Ce 479 Fall 06

Steel Deck and Concrete Slab Composite Construction

Types of Floor Deck on Steel Joists/Girders

- Cast in Place Concrete on Steel Deck
  - Composite Construction - Pages 42-49
    - SDI Specs and Commentary- Pages 50-59

Composite Steel Floor Decks

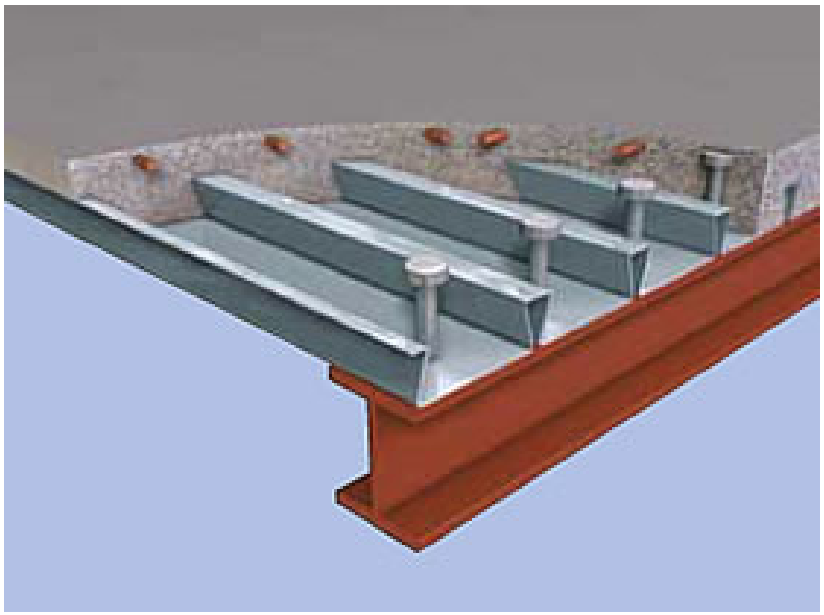
- A composite form deck serves a dual function. It must safely support self weight, the weight of the wet concrete, and construction activity (rarely shored). After the concrete has reached the desired strength, it is engaged with the steel deck so that they form a composite section to resist the loads applied to the concrete slab.

- Composite action is achieved by:
  - Welding cross wires to the top of the steel deck
  - Shape (EPIC System)
  - Deformations on the interior surface of the deck (United Steel Deck, Vulcraft and others)

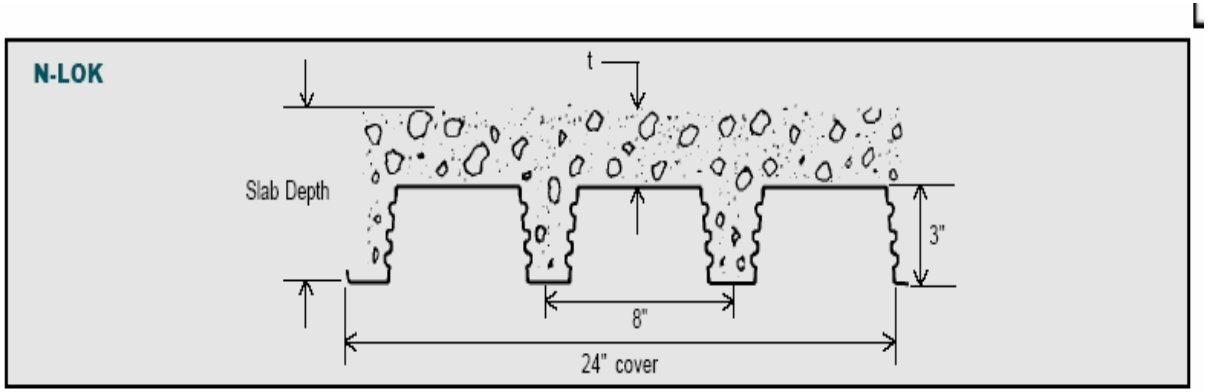
- Steel form deck for composite floors must be of the permanent type (painted and galvanized). It provides the positive moment reinforcement in this type of construction.

