

APPENDIX A: TWO-WAY REINFORCED CONCRETE REDESIGN

The tables below were used during the two-way structural redesign on the parking garage waffle slab. The information was taken from AE 431 Advance Concrete. Table 7 corresponds with the information below.

Given Information	
l_1 (ft)	30
l_2 (ft)	30
t_{slab} (in)	12
γ_c (pcf)	150
f'_c (psi)	4000
f_y (psi)	60000
Column Size (in) l_2, l_1	26
w_{SDL} (psf)	15
w_{DL} (psf)	150
w_{LL} (psf)	50
w_u (psf)	278
Φ_{bar} (in)	1
A_{bar} (in ²)	0.79

13.6.3.2 — In an interior span, total static moment, M_o , shall be distributed as follows:

Negative factored moment.....0.65

Positive factored moment0.35

13.6.3.3 — In an end span, total factored static moment, M_o , shall be distributed as follows:

	(1)	(2)	(3)		(4)	(5)
	Exterior edge unrestrained	Slab with beams between all supports	Without edge beam	With edge beam	Exterior edge fully restrained	
Interior negative factored moment	0.75	0.70	0.70	0.70	0.65	
Positive factored moment	0.63	0.57	0.52	0.50	0.35	
Exterior negative factored moment	0	0.16	0.26	0.30	0.65	

ρ	$f_y = 40,000$ psi				$f_y = 60,000$ psi			
	f'_{cr} psi				f'_{cr} psi			
	3000	4000	5000	6000	3000	4000	5000	6000
0.0005	20	20	20	20	30	30	30	30
0.0010	40	40	40	40	59	59	60	60
0.0015	59	59	60	60	88	89	89	89
0.0020	79	79	79	79	117	118	118	119
0.0025	98	99	99	99	146	147	147	148
0.0030	117	118	118	119	174	175	176	177
0.0035	136	137	138	138	201	204	205	206
0.0040	155	156	157	157	229	232	233	234
0.0045	174	175	176	177	256	259	261	263
0.0050	192	194	195	196	282	287	289	291
0.0055	211	213	214	215	309	314	317	319
0.0060	229	232	233	234	335	341	345	347
0.0065	247	250	252	253	360	368	372	375
0.0070	265	268	271	272	385	394	399	403
0.0075	282	287	289	291	410	420	426	430
0.0080	300	305	308	310	435	446	453	457
0.0085	317	323	326	329	459	472	479	485
0.0090	335	341	345	347	483	497	506	511
0.0095	352	359	363	366	506	522	532	538
0.0100	369	376	381	384	529	547	558	565
0.0105	385	394	399	403	552	572	583	591
0.0110	402	412	417	421	575	596	609	617
0.0115	419	429	435	439	597	620	634	643
0.0120	435	446	453	457	618	644	659	669
0.0125	451	463	471	476	640	667	684	695
0.0130	467	480	488	494	661	691	708	720
0.0135	483	497	506	511	681	714	733	746
0.0140	499	514	523	529	702	736	757	771
0.0145	514	531	540	547	722	759	781	796
0.0150	529	547	558	565	741	781	805	821
0.0155	545	563	575	582	760	803	828	845
0.0160	560	580	592	600		825	852	870
0.0165	575	596	609	617		846	875	894
0.0170	589	612	626	635		867	898	918
0.0175	604	628	642	652		888	920	942
0.0180	618	644	659	669		909	943	966
0.0185	633	660	676	686		929	965	989
0.0190	647	675	692	703		949	987	1013
0.0195	661	691	708	720		969	1009	1036
0.0200	675	706	725	737		988	1031	1059

Transverse Distribution of Longitudinal Moments										
		Negative Moment					Positive Moment			
Frame	l_2/l_1	a_2/l_1	% To CS	M In CS	% To MS	M in MS	% To CS	M In CS	% To MS	M in MS
	1.00	0	75	-424.00	25	-141.33	60	251.98	40	167.98
B	1.00	0	100 (Ext.)	-104.99	0	0.00	60	125.99	40	83.99
	1.00	0	75 (Int.)	-212.00	25	-70.67				
	1.00	0	75	-424.00	25	-141.33	60	251.98	40	167.98
D	1.00	0	100 (Ext.)	-104.99	0	0.00	60	125.99	40	83.99
	1.00	0	75 (Int.)	-212.00	25	-70.67				

Frame	Total Width (ft)	CS (ft)	MS (ft)	Total - Moment	CS (-M)	MS (-M)	Total + Moment	CS (+M)	MS (+M)
A	30	15	15	-565.33	-424.00	-141.33	419.96	251.98	167.98
B	15	7.5	7.5	-104.99	-104.99	0.00	209.98	125.99	83.99
				-282.67	-212.00	-70.67			
C	30	15	15	-565.33	-424.00	-141.33	419.96	251.98	167.98
D	15	7.5	7.5	-104.99	-104.99	0.00	209.98	125.99	83.99
				-282.67	-212.00	-70.67			

Frame Moments				
Frame	A	B	C	D
M _o (ft-Kip)	807.62	403.81	807.62	403.81
Positive & Negative Moments	-565.33	-104.99	-565.33	-104.99
	419.96	209.98	419.96	209.98
	-565.33	-282.67	-565.33	-282.67

Torsional Constant	
* Use .5 of I ₁ or I ₂ (Whichever is greater)	
c (in ⁴)	99325

