البيتون مسبق الإجهاد (Prestressed Concrete)

خواص المقاطع   AASHTO & PCI

SELECTED TYPICAL STANDARD PRECAST DOUBLE TEES, INVERTED TEES, HOLLOW CORE SECTIONS, AND AASHTO BRIDGE SECTIONS

Table 4.1   Section Properties and Moduli of Standard PCI Rectangular Sections

Designation	12RB16	12RB20	12RB24	12RB28	12RB32	12RB36	16RB32	16RB36	16RB40
Section modulus S, (in.^{3})	512	800	1,152	1,568	2,048	2,592	2,731	3,456	4,267
Width, b (in.)	12	12	12	12	12	12	16	16	16
Depth, h (in.)	16	20	24	28	32	36	32	36	40

Table 4.2   Geometrical Outer Dimensions and Section Moduli of Standard PCI Double T-Sections

| Designation	Top-/bottom-section modulus, in.^{3}	Flange width b_f, in.	Flange depth t_f, in.	Total depth h, in.	Web width $2\,b_w$, in.
8DT12	1,001/315	96	2	12	9.5
8DT14	1,307/429	96	2	14	9.5
8DT16	1,630/556	96	2	16	9.5
8DT20	2,320/860	96	2	20	9.5
8DT24	3,063/1,224	96	2	24	9.5
8DT32	5,140/2,615	96	2	32	9.5
10DT32	5,960/2,717	120	2	32	12.5
*12DT34	10,458/3,340	144	4	34	12.5
*15DT34	13,128/4,274	180	4	34	12.5

*Pretopped

Table 4.3 Geometrical Outer Dimensions and Section Moduli of Standard AASHTO Bridge Sections

Designation	AASHTO sections					
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Area A_c in.^{2}	276	369	560	789	1,013	1,085
Moment of inertia,						
$\quad I_{g(x-x)}$ in.^{4}	22,750	50,979	125,390	260,741	521,180	733,320
$\quad I_{g(y-y)}$, in.^{4}	3,352	5,333	12,217	24,347	61,235	61,619
Top-/bottom-section	1,476	2,527	5,070	8,908	16,790	20,587
$\quad$ modulus, in.^{3}	1,807	3,320	6,186	10,544	16,307	20,157
Top flange width, b_f (in.)	12	12	16	20	42	42
Top flange average thickness, t_f (in.)	6	8	9	11	7	7
Bottom flange width, b_2 (in.)	16	18	22	26	28	28
Bottom flange average thickness, t_2 (in.)	7	9	11	12	13	13
Total depth, h (in.)	28	36	45	54	63	72
Web width, b_w (in.)	6	6	7	8	8	8
c_t/c_b	15.41	20.17	24.73	29.27	31.04	35.62
$\quad$ (in.)	12.59	15.83	20.27	24.73	31.96	36.38
r^2, in.^{2}	82	132	224	330	514	676
Self-weight w_D lb/ft	287	384	583	822	1055	1130

Table 4.4(a) Geometrical Details of As-Built PCI and AASHTO Sections

Designation	b_f (in.)	h_f (in.)	b_{w1} (in.)	b_{w2} (in.)	h (in.)	b (in.)
8DT12	96	2	5.75	3.75	12	48
8DT14	96	2	5.75	3.75	14	48
8DT16	96	2	5.75	3.75	16	48
8DT18	96	2	5.75	3.75	18	48
8DT20	96	2	5.75	3.75	20	48
8DT24	96	2	5.75	3.75	24	48
8DT32	96	2	7.75	4.75	32	48
10DT32	120	2	7.75	4.75	32	60
12DT34	144	4	7.75	4.75	34	60
15DT34	180	4	7.75	4.75	34	90

Actual double-T sections
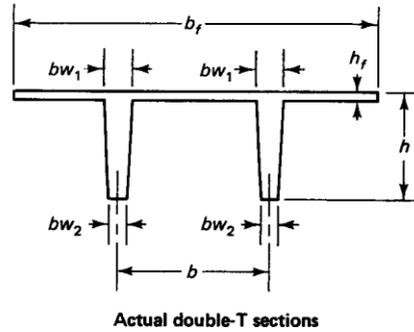
Designation	b_f (in.)	x_1 (in.)	x_2 (in.)	b_2 (in.)	x_3 (in.)	x_4 (in.)	b_w (in.)	h (in.)
AASHTO 1	12	4	3	16	5	5	6	28
AASHTO 2	12	6	3	18	6	6	6	36
AASHTO 3	16	7	4.5	22	7.5	7	7	45
AASHTO 4	20	8	6	26	9	8	8	54
AASHTO 5	42	5	7	28	10	8	8	63
AASHTO 6	42	5	7	28	10	8	8	72

Actual I sections

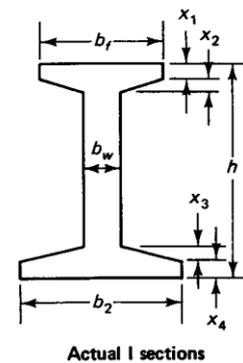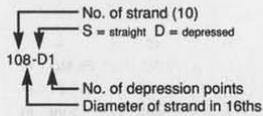**Figure 4.6** Cross Sections of Optimized Bridge Girder Sections [See Table 4.4(b)]

Table 4.4(b) Girder Properties of Optimized Sections

Agency	Girder Type	Depth (in.)	Web Width (in.)	area (in.²)	Inertia (in.⁴)	y_t (in.)	y_b (in.)	S_t (in.³)	S_b (in.³)	ρ	α
CTL	BT-48	48	6	557	177,736	23.53	24.47	7,553	7,264	0.554	0.940
	BT-60	60	6	629	308,722	29.59	30.41	10,432	10,154	0.545	0.931
	BT-72	72	6	701	484,993	35.64	36.36	13,606	13,340	0.534	0.914
PCI	BT-54	54	6	659	268,077	26.37	27.63	10,166	9,702	0.558	0.943
	BT-63	63	6	713	392,638	30.82	32.12	12,715	12,224	0.556	0.942
	BT-72	72	6	767	545,894	35.40	36.60	15,421	14,915	0.549	0.934
AASHTO	Type VI	72	8	1,085	733,320	35.62	36.38	20,587	20,157	0.522	0.893
	Mod. Type VI	72	6	941	671,088	35.56	36.44	18,871	18,417	0.550	0.941
Washington	80/6	50	6	513	159,191	27.24	22.76	5,844	6,994	0.501	0.943
	100/6	58	6	591	256,560	30.01	27.99	8,549	9,166	0.517	0.925
	120/6	73.5	6	688	475,502	37.68	35.82	12,619	13,275	0.512	0.908
	14/6	73.5	6	736	534,037	35.30	38.20	15,122	13,985	0.538	0.894
Colorado	G54/6	54	6	631	242,592	27.33	26.67	8,877	9,095	0.527	0.924
	G68/6	68	6	701	426,575	33.99	34.01	12,548	12,544	0.526	0.911
Nebraska	1600	63	5.9	852	494,829	32.64	30.36	15,159	16,300	0.586	1.051
	1800	70.9	5.9	898	659,505	36.72	34.18	17,959	19,297	0.585	1.049
	2000	78.7	5.9	944	849,565	40.74	37.96	20,854	22,380	0.582	1.042
	2400	94.5	5.9	1,038	1,323,985	48.84	45.66	27,106	28,999	0.572	1.023
Florida	BT-54	54	6.5	785	311,765	28.11	25.89	11,091	12,042	0.546	0.983
	BT-63	63	6.5	843	458,521	32.88	30.12	13,945	15,223	0.549	0.992
	BT-72	72	6.5	901	638,672	37.64	34.36	16,968	18,588	0.548	0.991
Texas	U54A	54	10.2	1,022	379,857	30.12	23.90	12,612	15,895	0.516	0.996
	U54B	54	10.2	1,118	403,878	31.54	22.48	12,807	17,966	0.509	1.029

