SKYLINE DRIVE
ACTON, MA

SIDEWALK
DESIGN CALCULATIONS

COMMONWEALTH OF MASSACHUSETTS
THOMAS J. QUINLAN JR.
STRUCTURAL
No. 31223
REGISTERED PROFESSIONAL ENGINEER

6/3/14

Prepared For:
Coughlin Environmental Services, LLC
62 Montvale Avenue, Suite #1
Stoneham, MA 02180

Prepared By:

BMC ENGINEERING LLC
50-S Audubon Road
Wakefield, MA 01880
978-774-1884

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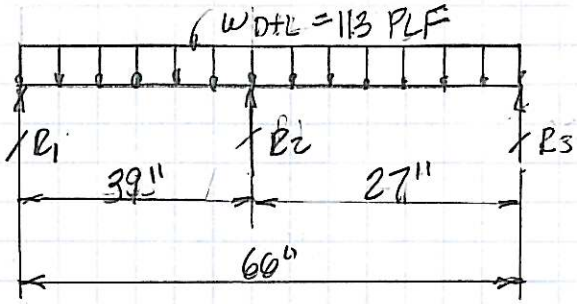
BMC ENGINEERING LLC	CLIENT	COUGHLIN ENVIRONMENTAL SERVICES	CALC BY	TJQ	JOB NO.	19-997
	PROJECT	SKYLINE DRIVE	CHECK BY		SHT NO.	1
	DETAIL	SIDEWALK DESIGN	REV. BY		DATE	

CASE I - DURING CONSTRUCTION (SHORED - UFS DECK CARRIES LOAD)



DL DECK+CONC = 63 PSF
LL DECK = 50 PSF
113 PSF

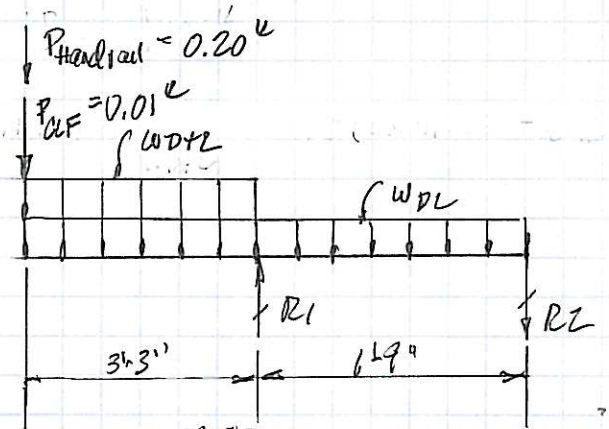
UFS DECK (9/16 x 22ga)

TOTAL SLAB DEPTH = 5½"

UNIFORM TOTAL LOAD CAPACITY = 182 PSF > 113 PSF OK

R_1 = 150 #/FT
R_2 = 400 #/FT
R_3 = 70 #/FT
$f_{bx} = M_x/S_x = 1.49^{\text{"-k}}/0.079 = 17.8$ ksi < 36 ksi OK

CASE II - AFTER CONSTRUCTION (UNSHORED - CONC DECK CARRIES LOAD)



DL DECK+CONC = 63 psf
LL DECK = 85 psf
P_{DECK} = .21 k

d_{slab} $[(5.5 - 9/16)] - (1\frac{1}{2} + 0.25) = 3.18"$ (4.93, 1.75)

$-M = 19.6^{\text{"-k}} = 1.63^{\text{'k}}$

Impact handrail

by WSD $A_{s\,reqd} = M/ad = 1.46/1.76 \times 3.18 = 0.26\ in^2/ft / 1.33 = 0.20\ in^2/ft$

$d_{reqd} = \sqrt{M/.295} = 2.35"$ $d_{act} = 3.18"$ OK

$R_1 = 1410$ #/ft

$R_2 = -580$ #/ft

$I_{eff} \simeq 0.5\, I_g = (0.5(12 \times 4.93^3/12) = 60\ in^4$

BMC ENGINEERING	Project: SKYLINE DRIVE	Engineer: Date: 02-Jun-14	Project # 14-997
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CASE I
SHORED CONSTRUCTION

Modulus of elasticity, E

Beam:	3600	ksi
Columns:	3600	ksi

Beam end restraints

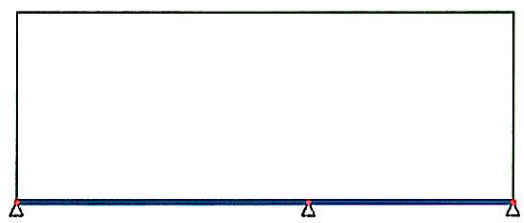
Left End	Right End
Support	Support

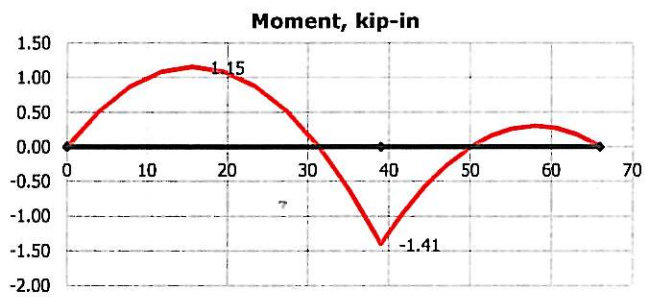
Sway frame: ☐

Span №	1	2
Length, in	39	27
Moment of Inertia, in⁴	0.025	0.025

Support №	1	2	3
Support coordinate, in	0	39	66
Vertical spring constant, kip/in			
Support type or hinge	Roller	Roller	Roller
Column under Length, in			
Moment of Inertia, in⁴			
Column above Length, in			
Moment of Inertia, in⁴			
Induced support displacements, in			

