0.00	0.00	0.00	0.00	1073.00	0.00	1073.00	0.00
0.05	0.25	0.00	0.00	1073.00	0.00	1073.00	0.00
0.10	0.50	0.00	0.00	1073.00	0.00	1073.00	0.00
0.15	0.75	0.00	0.00	1073.00	0.00	1073.00	0.00
0.20	1.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	1.25	0.00	0.00	0.00	0.00	0.00	0.00
0.30	1.50	0.00	0.00	0.00	0.00	0.00	0.00
0.35	1.75	0.00	0.00	1073.00	0.00	1073.00	0.00
0.40	2.00	0.00	0.00	1073.00	0.00	1073.00	0.00
0.45	2.25	0.00	0.00	1073.00	0.00	1073.00	0.00
0.50	2.50	0.00	0.00	0.00	961.70	0.00	961.70
0.55	2.75	0.00	0.00	0.00	961.70	0.00	961.70
0.60	3.00	0.00	0.00	0.00	961.70	0.00	961.70
0.65	3.25	0.00	0.00	0.00	961.70	0.00	961.70
0.70	3.50	0.00	0.00	0.00	0.00	0.00	0.00
0.75	3.75	0.00	0.00	0.00	0.00	0.00	0.00
0.80	4.00	0.00	0.00	0.00	0.00	0.00	0.00
0.85	4.25	0.00	0.00	1073.00	0.00	1073.00	0.00
0.90	4.50	0.00	0.00	1073.00	0.00	1073.00	0.00
0.95	4.75	0.00	0.00	1073.00	0.00	1073.00	0.00
1.00	5.00	0.00	0.00	1073.00	0.00	1073.00	0.00

Legend (2.1):
Span C = Cantilever
Form 1 = Rectangular, 2 = T or Inverted L, 3 = I, 4 = Extended T or L section
Rh Elevation of top surface
TF Top flange
MF Middle flange
BF Bottom flange

Legend (2.7):
The Column Boundary Condition (CBC):
Fixed at both 1
Hinged at near end, fixed at far end 2
Fixed at near end, hinged at far end 3
Fixed at near end, roller with rotational fixity at far end 4
LC Lower Column
UC Upper Column

Legend (3.1):
Class: SW: Selfweight, LL: Live Load, SDL: Superimposed Dead Load, X: Other Loading
Type: U: Uniform, P: Partial Uniform, L: Line Load, M: Applied Moment
C: Concentrated Load, R: Triangle, V: Variable, T: Trapezoidal

Legend (4.1, 4.2):
Yb: distance from centroid to bottom fiber
Yt: distance from centroid to top fiber
I: gross moment of inertia

Legend (7.1):
Type
1 = reversed parabola
2 = simple parabola with straight portion over support
3 = harped tendon
4 = straight tendon
5 = extended reversed parabola

Legend (7.2):
CGS C1: CGS of left middle point of tendon for type 5 profile
CGS C2: CGS of right middle point of tendon for type 5 profile or middle point of other types

Legend (10.1, 11.1):
From: Beginning of rebar measured from left support of the span
To: End of rebar measured from left support of the span
As Required: Envelope of minimum and ultimate rebar
Ultimate: Required rebar for ultimate load combinations
Minimum: Required minimum rebar

Legend (10.2, 11_2):
ID: ID number of the bar as shown on graph
From: Beginning of rebar measured from left support of the span
Quantity: Number of bars
Size: Bar number
Length: Total length of the bar
Area: Area of reinforcement

Legend (12):
d: Effective depth of section for shear rebar calculation
Vu: Ultimate shear
Ratio: ratio of ultimate to allowable shear stress
Req.: Required shear reinforcement per unit length
Spacing: Spacing between shear rebar

6 Appendix

A = Depth of compression zone
A_c = area of concrete resisting shear
A_{min} = code required minimum area of non-prestressed reinforcement
A_{ps} = cross sectional area of tendon at the location of shear check
A_s = area of nonprestressed tensile reinforcement
A_s' = area of nonprestressed compressive reinforcement
A_{sv} = area of links (in^2/ft or mm^2/m)
A_v = area of stirrups