1 in. = 25.4 mm; 1 in.² = 645 mm²; 1 in.³ = 16,390 mm³; 1 in.⁴ = 416,000 mm⁴

Strand Pattern Designation

- No. of strand (10)
- S = straight D = depressed

108-D1

- No. of depression points
- Diameter of strand in 16ths

Safe loads shown include dead load of 10 psf for untopped members and 15 psf for topped members. Remainder is live load. Long-time cambers include superimposed dead load but do not include live load.

Key

173 — Safe superimposed service load, psf
0.5 — Estimated camber at erection, in.
0.7 — Estimated long-time camber, in.

DOUBLE TEE

8'-0" x 24"
Normal Weight Concrete

8'-0"
2"   5 3/4"   2"
24"
4'-0"   3 3/4"
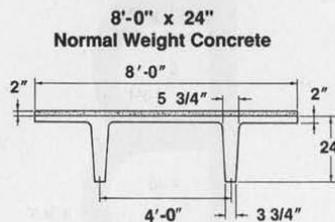
$f'_c = 5,000$ psi
$f_{pu} = 270,000$ psi

Section Properties

		Untopped		Topped	
A	=	401	in.^{2}	—	
I	=	20.985	in.^{4}	27,720	in.^{4}
y_b	=	17.15	in.	19.27	in.
y_t	=	6.85	in.	6.73	in.
Z_b	=	1,224	in.^{3}	1,438	in.^{3}
Z_t	=	3,063	in.^{3}	4,119	in.^{3}
wt	=	418	plf	618	plf
		52	psf	77	psf
V/S	=	1.41	in.		

8DT24

Table of safe superimposed service load (psf) and cambers — No Topping

Strand Pattern	e_e / e_c	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74
68-S	11.15 / 11.15	173 0.5 0.7	147 0.6 0.8	126 0.6 0.8	108 0.7 0.8	92 0.7 0.8	79 0.7 0.8	68 0.7 0.8	58 0.7 0.8	50 0.7 0.7	43 0.6 0.6	36 0.6 0.4	30 0.5 0.2											
88-S	9.15 / 9.15		180 0.7 0.9	155 0.7 0.9	134 0.8 1.0	116 0.8 1.0	100 0.8 1.0	87 0.9 1.0	76 0.9 1.0	66 0.8 0.9	57 0.8 0.8	49 0.7 0.7	43 0.6 0.5	36 0.6 0.3	31 0.5 0.1									
88-D1	9.15 / 14.40			190 1.1 1.5	166 1.2 1.5	146 1.3 1.6	129 1.4 1.7	114 1.5 1.8	100 1.5 1.8	89 1.6 1.8	79 1.6 1.8	70 1.6 1.6	62 1.6 1.6	54 1.6 1.5	48 1.5 1.4	42 1.4 1.2	37 1.3 0.9	32 1.2 0.5						
108-D1	7.15 / 14.15							145 1.7 2.2	129 1.8 2.2	116 1.9 2.3	103 2.0 2.3	92 2.0 2.3	83 2.1 2.3	74 2.1 2.2	66 2.1 2.1	59 2.1 2.0	53 2.0 1.8	47 2.0 1.6	42 1.8 1.3	37 1.7 1.0	32 1.5 0.5			
128-D1	5.48 / 13.90															83 2.5 2.7	75 2.5 2.7	68 2.5 2.5	61 2.5 2.3	55 2.5 2.1	49 2.4 1.8	44 2.3 1.5	40 2.1 1.1	35 1.9 0.6
148-D1	4.29 / 13.65																				61 2.9 2.6	55 2.9 2.3	50 2.8 1.9	45 2.6 1.5

8DT24 + 2

Table of safe superimposed service load (psf) and cambers — 2" Normal Weight Topping

Strand Pattern	e_e / e_c	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64
48-S	14.15 / 14.15	183 0.4 0.4	149 0.4 0.4	122 0.4 0.4	100 0.5 0.4	82 0.5 0.4	66 0.5 0.3	53 0.5 0.3	42 0.5 0.2	33 0.5 0.0											
68-S	11.15 / 11.15			175 0.5 0.5	147 0.6 0.6	123 0.6 0.6	103 0.7 0.5	86 0.7 0.5	72 0.7 0.4	60 0.7 0.3	49 0.7 0.2	39 0.7 0.0									
68-D1	11.15 / 14.65					184 0.7 0.8	156 0.8 0.8	133 0.9 0.8	113 0.9 0.7	96 1.0 0.7	81 1.0 0.7	69 1.0 0.6	58 1.0 0.5	48 1.0 0.3	39 1.0 0.1						
88-D1	9.15 / 14.40							190 1.1 1.1	165 1.2 1.1	143 1.3 1.2	124 1.4 1.2	107 1.5 1.1	93 1.5 1.1	80 1.6 0.9	69 1.6 0.8	59 1.6 0.6	51 1.6 0.4	43 1.6 0.1			
108-D1	7.15 / 14.15									142 1.7 1.5	124 1.8 1.5	109 1.9 1.4	96 2.0 1.3	84 2.0 1.2	74 2.1 1.0	64 2.1 0.7	56 2.1 0.5	48 2.1 0.1			
128-D1	5.48 / 13.90															74 2.5 1.0	65 2.5 0.7	57 2.5 0.3	49 2.5 0.1		

Strength based on strain compatibility; bottom tension limited to $12\sqrt{f'_c}$;
Shaded values require release strengths higher than 3500 psi.

Figure B–1 8"–0" × 24" Double Tee (Courtesy PCI, Ref. 4.9)

Strand Pattern Designation

108 -D1

- No. of strand (10)
- S = straight   D = depressed
- No. of depression points
- Diameter of strand in 16ths

Because these units are pretopped and are typically used in parking structures, safe loads shown do not include any super-imposed dead loads. Loads shown are live load. Long-time cambers do not include live load.

Key

196 — Safe superimposed service load, psf
0.4 — Estimated camber at erection, in.
0.5 — Estimated long-time camber, in.