Positive loads: ↑ ↺	Load case:	DL + LL			
Comment	Load Type	WA kip or kip/in	WB kip/in	LA in	LB in
	Linear	-0.0094	-0.0094	0	66





Type of Analysis: Static Loads

Notes:

BMC ENGINEERING	Project: SKYLINE DRIVE	Engineer: Date: 02-Jun-14	Project # 14-997
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LOAD CASE: DL + LL

	ANALYSIS RESULTS			
X, in	Shear, kip	Moment, kip-in	Deflections, in	Rotations, rad
0	0.15	0.00	0.000	-0.15657
1E-06	0.15	0.00	0.000	-0.15657
3.9	0.11	0.50	-0.595	-0.14516
7.8	0.07	0.86	-1.108	-0.11506
11.7	0.04	1.08	-1.477	-0.07248
15.6	0.00	1.15	-1.665	-0.02359
19.5	-0.04	1.08	-1.661	0.02539
23.4	-0.07	0.87	-1.475	0.06829
27.3	-0.11	0.52	-1.144	0.09889
31.2	-0.15	0.02	-0.728	0.11100
35.1	-0.18	-0.62	-0.310	0.09843
39	-0.22	-1.41	0.000	0.05499
39	-0.22	-1.41	0.000	0.05499
39	0.18	-1.41	0.000	0.05499
41.7	0.15	-0.96	0.098	0.01970
44.4	0.13	-0.58	0.118	-0.00314
47.1	0.10	-0.27	0.090	-0.01560
49.8	0.08	-0.02	0.041	-0.01973
52.5	0.05	0.15	-0.011	-0.01758
55.2	0.03	0.26	-0.050	-0.01121
57.9	0.00	0.30	-0.069	-0.00268
60.6	-0.02	0.27	-0.065	0.00596
63.3	-0.05	0.17	-0.039	0.01265
66	-0.07	0.00	0.000	0.01533
66	-0.07	0.00	0.000	0.01533

Horizontal sway displacements = 0 in

	Max	Min	Area	Area(+)	Area(-)
Shear	0.18	-0.22	0.00	2.86	-2.86
Moment	1.15	-1.41	14.85	26.78	-11.92
Deflections	0.118	-1.665	-39.330	0.924	-40.254
Rotations	0.11100	-0.15657	-0.01031	1.84339	-1.85370
Reactions	0.40	0.07			

Coordinate	Reaction	Displ.
X, in	R, kip	Δ, in
0	0.15	0.000
39	0.40	0.000
66	0.07	0.000

ΣR = 0.6204 kip

BMC ENGINEERING	Project: SKYLINE DRIVE	Engineer: Date: 2-Jun	Project # 14-997
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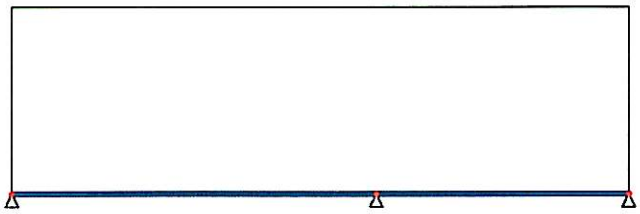
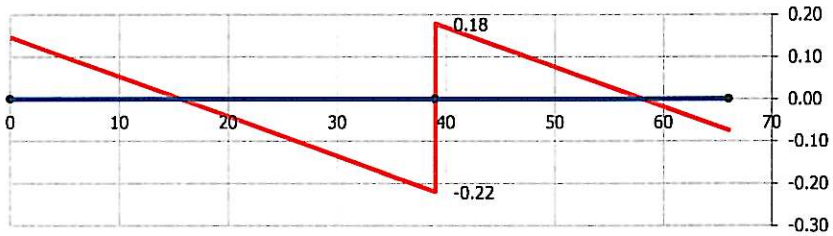
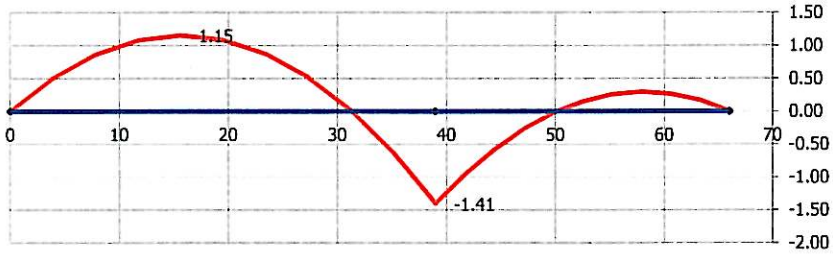
FORCE/DISPLACEMENTS DIAGRAMS DUE TO STATIC LOAD CASE: DL + LL