B = width of section (stem in the case of T sections)
b_o = perimeter of critical section
b_v = width of section (stem width for T sections)

C = torsional constant of section

d_p = distance of centroid of post-tensioning to extreme compression fiber
d_r = distance of compression fiber to centroid of nonprestressed reinforcement (but not less than 0.8 times total depth of section when checking shear)

e = eccentricity of post-tensioning/prestressing with respect to the centroidal axis of the section (positive if CGS is above the neutral axis)
E = modulus of elasticity

f_{bot} = stress at bottom
f_{cp} = design compressive stress at centroid due to prestressing
f_{cu} = cube strength at 28 days
f'_c = 28-day compressive strength of concrete
f_{pbot} = stresses due to prestressing only, at bottom fiber
f_{pe} = stress in prestressing steel
f_{pea} = $PTF/(A_{ps} + (f_y/f_{pu})*A_s)$
f_{ps} = stress in tendon of limited state
f_{ptop} = stresses due to prestressing only, at top fiber
f_{pu} = tendon's ultimate strength
f_{se} = effective stress in tendon after all losses
f_t = maximum design principal tensile stress, $0.24*(f_{cu})^{1/2}$
f_{top} = stress at top
f_y = yield strength of stirrups
f_y = yield stress of reinforcement
f_{yv} = yield stress of link (stirrup) reinforcement
FEM = Fixed End Moment

h = member thickness (height of section)

I = gross moment of inertia

J_c = a parameter similar to the moment of inertia of the critical surface, defined in ACI-318 (Chapter 11) Commentary [2]

K_c = column stiffness
K_{ec} = equivalent column stiffness
K_t = stiffness of torsional member

L = span length

M = $1.2*M_d + 1.6*M_l + M_{sec}$
M_{bal} = balanced moment due to balanced loading
M_d = dead load moment
M_l = live load moment
M_n = nominal moment of a section
M_o = static moment of span
= moment reduce to zero precompression in extreme fiber (decompression moment)
M_{sec} = secondary moment
M_u = factored moment

N_c = force of tensile block

PT = post-tensioning force
PTF = prestressing force

s_v = spacing of links
S = section modulus
S_b = bottom section modulii
S_t = top section modulii

T = tension force
T_p = tension due to post-tensioning
T_s = tension due to nonprestressed rebar
T_u = total tension
v = factored shear stress
v_a = allowable shear stress
v_c = design concrete shear stress
v_{ca} = $V_c/b*h$
v_{co} = design concrete shear resistance of uncracked sections
v_{cr} = resisting design concrete shear stress for cracked sections
v_u = factored maximum shear stress
V = factored applied shear force

V_c	=	shear resistance of concrete
V_d	=	factored shear force due to dead load
V_l	=	factored shear force due to live load
V_{sec}	=	factored shear force due to secondary load
V_u	=	factored column reaction; factored shear force
w	=	load intensity
W_{bal}	=	balanced loading
W_u	=	factored loading
ωY_b	=	distance of centroidal axis to bottom fiber
Y_t	=	distance of centroidal axis to top fiber
β_1	=	0.85 for 4000 psi concrete, otherwise as defined in ACI-318(10)
γ_m	=	material constant stipulated as 1.25
ϕ	=	strength reduction factor
ρ	=	ratio of nonprestressed tensile reinforcement (see ACI-318(8))
ρ'	=	ratio of nonprestressed compression reinforcement (see ACI-318(8))
ρ_{bal}	=	reinforcement ratio producing balanced strain condition (see ACI-318(8))
ρ_p	=	ratio of prestressed reinforcement
ω	=	index of nonprestressed tensile reinforcement (see ACI-318(18))
ω'	=	index of nonprestressed compressive reinforcement (see ACI-318(18))
ω_p	=	index of prestressing reinforcement as defined in ACI-318(18)