PRETOPPED DOUBLE TEE

10'-0" x 26"

10'-0"
5 3/4"   4"
26"
5'-0"   3 3/4"

$f'_c = 5,000$ psi
$f_{pu} = 270,000$ psi
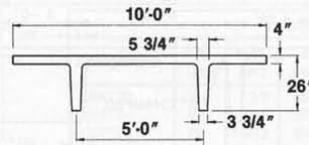
Section Properties

		Normal Weight		Lightweight	
A	=	689	in.²	689	in.²
I	=	30,716	in.⁴	30,716	in.⁴
y_b	=	20.29	in.	20.29	in.
y_t	=	5.71	in.	5.71	in.
Z_b	=	1,514	in.³	1,514	in.³
Z_t	=	5,379	in.³	5,379	in.³
wt	=	718	plf	550	plf
		72	psf	55	psf
V/S	=	2.05	in.	2.05	in.

10DT26 — No Topping

Table of safe superimposed service load (psf) and cambers

Strand Pattern	e_e / e_c	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68
68-S	14.29 / 14.29	196 0.4 0.5	161 0.4 0.5	133 0.4 0.6	109 0.4 0.6	90 0.5 0.6	74 0.5 0.6	60 0.5 0.6	49 0.4 0.6	39 0.4 0.6	30 0.4 0.5												
88-S	12.29 / 12.29			169 0.5 0.7	142 0.6 0.8	119 0.6 0.8	100 0.6 0.8	83 0.6 0.9	69 0.6 0.8	57 0.6 0.8	47 0.6 0.8	38 0.5 0.7	30 0.4 0.6										
88-D1	12.29 / 17.54				200 0.7 1.0	170 0.8 1.1	146 0.9 1.2	125 0.9 1.3	107 1.0 1.3	91 1.0 1.3	78 1.0 1.4	66 1.0 1.4	56 1.0 1.3	47 0.9 1.3	39 0.9 1.2	32 0.8 1.0							
108-D1	10.29 / 17.29						189 1.1 1.5	163 1.1 1.6	142 1.2 1.7	123 1.3 1.7	107 1.3 1.7	93 1.4 1.8	80 1.4 1.8	69 1.4 1.8	60 1.3 1.8	51 1.3 1.7	43 1.2 1.6	36 1.1 1.5					
128-D1	8.62 / 17.04									134 1.6 2.1	118 1.6 2.2	103 1.7 2.3	90 1.7 2.3	79 1.7 2.3	69 1.7 2.3	60 1.6 2.2	52 1.6 2.1	45 1.5 2.0	38 1.4 1.9	32 1.3 1.7			
148-D1	7.43 / 16.79														98 2.0 2.8	87 2.1 2.8	76 2.1 2.8	67 2.1 2.8	59 2.1 2.7	51 2.0 2.5	45 1.9 2.4	38 1.7 2.2	33 1.5 1.9

10LDT26 — No Topping

Table of safe superimposed service load (psf) and cambers

Strand Pattern	e_e / e_c	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72
68-S	14.29 / 14.29	175 0.6 0.9	146 0.7 1.0	123 0.7 1.0	104 0.8 1.1	88 0.8 1.2	74 0.9 1.2	63 0.9 1.3	53 0.9 1.3	44 0.9 1.2	36 0.9 1.2	30 0.8 1.1												
88-S	12.29 / 12.29		183 0.8 1.1	156 0.9 1.2	133 1.0 1.3	113 1.0 1.4	97 1.1 1.5	83 1.2 1.6	71 1.2 1.6	61 1.2 1.6	52 1.2 1.6	44 1.2 1.6	37 1.1 1.5	31 1.0 1.4										
88-D1	12.29 / 17.54				184 1.3 1.8	159 1.4 1.9	138 1.5 2.1	120 1.7 2.2	105 1.7 2.3	92 1.8 2.4	80 1.9 2.4	70 1.9 2.5	61 1.9 2.5	53 1.9 2.5	46 1.9 2.5	39 1.8 2.4	34 1.7 2.3							
108-D1	10.29 / 17.29					177 1.8 2.5	155 2.0 2.7	137 2.1 2.9	121 2.2 3.0	106 2.3 3.2	94 2.5 3.3	83 2.6 3.4	73 2.6 3.4	65 2.6 3.4	57 2.6 3.4	50 2.6 3.3	44 2.5 3.2	38 2.4 3.1	33 2.3 3.0					
128-D1	8.62 / 17.04											104 3.0 4.0	93 3.1 4.1	83 3.2 4.2	74 3.3 4.3	66 3.3 4.3	59 3.4 4.3	52 3.3 4.2	46 3.2 4.0	41 3.1 3.8	36 3.0 3.6	31 2.8 3.4		
148-D1	7.43 / 16.79																73 4.0 5.3	65 4.0 5.3	58 4.0 5.2	52 4.0 5.1	47 4.0 5.0	41 3.8 4.7	37 3.6 4.3	

Strength based on strain compatibility; bottom tension limited to $12\sqrt{f'_c}$;
*Shaded values require release strengths higher than 3500 psi.*