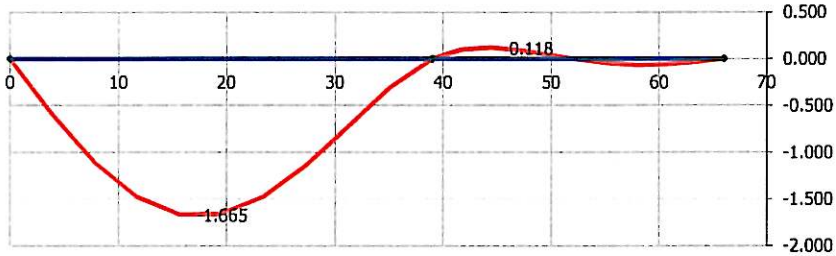




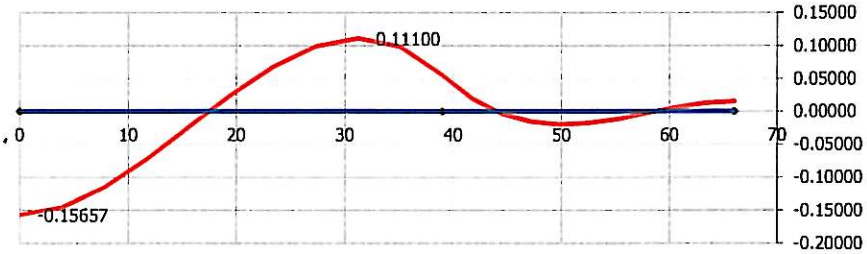
Shear, kip	
Max =	0.18
Min =	-0.22



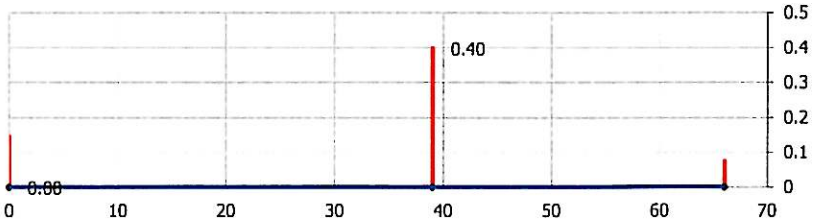
*Moment, kip*in*	
Max =	1.15
Min =	-1.41



Deflections, in	
Max =	0.118
Min =	-1.665



Rotations, rad	
Max =	0.11100
Min =	-0.15657



Reactions, kip	
Max =	0.40
Min =	0.00
ΣR =	0.6204

BMC ENGINEERING	Project: SKYLINE DRIVE	Engineer: Date: 02-Jun-14	Project # 14-997
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CASE II
UNSHORED DECK

Modulus of elasticity, E

Beam:	3600	ksi
Columns:	3600	ksi

Beam end restraints

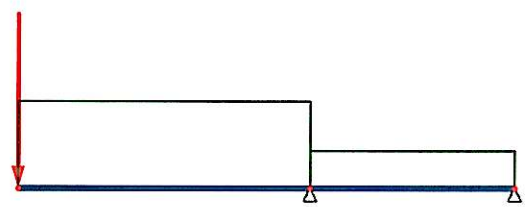
Left End	Right End
Free	Support

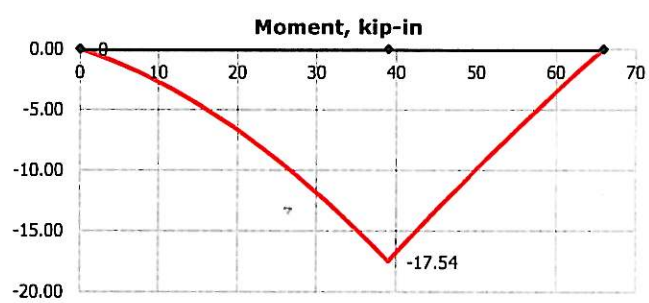
Sway frame: ☐

Span №	1	2
Length, in	39	27
Moment of Inertia, in⁴	60	60

Support №	1	2	3
Support coordinate, in	0	39	66
Vertical spring constant, kip/in			
Support type or hinge		Roller	Roller
Column under Length, in			
Moment of Inertia, in⁴			
Column above Length, in			
Moment of Inertia, in⁴			
Induced support displacements, in			

Positive loads: ↑ ↺	Load case:	DL + LL			
Comment	Load Type	WA kip or kip/in	WB kip/in	LA in	LB in
	Linear	-0.0053	-0.0053	39	66
	Linear	-0.0123	-0.0123	0	39
	P	-0.21		0	