Composite Steel Deck

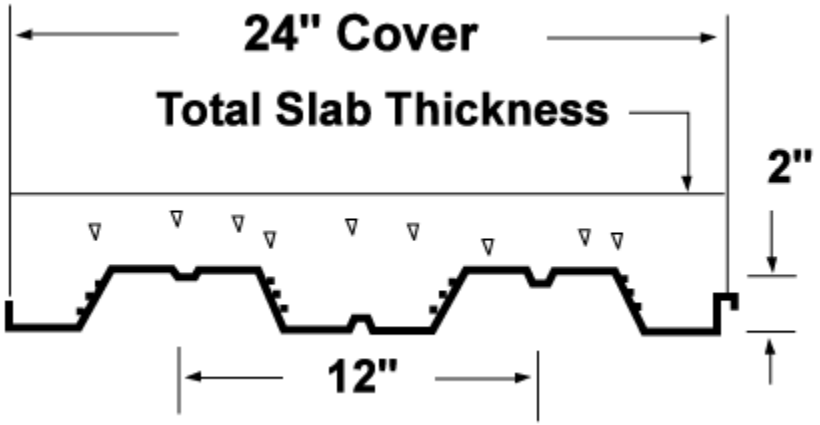
- Epic Shape



Composite Steel Deck Deformations



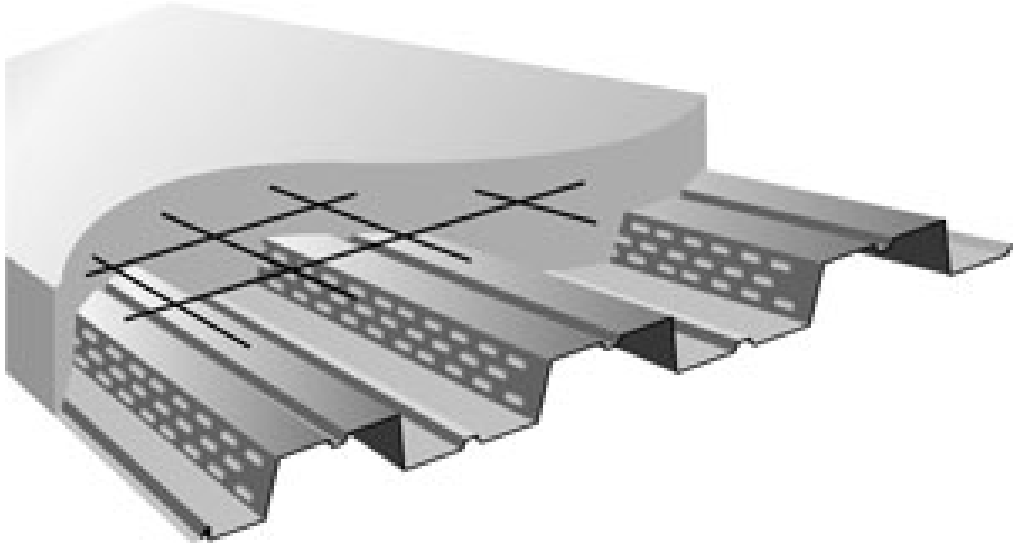
United Steel



James River Steel

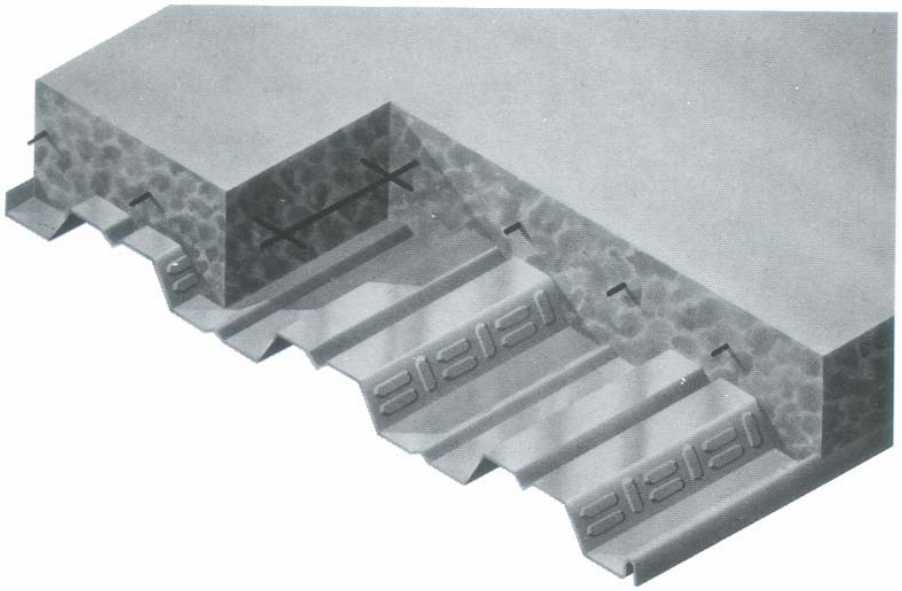
Composite Steel Deck Deformations

- CANAM STEEL



Composite Steel Deck Deformations

- Vulcraft



Design Criteria for Steel Deck

- Design: SDI Specs and Commentary- Pages 50-56
  - Material Properties:
    - Steel deck yield strength of at least 33 ksi and it must be permanent (for the life of the structure).
    - Concrete: in accordance with ACI 318 and at least 3000 psi.

Design Criteria for Composite Steel Deck- same as non-composite

- **Allowable stress**