Figure B–2   10'–0" × 26" Double Tee (Courtesy PCI, Ref. 4.9)
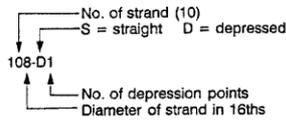
Strand Pattern Designation

```
        No. of strand (10)
        S = straight   D = depressed
108-D1
        No. of depression points
        Diameter of strand in 16ths
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Because these units are pretopped and are typically used in parking structures, safe loads shown do not include any superimposed dead loads. Loads shown are live load. Long-time cambers do not include live load.

Key
176 — Safe superimposed service load, psf
0.8 — Estimated camber at erection, in.
1.1 — Estimated long-time camber, in.

PRETOPPED DOUBLE TEE

12'-0" x 34"

3" CHAMFER
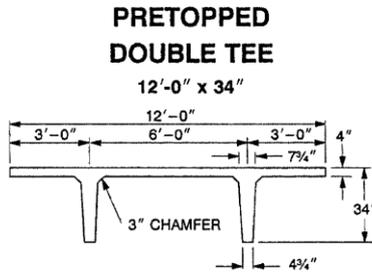
$f_c' = 5,000$ psi
$f_{pu} = 270,000$ psi

Section Properties

		Normal Weight		Lightweight	
A	=	978	in²	978	in²
I	=	86,072	in⁴	86,072	in⁴
y_b	=	25.77	in.	25.77	in.
y_t	=	8.23	in.	8.23	in.
S_b	=	3,340	in³	3,340	in³
S_t	=	10,458	in³	10,458	in³
wt	=	1,019	plf	781	plf
		85	psf	65	psf
V/S	=	2.39	in.	2.39	in.

12DT34

Table of safe superimposed service load (psf) and cambers (in.)   **No Topping**

Strand Pattern	e_e, in. / e_c, in.	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86
128-D1	14.10 / 22.52	176	155	135	119	104	91	79	69	59	51	43	36	30										
		0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.5										
		1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.0	0.9	0.6										
148-D1	12.91 / 22.27		187	165	146	129	114	101	89	78	68	60	52	44	38	32	26							
			1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	0.9	0.7	0.6	0.4							
			1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.3	1.1	1.0	0.8	0.5							
168-D1	12.77 / 22.02			196	174	155	138	123	110	97	86	76	67	59	52	45	39	33	28					
				1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.2	1.1	1.0	0.8	0.6					
				1.7	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.5	1.3	1.0	0.7					
188-D1	11.38 / 21.77				178	160	143	128	115	102	91	82	73	64	57	50	43	38	32	27				
					1.5	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.5	1.4	1.2	1.1	0.9	0.6				
					2.0	2.1	2.1	2.2	2.2	2.2	2.2	2.1	2.0	1.9	1.8	1.6	1.4	1.1	0.7					
208-D1	10.27 / 21.52									131	118	106	95	85	76	68	61	54	47	41	36	31	26	
										1.8	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.5	1.3	1.1	0.8	0.6	
										2.5	2.5	2.5	2.5	2.5	2.4	2.3	2.2	2.1	1.9	1.7	1.4	1.1	0.7	
228-D1	9.36 / 21.27												109	98	88	79	71	64	57	50	44	39	34	29
													2.1	2.1	2.1	2.1	2.1	2.0	1.9	1.7	1.6	1.4	1.1	0.8
													2.8	2.8	2.8	2.7	2.6	2.5	2.4	2.2	2.0	1.7	1.4	1.0

12LDT34

Table of safe superimposed service load (psf) and cambers (in.)   **No Topping**

Strand Pattern	e_e, in. / e_c, in.	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86
128-D1	14.10 / 22.52	193	171	152	135	120	107	95	85	76	67	59	52	46	40	35	30	26						
		1.3	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.5	1.4	1.2	1.0						
		1.8	1.9	2.0	2.0	2.1	2.1	2.2	2.2	2.2	2.2	2.2	2.1	2.1	2.0	1.8	1.6	1.3						
148-D1	12.91 / 22.27			182	162	146	130	117	105	94	85	76	68	61	54	48	42	37	33	28				
				1.7	1.8	1.9	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.0	1.9	1.8	1.6	1.4				
				2.3	2.4	2.5	2.6	2.7	2.8	2.8	2.8	2.8	2.8	2.7	2.7	2.6	2.4	2.3	2.1	1.8				
168-D1	12.77 / 22.02				191	172	155	139	126	114	103	93	84	76	68	61	55	49	44	39	34	30	26	
					2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.5	2.4	2.3	2.1	1.9	1.6	
					2.8	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.5	3.5	3.5	3.4	3.3	3.2	3.1	2.9	2.7	2.4	2.1	