Type of Analysis: Static Loads

Notes:

BMC ENGINEERING	Project: SKYLINE DRIVE	Engineer: Date: 02-Jun-14	Project # 14-997
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LOAD CASE: DL + LL

	ANALYSIS RESULTS			
X, in	Shear, kip	Moment, kip-in	Deflections, in	Rotations, rad
0	-0.21	0.00	-0.063	0.00201
1E-06	-0.21	0.00	-0.063	0.00201
3.9	-0.26	-0.91	-0.056	0.00201
7.8	-0.31	-2.01	-0.048	0.00198
11.7	-0.35	-3.30	-0.040	0.00193
15.6	-0.40	-4.77	-0.033	0.00186
19.5	-0.45	-6.43	-0.026	0.00176
23.4	-0.50	-8.28	-0.019	0.00163
27.3	-0.55	-10.32	-0.013	0.00146
31.2	-0.59	-12.54	-0.008	0.00125
35.1	-0.64	-14.95	-0.003	0.00100
39	-0.69	-17.54	0.000	0.00071
39	-0.69	-17.54	0.000	0.00071
39	0.72	-17.54	0.000	0.00071
41.7	0.71	-15.62	0.002	0.00050
44.4	0.69	-13.73	0.003	0.00032
47.1	0.68	-11.88	0.003	0.00016
49.8	0.66	-10.06	0.004	0.00002
52.5	0.65	-8.29	0.004	-0.00009
55.2	0.64	-6.55	0.003	-0.00018
57.9	0.62	-4.86	0.003	-0.00026
60.6	0.61	-3.20	0.002	-0.00031
63.3	0.59	-1.58	0.001	-0.00034
66	0.58	0.00	0.000	-0.00035
66	0.58	0.00	0.000	-0.00035

Horizontal sway displacements = 0 in

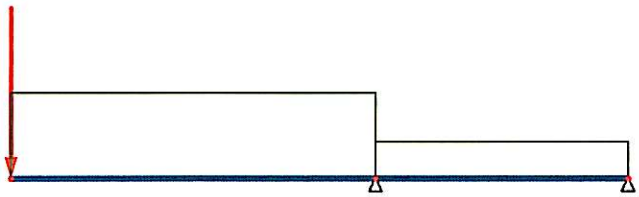
	Max	Min	Area	Area(+)	Area(-)
Shear	0.72	-0.69	0.00	17.54	-17.54
Moment	0.00	-17.54	-510.16	0.00	-510.16
Deflections	0.004	-0.063	-1.017	0.063	-1.080
Rotations	0.00201	-0.00035	0.06336	0.06697	-0.00361
Reactions	1.41	-0.58			

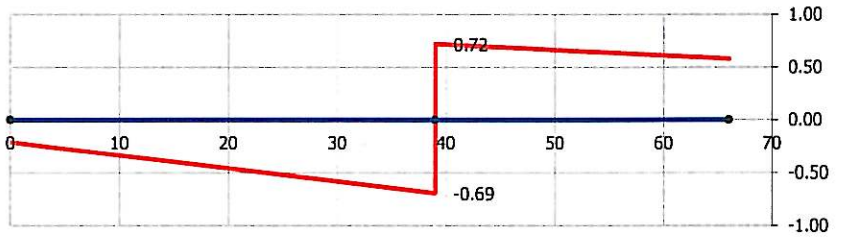
Coordinate	Reaction	Displ.
X, in	R, kip	Δ, in
0	0.00	-0.063
39	1.41	0.000
66	-0.58	0.000

ΣR = 0.8328 kip

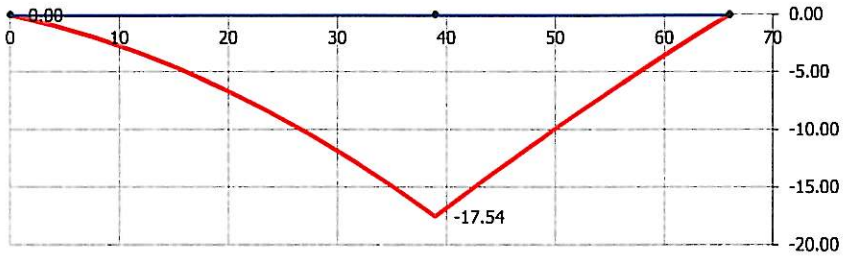
BMC ENGINEERING	Project: SKYLINE DRIVE	Engineer: Date: 2-Jun	Project # 14-997
GoBeam Version 2014.1	Subject: CASE II - UNSHORED CONST	Checker: Date:	Page: 7