Table A.5a	
ρ	f'c (4000psi)
0.001	59
0.0015	89
0.002	118
0.0025	147
0.003	175
0.0035	204
0.004	232
0.0065	368
0.007	394

For Frame A Design Reinforcement For CS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-424.00	251.98	
2	b (in)	154.00	154.00	
3	d (in)	11.50	11.50	
4	M _n = M _u /0.9 (ft-Kip)	-471.11	279.97	
5	R = M _n /bd ²	277.58	164.96	
6	ρ [Table A.5a]	0.00	0.00	
7	A _{st} = ρ bd (in ²)	8.43	4.96	
8	A _{st,min} = 0.002bt	3.70	3.70	
9	N = #7 or #8 (Greater)/A _{bar}	10.67	6.28	
10	N _{min} = width _{strip} /2t	7.50	7.50	

For Frame A Design Reinforcement For MS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-141.33	167.98	
2	b (in)	154.00	154.00	
3	d (in)	9.50	9.50	
4	M _n = M _u /0.9 (ft-Kip)	-157.04	186.65	
5	R = M _n /bd ²	135.59	161.15	
6	ρ [Table A.5a]	0.00	0.00	
7	A _{st} = ρbd (in ²)	3.37	4.03	
8	A _{st,min} = 0.002bt	3.70	3.70	
9	N = #7 or #8 (Greater)/A _{bar}	4.27	5.10	
10	N _{min} = width _{strip} /2t	7.50	7.50	

For Frame B Design Reinforcement For CS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-104.99	125.99	-212.00
2	b (in)	154.00	154.00	154.00
3	d (in)	9.50	9.50	9.50
4	M _n = M _u /0.9 (ft-Kip)	-116.66	139.99	-235.56
5	R = M _n /bd ²	100.72	120.87	203.38
6	ρ [Table A.5a]	0.00	0.00	0.00
7	A _{st} = ρbd (in ²)	2.49	3.00	5.10
8	A _{st,min} = 0.002bt	3.70	3.70	3.70
9	N = #7 or #8 (Greater)/A _{bar}	4.68	4.68	4.68
10	N _{min} = width _{strip} /2t	3.75	3.75	3.75

For Frame B Design Reinforcement For MS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	0.00	83.99	-70.67
2	b (in)	154.00	154.00	154.00
3	d (in)	9.50	9.50	9.50
4	M _n = M _u /0.9 (ft-Kip)	0.00	93.32	-78.52
5	R = M _n /bd ²	0.00	80.58	67.79
6	ρ [Table A.5a]	0.00	0.00	0.00
7	A _{st} = ρbd (in ²)	0.00	1.99	1.68
8	A _{st,min} = 0.002bt	3.70	3.70	3.70
9	N = #7 or #8 (Greater)/A _{bar}	4.68	4.68	4.68
10	N _{min} = width _{strip} /2t	3.75	3.75	3.75

For Frame C Design Reinforcement For CS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-424.00	251.98	
2	b (in)	154.00	154.00	
3	d (in)	9.50	9.50	
4	M _n = M _u /0.9 (ft-Kip)	-471.11	279.97	
5	R = M _n /bd ²	406.76	241.73	
6	ρ [Table A.5a]	0.01	0.00	
7	A _{st} = ρbd (in ²)	10.60	6.11	
8	A _{st,min} = 0.002bt	3.70	3.70	
9	N = #7 or #8 (Greater)/A _{bar}	13.42	7.73	
10	N _{min} = width _{strip} /2t	7.50	7.50	

For Frame C Design Reinforcement For MS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-141.33	167.98	
2	b (in)	154.00	154.00	
3	d (in)	9.50	9.50	
4	M _n = M _u /0.9 (ft-Kip)	-157.04	186.65	
5	R = M _n /bd ²	135.59	161.15	
6	ρ [Table A.5a]	0.00	0.00	
7	A _{st} = ρbd (in ²)	3.37	4.03	
8	A _{st,min} = 0.002bt	3.70	3.70	
9	N = #7 or #8 (Greater)/A _{bar}	4.68	4.68	
10	N _{min} = width _{strip} /2t	7.50	7.50	

For Frame D Design Reinforcement For CS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-104.99	125.99	-212.00
2	b (in)	154.00	154.00	154.00
3	d (in)	9.50	9.50	9.50
4	M _n = M _u /0.9 (ft-Kip)	-116.66	139.99	-235.56
5	R = M _n /bd ²	100.72	120.87	203.38
6	ρ [Table A.5a]	0.00	0.00	0.00
7	A _{st} = ρbd (in ²)	2.49	3.00	5.10
8	A _{st,min} = 0.002bt	3.70	3.70	3.70
9	N = #7 or #8 (Greater)/A _{bar}	4.68	4.68	4.68
10	N _{min} = width _{strip} /2t	3.75	3.75	3.75

For Frame D Design Reinforcement For MS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	0.00	83.99	-70.67
2	b (in)	154.00	154.00	154.00
3	d (in)	9.50	9.50	9.50
4	M _n = M _u /0.9 (ft-Kip)	0.00	93.32	-78.52
5	R = M _n /bd ²	0.00	80.58	67.79
6	ρ [Table A.5a]	0.00	0.00	0.00
7	A _{st} = ρbd (in ²)	0.00	1.99	1.68
8	A _{st,min} = 0.002bt	3.70	3.70	3.70
9	N = #7 or #8 (Greater)/A _{bar}	4.68	4.68	4.68
10	N _{min} = width _{strip} /2t	3.75	3.75	3.75