188-D1	11.38 / 21.77								144	131	119	108	98	89	81	73	66	60	54	48	43	39	34	30
									2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.2	3.2	3.1	3.0	2.9	2.8	2.6	2.4	2.1
									3.7	3.8	3.9	4.0	4.1	4.1	4.2	4.1	4.0	3.9	3.7	3.6	3.4	3.2	3.0	2.7
208-D1	10.27 / 21.52													102	93	85	77	70	64	58	52	47	42	38
														3.5	3.6	3.6	3.6	3.6	3.6	3.5	3.4	3.3	3.1	2.9
														4.6	4.7	4.7	4.7	4.7	4.6	4.4	4.2	3.9	3.7	3.5
228-D1	9.36 / 21.27																	80	73	67	61	55	50	45
																		4.1	4.1	4.1	4.0	3.9	3.8	3.6
																		5.3	5.2	5.2	5.0	4.8	4.6	4.2

Strength based on strain compatibility; bottom tension limited to $12\sqrt{f_c'}$; see pages 2-2—2-6 for explanation.
Shaded values require release strengths higher than 3500 psi.

Figure B-3   Pretopped 12'-0" × 34" Double Tee (Courtesy PCI, Ref. 4.9)

INVERTED TEE BEAMS

6″ 1′-6″ 6″

h_1 h h_2

2′-6″
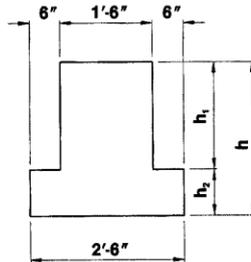
f'_c = 5,000 psi

f_{pu} = 270,000 psi

½ in. diameter
low-relaxation strand

Key
8,428 — Safe superimposed service load, plf
0.4 — Estimated camber at erection, in.
0.2 — Estimated long-time camber, in.

Normal Weight Concrete

				Section Properties				
Designation	h (in.)	h_1/h_2 (in.)	A (in.²)	I (in.⁴)	y_b (in.)	Z_b (in.³)	Z_t (in.³)	wt (plf)
30IT20	20	12/8	456	15,240	8.74	1,744	1,354	475
30IT24	24	12/12	576	26,352	10.50	2,510	1,952	600
30IT28	28	16/12	648	41,824	12.22	3,423	2,650	675
30IT32	32	20/12	720	62,400	14.00	4,457	3,467	750
30IT36	36	24/12	792	88,678	15.82	5,605	4,394	825
30IT40	40	24/16	912	121,923	17.47	6,979	5,412	950
30IT44	44	28/16	984	162,161	19.27	8,415	6,557	1,025
30IT48	48	32/16	1,056	210,199	21.09	9,967	7,811	1,100
30IT52	52	36/16	1,128	266,627	22.94	11,623	9,175	1,175
30IT56	56	40/16	1,200	332,032	24.80	13,388	10,642	1,250
30IT60	60	44/16	1,272	406,997	26.68	15,255	12,215	1,325

1. Check local area for availability of other sizes.

2. Safe loads shown include 50% dead load and 50% live load. 800 psi top tension has been allowed, therefore additional top reinforcement is required.

3. Safe loads can be significantly increased by use of structural composite topping.

Table of safe superimposed service load (plf) and cambers

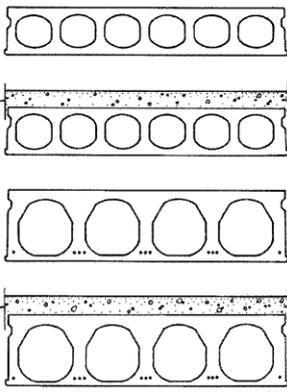| Desig-nation	No. Strand	e	Span, ft. 18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
30IT20	14	6.65	8,428 0.4 0.2	6,736 0.5 0.2	5,485 0.6 0.2	4,533 0.7 0.3	3,792 0.9 0.3	3,204 1.0 0.3	2,730 1.1 0.3	2,342 1.2 0.3	2,020 1.3 0.3	1,751 1.4 0.3	1,523 1.4 0.3	1,332 1.5 0.3	1,167 1.6 0.3	1,024 1.6 0.3			
30IT24	17	7.67		9,736 0.4 0.2	7,942 0.5 0.2	6,578 0.6 0.2	5,516 0.7 0.2	4,673 0.8 0.3	3,994 0.9 0.3	3,437 1.0 0.3	2,976 1.1 0.3	2,592 1.2 0.3	2,269 1.2 0.3	1,993 1.3 0.3	1,755 1.3 0.2	1,550 1.4 0.2	1,370 1.4 0.2	1,212 1.5 0.1	1,073 1.5 0.0
30IT28	20	9.06				9,087 0.6 0.2	7,643 0.6 0.2	6,497 0.7 0.3	5,573 0.8 0.3	4,816 0.9 0.3	4,189 1.0 0.3	3,664 1.1 0.3	3,219 1.2 0.3	2,839 1.2 0.3	2,513 1.3 0.3	2,334 1.4 0.3	1,990 1.4 0.3	1,776 1.5 0.3	1,588 1.5 0.2
30IT32	23	10.50						8,647 0.7 0.2	7,436 0.7 0.3	6,445 0.8 0.3	5,623 0.9 0.3	4,935 1.0 0.3	4,352 1.1 0.4	3,855 1.2 0.4	3,426 1.2 0.4	3,055 1.3 0.4	2,732 1.4 0.4	2,448 1.5 0.3	2,201 1.5 0.3
30IT36	24	12.32							9,492 0.7 0.2	8,243 0.7 0.2	7,207 0.8 0.3	6,340 0.9 0.3	5,605 1.0 0.3	4,978 1.0 0.3	4,439 1.1 0.3	3,971 1.2 0.3	3,563 1.3 0.3	3,205 1.3 0.3	2,892 1.4 0.3
30IT40	30	12.92									9,077 0.8 0.3	7,994 0.8 0.3	7,077 0.9 0.3	6,295 1.0 0.4	5,621 1.1 0.4	5,037 1.2 0.4	4,528 1.2 0.4	4,081 1.3 0.4	3,687 1.4 0.4