FORCE/DISPLACEMENTS DIAGRAMS DUE TO STATIC LOAD CASE: DL + LL

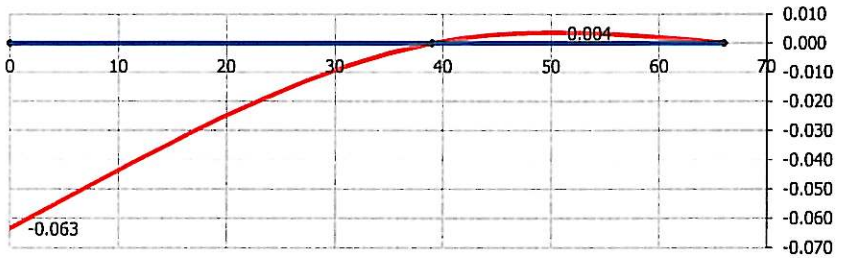




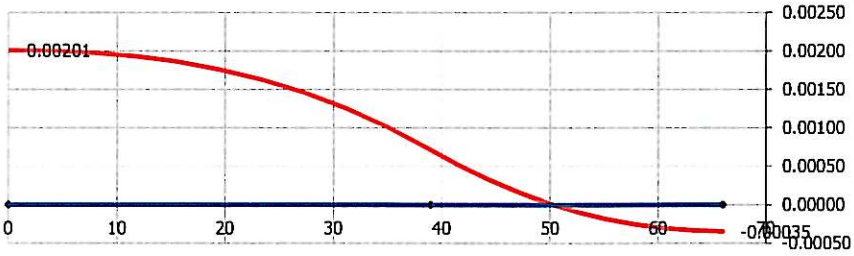
Shear, kip	
Max =	0.72
Min =	-0.69



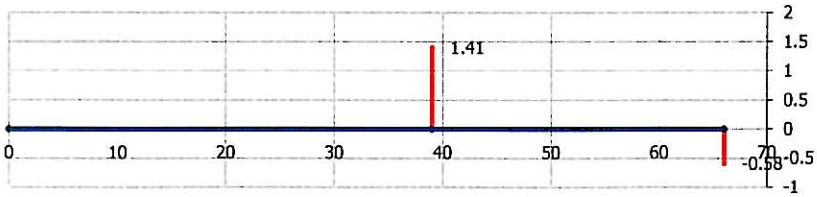
*Moment, kip*in*	
Max =	0.00
Min =	-17.54