3.2 Deck used as a form for structural (reinforced) concrete slab:

3.2a Stress shall not exceed 0.60 times the yield strength, nor exceed 36 ksi (250 MPa) under the combined loads of wet concrete, deck, and the following construction live loads: 20 pounds per square foot (1kPa) uniform load or 150 pound concentrated load on a 1′-0″ wide section of deck (2.2 kN per m). **See Figure 1.**

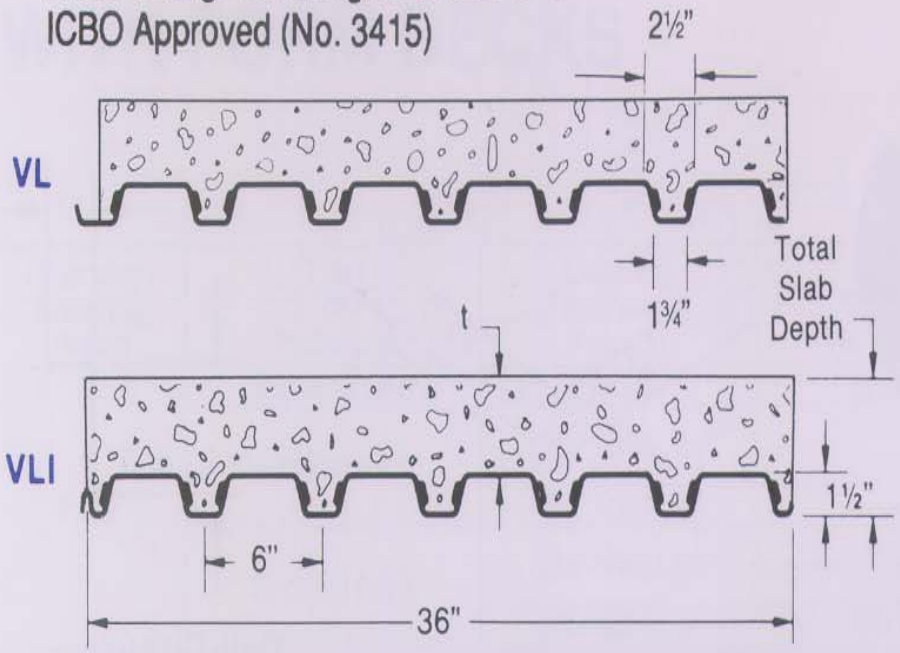
- **Calculated theoretical deflection** shall be based on the load of the concrete as determined by the design slab thickness and the load from the steel deck, uniformly applied on all the spans and shall be limited to L/180 or ¾ inch, whichever is smaller. **See Figure 2 (page 56).**