30IT44	30	14.73										9,659 0.7 0.3	8,564 0.8 0.3	7,629 0.9 0.3	6,825 1.0 0.3	6,127 1.0 0.3	5,519 1.1 0.3	4,985 1.2 0.3	4,514 1.2 0.3
30IT48	33	16.17												9,222 0.8 0.3	8,262 0.9 0.3	7,431 1.0 0.3	6,705 1.0 0.3	6,068 1.1 0.3	5,506 1.2 0.3
30IT52	36	17.62													9,836 0.9 0.3	8,858 0.9 0.3	8,004 1.0 0.3	7,255 1.1 0.3	6,594 1.1 0.4
30IT56	39	19.06															9,407 1.0 0.3	8,538 1.0 0.4	7,770 1.1 0.4
30IT60	42	20.49																9,917 1.0 0.3	9,036 1.0 0.4

Figure B–4   Inverted Tee Beam Sections (Courtesy PCI, Ref. 4.9)

HOLLOW-CORE SLABS

Section Properties — normal weight concrete   **Dy-Core**

Trade name: Dy-Core®
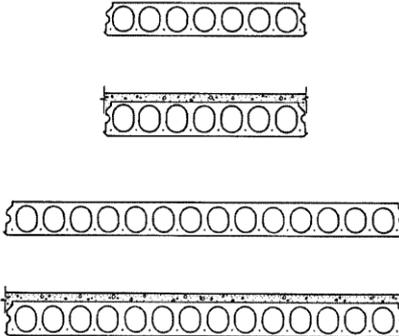Licensing Organization: Dy-Core Systems, Inc., Vancouver, British Columbia

Section	Untopped				With 2" topping		
width x depth	A in.²	y_b in.	I in.⁴	wt psf	y_b in.	I in.⁴	wt psf
4'-0" x 6"	151	3.11	683	40	4.54	1,552	65
4'-0" x 8"	190	3.95	1,568	51	5.54	3,130	76
4'-0" x 10"	216	5.10	2,892	58	6.80	5,097	83
4'-0" x 12"	262	6.34	4,875	71	8.01	7,823	96
4'-0" x 15"	289	7.34	8,701	78	9.36	13,776	103

Note: All sections not available from all producers. Check availability with local manufacturers.

Section Properties — normal weight concrete   **Dynaspan**

Trade name: Dynaspan®
Equipment Manufacturers: Dynamold Corporation, Salina, Kansas

Section	Untopped				With 2" topping		
width x depth	A in.²	y_b in.	I in.⁴	wt psf	y_b in.	I in.⁴	wt psf
4'-0" x 4"	133	2.00	235	35	3.08	689	60
4'-0" x 6"	165	3.02	706	43	4.25	1,543	68
4'-0" x 8"	233	3.93	1,731	61	5.16	3,205	86
4'-0" x 10"	260	4.91	3,145	68	6.26	5,314	93
8'-0" x 6"	338	3.05	1,445	44	4.26	3,106	69
8'-0" x 8"	470	3.96	3,525	61	5.17	6,444	86
8'-0" x 10"	532	4.96	6,422	69	6.28	10,712	94
8'-0" x 12"	615	5.95	10,505	80	7.32	16,507	105

Note: All sections not available from all producers. Check availability with local manufacturers.

Figure B–5   Hollow Core Slab Sections (Courtesy PCI, Ref. 4.9)
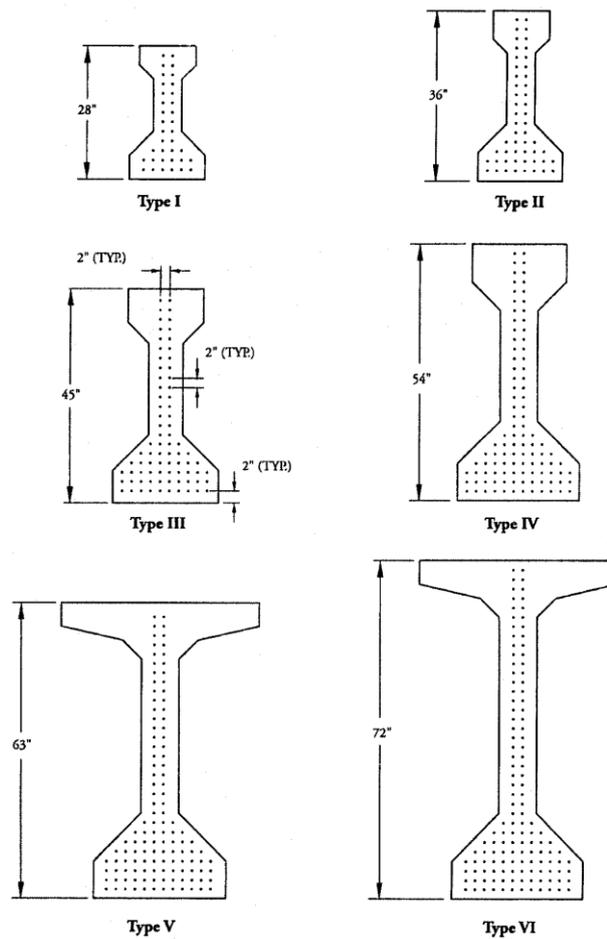
AASHTO I-Beams

Type I-IV   Type V-VI

Dimensions (inches)

Type	D1	D2	D3	D4	D5	D6	B1	B2	B3	B4	B5	B6
I	28.0	4.0	0.0	3.0	5.0	5.0	12.0	16.0	6.0	3.0	0.0	5.0
II	36.0	6.0	0.0	3.0	6.0	6.0	12.0	18.0	6.0	3.0	0.0	6.0
III	45.0	7.0	0.0	4.5	7.5	7.0	16.0	22.0	7.0	4.5	0.0	7.5
IV	54.0	8.0	0.0	6.0	9.0	8.0	20.0	26.0	8.0	6.0	0.0	9.0
V	63.0	5.0	3.0	4.0	10.0	8.0	42.0	28.0	8.0	4.0	13.0	10.0
VI	72.0	5.0	3.0	4.0	10.0	8.0	42.0	28.0	8.0	4.0	13.0	10.0

Properties

Type	Area in.^{2}	y_{bottom} in.	Inertia in.^{4}	Weight kip/ft	Maximum Span,* ft
I	276	12.59	22,750	0.287	48
II	369	15.83	50,980	0.384	70
III	560	20.27	125,390	0.583	100
IV	789	24.73	260,730	0.822	120
V	1,013	31.96	521,180	1.055	145
VI	1,085	36.38	733,320	1.130	167

*Based on simple span, HS-25 loading and $f_c' = 7,000$ psi.

Figure B–6 (a)   AASHTO/PCI Standard Bridge Sections (Courtesy PCI, Ref. 12.11)

AASHTO I-Beams

Figure B–6 (b)   Possible Strand Arrangement for Sections in Figure C-6 (a)

AASHTO-PCI Bulb-Tees
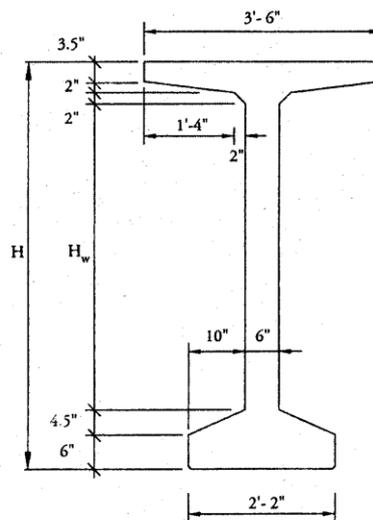
Properties

Type	H in.	H_w in.	Area in.^{2}	Inertia in.^{4}	y_{bottom} in.	Weight kip/ft	Maximum Span,* ft
BT-54	54	36	659	268,077	27.63	0.686	114
BT-63	63	45	713	392,638	32.12	0.743	130
BT-72	72	54	767	545,894	36.60	0.799	146

*Based on simple span, HS-25 loading and $f_c' = 7,000$ psi.

Figure B–7 (a)   AASHTO/PCI Bulb Tees (Courtesy PCI, Ref. 12.11)

AASHTO-PCI Bulb-Tees

BT-54

BT-63

BT-72
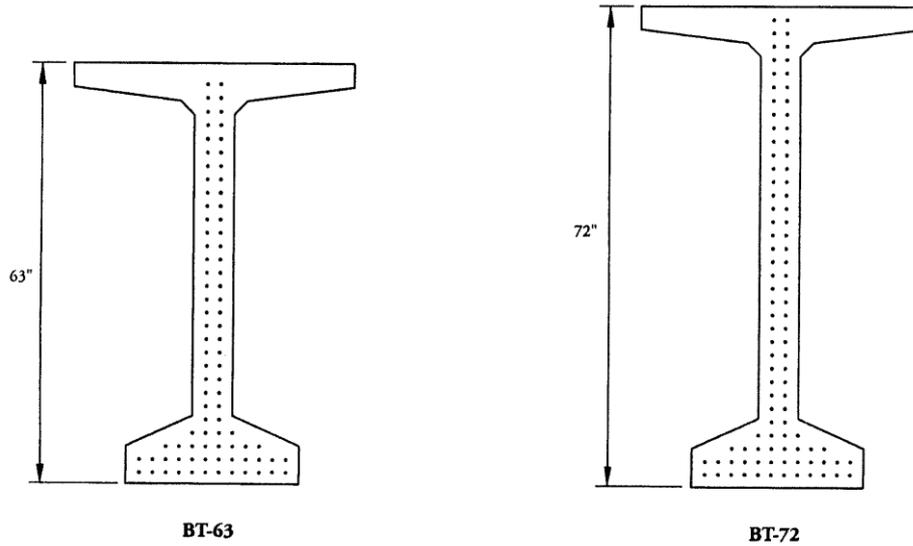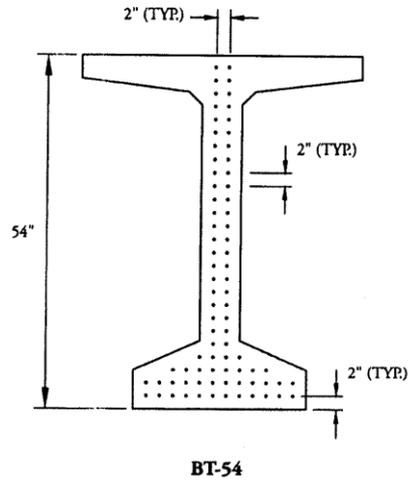
Figure B–7 (b)   Possible Strand Arrangement for Sections in Figure C–7 (a)

Deck Bulb-Tees
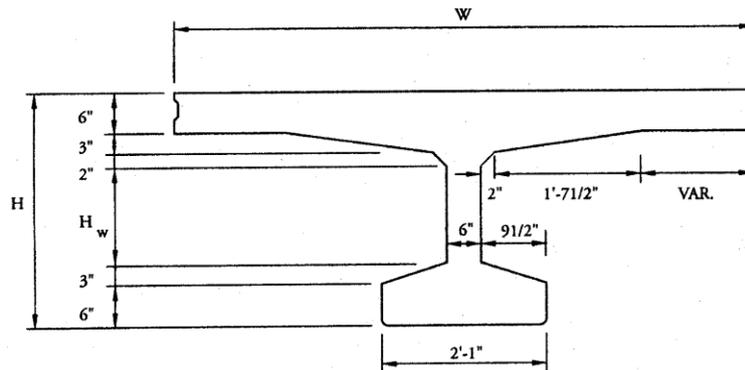
Dimensions and Properties