Deflections, in	
Max =	0.004
Min =	-0.063

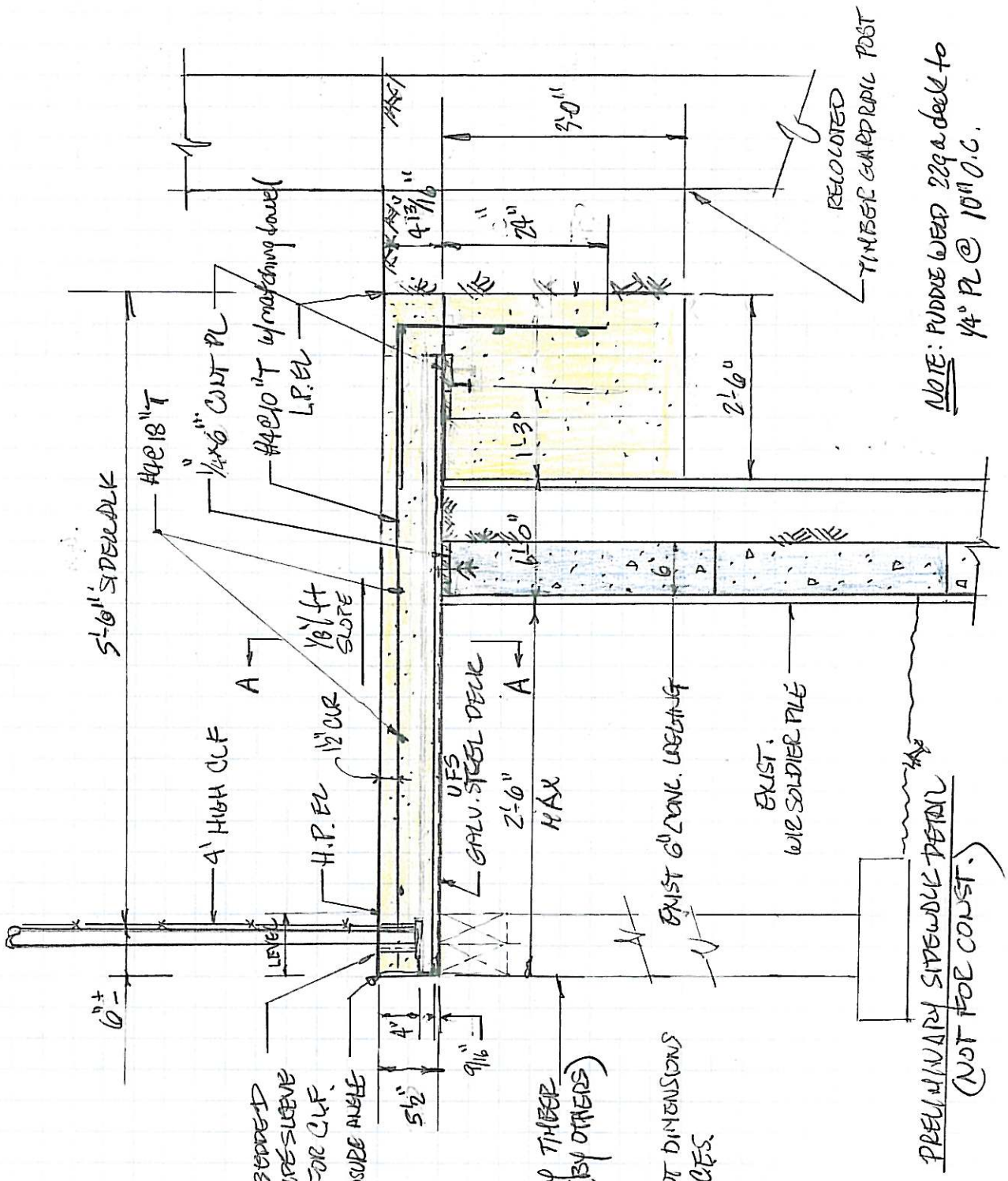


Rotations, rad	
Max =	0.00201
Min =	-0.00035



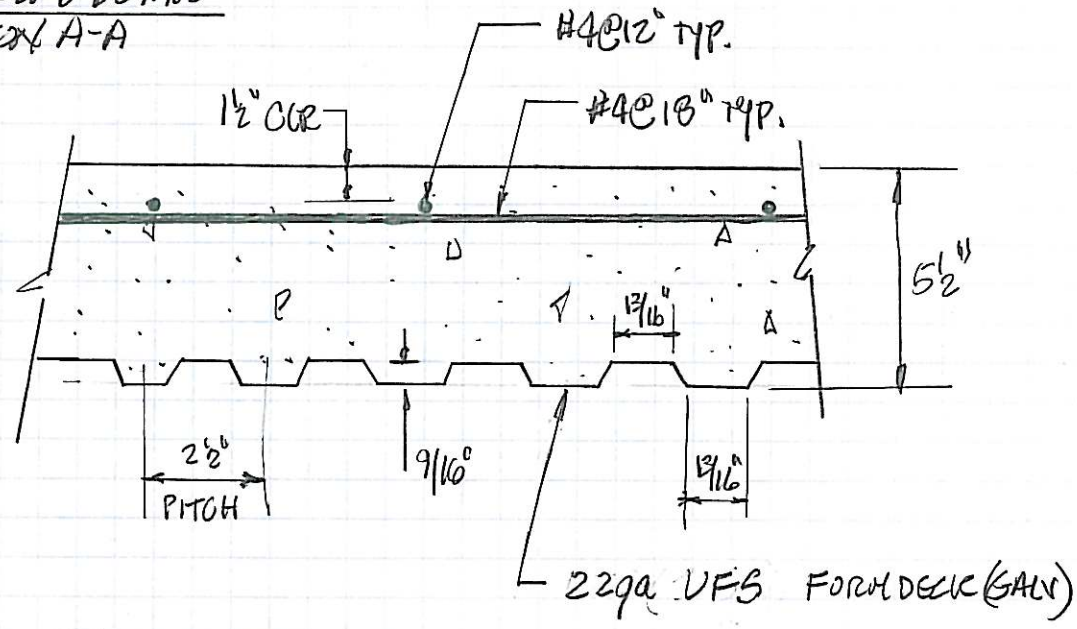
Reactions, kip	
Max =	1.41
Min =	-0.58
ΣR =	0.8328

BMC ENGINEERING LLC	CLIENT	C.E.S. LLC	CALC BY	DJZ	JOB NO.	14-997
	PROJECT	SKYLINE DRIVE ACTON, MA	CHECK BY		SHT NO.	8
	DETAIL	SKYLINE DRIVE SIDEWALK	REV. BY		DATE	

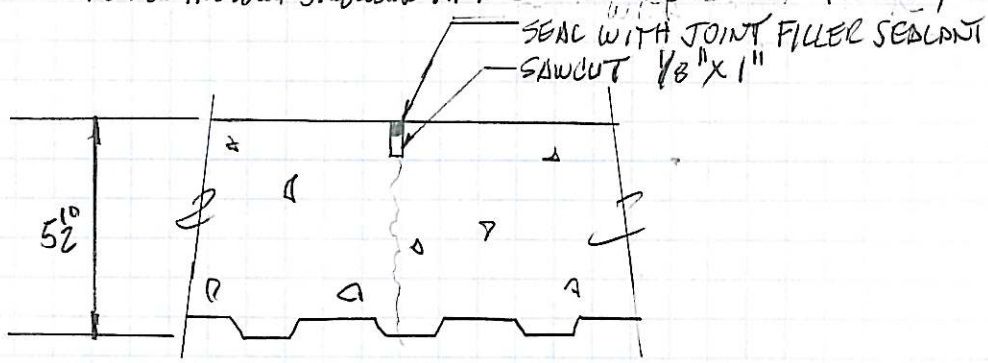


BMC ENGINEERING LLC	CLIENT	COUGHLIN ENVIRON. SERVICES	CALC BY	TJP	JOB NO.	14-997
	PROJECT	SILK LINE DRIVE	CHECK BY		SHT NO.	9
	DETAIL	SLAB DETAILS	REV. BY		DATE	

SIDEWALK SLAB DETAIL
SECTION A-A



NOTES: 1. $f_c' = 4000$ psi
2. $f_y = 60{,}000$ psi (A615 Grade 60)
3. Formdeck to be UFS 22ga or approved equal.
4. Galvanizing shall conform to ASTM A653 coating class G90
5. Temporary deck support by others. Do not remove shoring until concrete has attained 28 day compressive strength.
Do not liveload sidewalk until concrete has developed 28 day comp strength.



SIDEWALK CONTROL JOINT DETAIL
AT INTERVALS ≤ 25' O.C.

BMC ENGINEERING LLC	CLIENT	CES LLC	CALC BY	RJ	JOB NO.	14-997
	PROJECT	SKYLINE DRIVE ACTON MA	CHECK BY		SHT NO.	10
	DETAIL	SKYLINE DRIVE HAUNCH	REV. BY		DATE	

DEAD WEIGHT OF CONCRETE REQUIRED AT BACK OF BELL

ASSUME REQD FS = 2.0 AGAINST OT.

DL REQD = 580# × 2.0 = 1160#

TRY 18" WIDE × 24" CONCRETE

DL = 1.5 × 2.0 × 150 = 450# NG.

DL = 2.0 × 4.0 × 150 = 1200# OK 24" wide trench

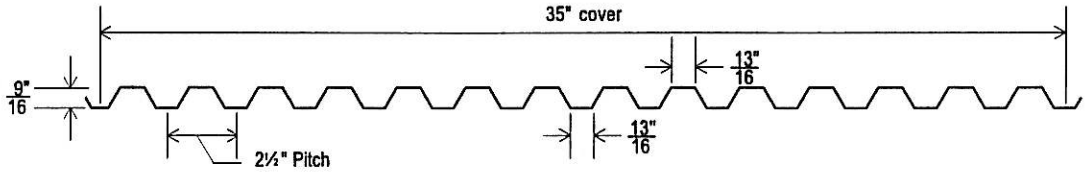
or DL = 2.5 × 3.5 × 150 = 1312# OK 30" wide trench

APPENDIX

A1/2

SECTION PROPERTIES						ASD			LRFD		
Metal Thickness Gage	Inches	Wt. (psf)	I_p (in.^{4})	S_p (in.^{3})	S_n (in.3)	V (lbs)	R_1 (lbs)	R_2 (lbs)	ϕV (lbs)	ϕR_1 (lbs)	ϕR_2 (lbs)
28	0.0149	1.00	0.012	0.036	0.037	1634	413	432	1944	643	643
26	0.0179	1.00	0.015	0.046	0.047	1956	547	797	2327	826	1104
24	0.0239	1.00	0.020	0.065	0.064	2595	864	1670	3087	1238	2323
22	0.0295	1.50	0.025	0.080	0.079	3224	1248	2803	3787	1690	3773

UFS



approx. scale: 1½" = 1'0"

UNIFORM TOTAL LOAD / Load that Produces l/180 Deflection, psf

	Gage	Span Condition	Span 2'0"	2'6"	3'0"	3'6"	4'0"	4'6"	5'0"	5'6"	6'0"
ASD	28	Single	216/131	138/67	96/39	71/25	54/16	43/12	35/8	29/6	24/5
		Double	219/316	141/162	98/94	72/59	55/40	44/28	35/20	29/15	25/12
		Triple	272/247	175/127	122/73	90/46	69/31	55/22	44/16	37/12	31/9
	26	Single	276/164	177/84	123/49	90/31	69/21	55/14	44/11	36/8	31/6
		Double	278/395	179/202	124/117	92/74	70/49	56/35	45/25	37/19	31/15
		Triple	345/309	222/158	155/92	114/58	88/39	69/27	56/20	46/15	39/11
	24	Single	390/219	250/112	173/65	127/41	98/27	77/19	62/14	52/11	43/8
		Double	378/527	243/270	169/156	125/98	96/66	76/46	61/34	51/25	43/20
		Triple	469/412	302/211	211/122	155/77	119/52	94/36	76/26	63/20	53/15
	22	Single	480/274	307/140	213/81	157/51	120/34	95/24	77/18	63/13	53/10
		Double	466/659	300/337	209/195	154/123	118/82	93/58	76/42	63/32	53/24
		Triple	579/515	373/264	261/153	192/96	147/64	116/45	94/33	78/25	66/19
LRFD	28	Single	342/131	219/67	152/39	112/25	85/16	68/12	55/8	45/6	38/5
		Double	257/316	206/162	154/94	114/59	87/40	69/28	56/20	46/15	39/12
		Triple	292/247	234/127	192/73	142/46	109/31	86/22	70/16	58/12	49/9
	26	Single	437/164	280/84	194/49	143/31	109/21	86/14	70/11	58/8	49/6
		Double	434/395	281/202	196/117	144/74	111/49	88/35	71/25	59/19	49/15
		Triple	502/309	348/158	244/92	180/58	138/39	109/27	89/20	73/15	62/11
	24	Single	617/219	395/112	274/65	202/41	154/27	122/19	99/14	82/11	69/8
		Double	590/527	382/270	267/156	197/98	151/66	119/46	97/34	80/25	67/20
		Triple	729/412	473/211	331/122	245/77	188/52	149/36	121/26	100/20	84/15
	22	Single	760/274	486/140	338/81	248/51	190/34	150/24	122/18	100/13	84/10
		Double	728/659	471/337	329/195	243/123	186/82	147/58	119/42	99/32	83/24
		Triple	899/515	584/264	409/153	302/96	232/64	184/45	149/33	123/25	104/19