H in.	H_w in.	W in.	Area in.²	Inertia in.⁴	y_{bottom} in.	Weight kip/ft	Maximum Span* ft
35	15	48	677	101,540	21.12	0.75	100
		72	823	116,071	23.04	0.91	78
		96	967	126,353	24.37	1.07	65
53	33	48	785	294,350	31.71	0.87	145
		72	931	335,679	34.56	1.03	121
		96	1,075	365,827	36.63	1.19	105
65	45	48	857	490,755	38.55	0.95	168
		72	1,003	559,367	41.95	1.11	148
		96	1,147	610,435	44.46	1.27	130

*Based on simple span, HS-25 loading and f'_c = 7,000 psi.

Figure B–8 (a)   AASHTO/PCI Shallow Bridge Deck Bulb Tees (Courtesy PCI, Ref. 12.11)

Deck Bulb-Tees

Deck BT-53

Deck BT-35

Deck BT-65
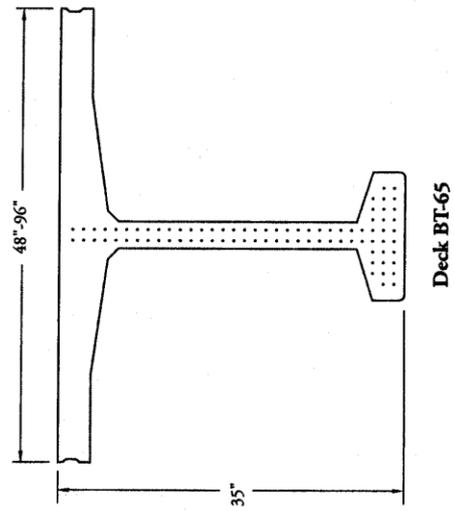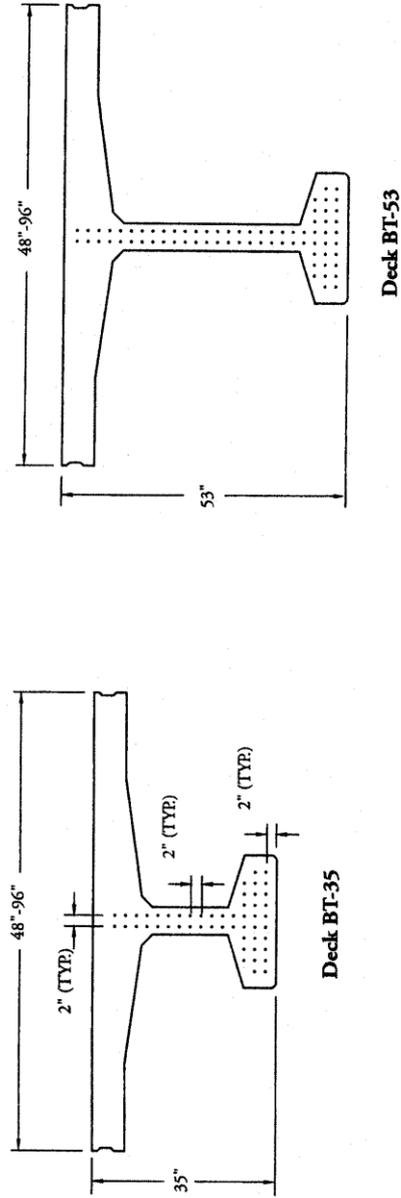
Figure B–8 (b) Possible Strand Arrangement for Sections in Figure C–8 (a)

940

AASHTO Box Beams

Typical Keyway Details   Typical Longitudinal Section
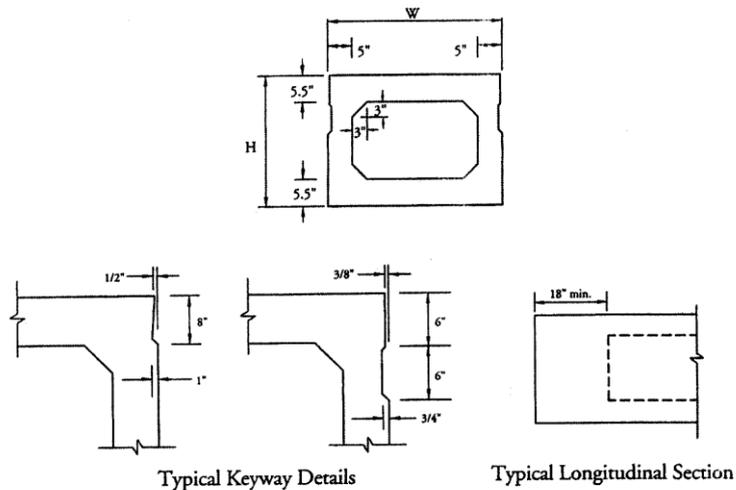
Dimensions (inches)

Type	W	H
BI-36	36	27
BI-48	48	27
BII-36	36	33
BII-48	48	33
BIII-36	36	39
BIII-48	48	39
BIV-36	36	42
BIV-48	48	42

Properties

Type	Area in.²	y_{bottom} in.	Inertia in.⁴	Weight kip/ft	Max. Span* ft
BI-36	560.5	13.35	50,334	0.584	92
BI-48	692.5	13.37	65,941	0.721	92
BII-36	620.5	16.29	85,153	0.646	107
BII-48	752.5	16.33	110,499	0.784	108
BIII-36	680.5	19.25	131,145	0.709	120
BIII-48	812.5	19.29	168,367	0.846	125
BIV-36	710.5	20.73	158,644	0.740	124
BIV-48	842.5	20.78	203,088	0.878	127

*Based on simple span, HS-25 loading and f'_c = 7,000 psi.

Figure B–9 (a)   AASHTO/PCI Bridge Box Girders (Courtesy PCI, Ref. 12.11)

AASHTO Box Beams
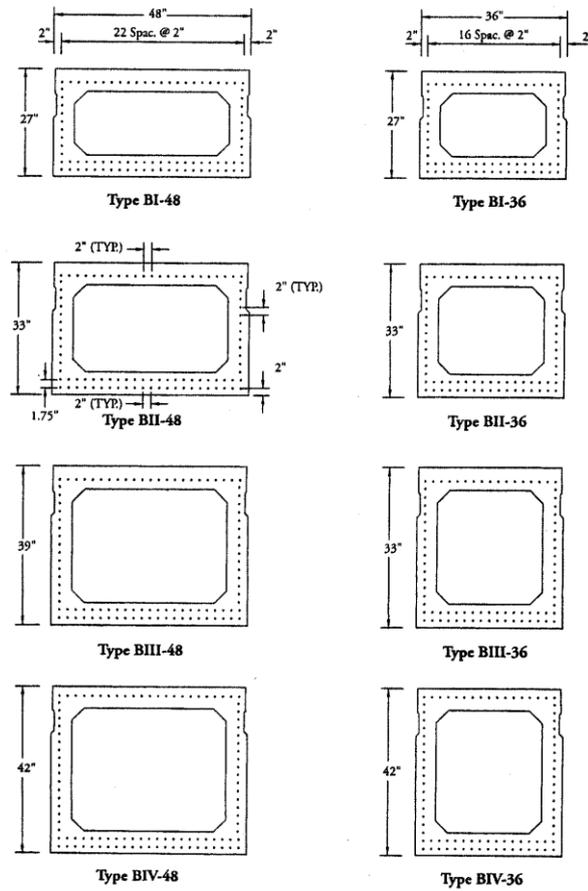
Figure B-9 (b)   Possible Strand Arrangement for Sections in Figure C-9 (a)

V_j = factored shear force at section due to externally applied loads occurring simultaneously with M_{max}.

V_n = nominal shear strength.

w_u = factored load per unit length of beam or per unit area of slab.

x = shorter overall dimension of rectangular part of cross section.

x_1 = shorter center-to-center dimension of closed rectangular stirrup.

y = longer overall dimension of rectangular part of cross section.

y_t = distance from centroidal axis of gross section, neglecting reinforcement, to extreme fiber in tension.

y_1 = longer center-to-center dimension of closed rectangular stirrup.

α = total angular change of prestressing tendon profile in radians from tendon jacking end to any point x.

α = ratio of flexural stiffness of beam section to flexural stiffness of a width of slab bounded laterally by centerlines of adjacent panels (if any) on each side of the beam.

$$= \frac{E_{cb}I_b}{E_{ca}I_s}$$

α_m = average value of α for all beams on edges of a panel.

β_a = ratio of dead load per unit area to live load per unit area (in each case without load factors).

β_d = ratio of maximum factored dead load moment to maximum factored total load moment, always positive.

β = a ratio of clear spans in long to short direction of two-way slabs.

γ_f = fraction of unbalanced moment transferred by flexure at slab-column connections.

γ_p = factor for type of prestressing tendon.

= 0.55 for f_{py}/f_{pu} not less than 0.80

= 0.40 for f_{py}/f_{pu} not less than 0.85

= 0.28 for f_{py}/f_{pu} not less than 0.90

γ_v = fraction of unbalanced moment transferred by eccentricity of shear at slab-column connections.

= $1 - \gamma_f$

δ_{ns} = moment magnification factor for frames braced against sidesway, to reflect effects of member curvature between ends of compression member.

δ_s = moment magnification factor for frames not braced against sidesway, to reflect lateral drift resulting from lateral and gravity loads.