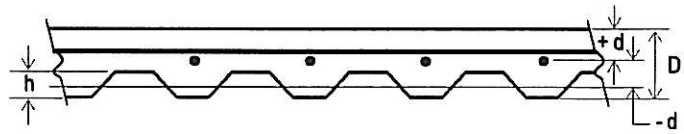
NOTES:
Vented deck with 1.5% open area is available for use with insulating fills. Insulating fill manufacturers have determined load capacities of various combinations of fill and deck both with and without foamed plastic insulation boards. Refer to the fill manufacturer's literature for loading limitations.
R_1 is the bearing capacity at an exterior condition. R_2 is the bearing capacity at an interior condition.

A2/2

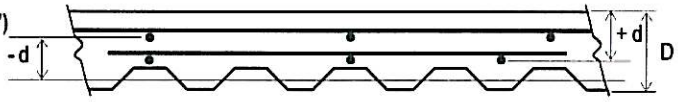
profile considerations

Draped Mesh Slabs: Deck depth = h; Total Slab Depth = D; Wire diameter = w.

D = 2.5" to 3"
+ d = (D - h)/2
- d = (D - h)/2 + h/2 = D/2
TOP COVER = 0.75"



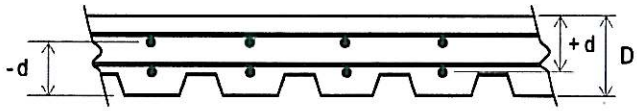
D > 3"
- d = (D - h/2 - 3w/2 - 0.75")
+ d = (D - h - w/2)
TOP COVER = 0.75"



(Mesh is draped, not layered.)

UFS, UF1X and UFX-36 have a b width of 12" for both positive and negative bending. For D < 3" place the mesh in the center of the concrete that is above the ribs. For D > 3", mesh is draped, not layered.

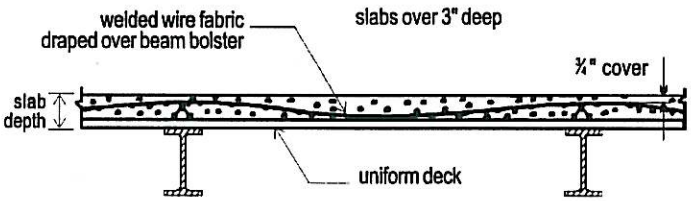
- d = (D - 0.75 - 3w/2)
+ d = (D - h - w/2)
TOP COVER = 0.75"



(Mesh is draped, not layered.)

Inverted B and UF2X have a b width of 12" for positive bending. For negative bending the b width for Inverted B deck is 7.5"; for UF2X the negative bending b width is 6". For D > 3" mesh is draped, not layered.

DRAPED MESH



FORM DECKS weights and volumes

Total Slab Depth		UFS C_v = .0234	UF1X C_v = .0417	UFX C_v = .0547	INV. B C_v = .0781	UF2X C_v = .0833
2.5"	Wt	27				
	Vol.	0.185				
3.0"	Wt	33	30	28		
	Vol.	0.226	0.208	0.195		
3.5"	Wt	39	36	34	36	
	Vol.	0.268	0.250	0.237	0.245	
4.0"	Wt	45	42	40	41	36
	Vol.	0.310	0.292	0.279	0.286	0.250
4.5"	Wt	51	48	46	48	42
	Vol.	0.352	0.333	0.320	0.328	0.292
5.0"	Wt	57	54	52	54	48
	Vol.	0.393	0.375	0.362	0.370	0.333
5.5"	Wt	63	60	59	60	54
	Vol.	0.435	0.417	0.404	0.411	0.375
6.0"	Wt	69	66	65	66	60
	Vol.	0.476	0.458	0.445	0.453	0.417
6.5"	Wt	75	73	71	72	67
	Vol.	0.518	0.500	0.487	0.495	0.459
7.0"	Wt	81	79	77	78	73
	Vol.	0.560	0.542	0.528	0.536	0.500

The weights are shown in pounds per square foot and are based on 145 pcf concrete. Volumes are in ft.^{3} per ft.^{2}. C_v is the volume of concrete required to fill the ribs. Multiply the volume shown in the table by 144 to find the gross area of concrete in in^2/ft.