μ = curvature friction coefficient.

$\xi_{(xi)}$ = time-dependent factor for sustained load.

$\rho_{(rho)}$ = ratio of nonprestressed tension reinforcement.

= A_s/bd

ρ' = ratio of nonprestressed compression reinforcement

= A_s'/bd

ρ_b = reinforcement ratio producing balanced strain conditions.

ρ_p = ratio of prestressed reinforcement.

= A_{ps}/bd_p

ρ_t = A_{sv}/A_{cv}; where A_{sv} is the projection on A_{cv} of area of distributed shear reinforcement crossing the plane of A_{cv}.

θ = angle of compression diagonals in truss analogy for torsion.

ϕ = strength reduction factor.

ω = pf_y/f_c'.

ω' = $p'f_y/f_c'$.

ω_p = $\rho_p f_{pe}/f_c'$.

$\omega_{pw}, \omega_w, \omega_w'$

= reinforcement indices for flanged sections computed as for ω, ω_p, and ω' except that b shall be the web width, and reinforcement area shall be that required to develop compressive strength of web only.

To convert from	to	multiply by
Length		
inch (in.)	millimeter (mm)	25.4
inch (in.)	meter (m)	0.0254
foot (ft)	meter (m)	0.3048
yard (yd)	meter (m)	0.9144
Area		
square foot (sq. ft)	square meter (sq m)	0.09290
square inch (sq. in.)	square millimeter (sq mm)	645.2
square inch (sq. in.)	square meter (sq m)	0.0006452
square yard (sq yd)	square meter (sq m)	0.8361
acre (A)	hectare (ha) = 10,000 sq m	0.4047
Volume		
cubic inch (cu in.)	cubic meter (cu m)	0.00001639
cubic foot (cu ft)	cubic meter (cu m)	0.02832
cubic yard (cu yd)	cubic meter (cu m)	0.7646
gallon (gal) Can. liquid*	liter	4.546
gallon (gal) Can. liquid*	cubic meter (cu m)	0.004546
gallon (gal) U.S. liquid*	liter	3.785
gallon (gal) U.S. liquid*	cubic meter (cu m)	0.003785
Force		
kip	kilogram (kgf)	453.6
kip	newton (N)	4448.0
pound (lb)	kilogram (kgf)	0.4536
pound (lb)	newton (N)	4.448
Pressure or Stress		
kips/square inch (ksi)	megapascal (MPa)**	6.895
pound/square foot (psf)	kilopascal (kPa)**	0.04788
pound/square inch (psi)	kilopascal (kPa)**	6.895
pound/square inch (psi)	megapascal (MPa)**	0.006895
pounds/square foot (psf)	kilogram/square meter (kgf/sq m)	4.882
Mass		
pound (avdp)	kilogram (kg)	0.4536
ton (short, 2000 lb)	kilogram (kg)	907.2
ton (short, 2000 lb)	tonne (t)	0.9072
grain	kilogram (kg)	0.00006480
tonne (t)	kilogram (kg)	1000
Mass (weight per Length)		
kip/linear foot (klf)	kilogram/meter (kg/m)	1488
pound/linear foot (plf)	kilogram/meter kg/m	1.488
pound/linear foot (plf)	newton/meter (N/m)	14.593
Mass per volume (density)		
pound/cubic foot (pcf)	kilogram/cubic meter (kg/cu m)	16.02
pound/cubic yard (pcy)	kilogram/cubic meter (kg/cu m)	0.5933
gallon per yd^3	Kg/m^3	4.985
oz per yd^3	Kg/m^3	0.037
Bending Moment or Torque		
inch-pound (in.-lb)	newton-meter	0.1130
foot-pound (ft-lb)	newton-meter	1.356
foot-kip (ft-k)	newton-meter	1356
Temperature		
degree Fahrenheit (deg F)	degree Celsius (C)	$t_c = (t_F - 32)/1.8$
degree Fahrenheit (deg F)	degree Kelvin (K)	$t_K = (t_F + 459.7)/1.8$
Energy		
British thermal unit (Btu)	joule (j)	1056
kilowatt-hour (kwh)	joule (j)	3,600,000
Power		
horsepower (hp) (550 ft lb/sec)	watt (W)	745.7
Velocity		
mile/hour (mph)	kilometer/hour	1.609
mile/hour (mph)	meter/second (m/s)	0.4470
Other		
Section modulus (in.^{3})	mm^3	16,387
Moment of inertia (in.^{4})	mm^4	416,231
Coefficient of heat transfer (Btu/ft^2/h/°F)	W/m^2/°C	5.678
Modulus of elasticity (psi)	MPa	0.006895
Thermal conductivity (BTU-in./ft^2/h/°F)	Wm/m^2/°C	0.1442
Thermal expansion in./in./°F	mm/mm/°C	1.800
Area/length (in.^{2}/ft)	mm^2/m	2116.80

*One U.S. gallon equals 0.8321 Canadian gallon
**A pascal equals one newton/square meter