Composite Form Decks

VULCRAFT

1.5 VL,VLI

Maximum Sheet Length 42'-0
Extra Charge for Lengths Under 6'-0
ICBO Approved (No. 3415)



STEEL SECTION PROPERTIES Fy= 40 KSI

Deck Type	Design Thick.	Weight PSF	Ip in^4/Ft	In in^4/Ft	Sp in^3/Ft	Sn in^3/Ft
1.5VL22	0.0295	1.78	0.150	0.182	0.178	0.186
1.5VL21	0.0329	1.97	0.174	0.205	0.209	0.215
1.5VL20	0.0358	2.14	0.195	0.222	0.231	0.240
1.5VL19	0.0418	2.49	0.239	0.260	0.274	0.288
1.5VL18	0.0474	2.82	0.282	0.295	0.315	0.327
1.5VL17	0.0538	3.19	0.331	0.335	0.361	0.371
1.5VL16	0.0598	3.54	0.373	0.373	0.404	0.411

(N=9) NORMAL WEIGHT CONCRETE (145 PCF)

Total Slab Depth	Deck Type	SDI Max. Unshored Clear Span			Superimposed Live Load, PSF Clear Span (ft.-in.)														
		1 Span	2 Span	3 Span	5'-0	5'-6	6'-0	6'-6	7'-0	7'-6	8'-0	8'-6	9'-0	9'-6	10'-0	10'-6	11'-0	11'-6	12'-0
	1.5VL22	5'-2	6'-11	7'-0	314	259	230	206	186	169	154	141	130	120	111	100	87	76	67
3 1/2"	1.5VL21	5'-9	7'-8	7'-9	331	294	243	218	197	179	163	150	138	127	118	104	91	80	70
	1.5VL20	6'-2	8'-3	8'-4	345	306	275	228	206	187	171	157	144	133	124	108	94	82	73
(t=2")	1.5VL19	6'-10	9'-2	9'-4	372	330	296	268	223	203	186	171	157	145	134	116	101	88	78
	1.5VL18	7'-6	9'-11	10'-2	395	351	315	285	260	238	199	182	168	156	142	123	107	94	82
33 PSF	1.5VL17	8'-2	10'-6	10'-10	397	353	316	286	261	239	221	183	169	157	145	131	114	99	87
	1.5VL16	8'-8	11'-0	11'-5	397	353	316	286	261	239	221	205	169	156	145	135	119	105	92
	1.5VL22	4'-11	6'-6	6'-7	342	301	267	240	216	196	179	164	151	139	129	119	111	103	96
4"	1.5VL21	5'-5	7'-3	7'-4	385	318	283	253	229	208	190	174	160	148	137	127	118	110	102
	1.5VL20	5'-10	7'-9	7'-11	400	356	295	264	239	217	198	182	167	155	143	133	124	116	108
(t=2 1/2")	1.5VL19	6'-6	8'-8	8'-10	400	383	344	311	259	235	215	197	182	168	156	145	135	126	115
	1.5VL18	7'-1	9'-5	9'-7	400	400	365	330	301	251	229	211	194	180	167	156	145	136	122
39 PSF	1.5VL17	7'-8	10'-0	10'-4	400	400	366	331	302	277	230	211	195	180	168	156	146	136	128
	1.5VL16	8'-2	10'-6	10'-10	400	400	365	330	301	276	255	211	194	180	167	155	145	136	127
	1.5VL22	4'-8	6'-3	6'-4	392	345	307	275	248	225	205	188	173	159	147	137	127	118	110
4 1/2"	1.5VL21	5'-2	6'-11	7'-0	400	364	324	290	262	238	217	199	183	169	157	145	135	126	117
	1.5VL20	5'-6	7'-5	7'-6	400	400	338	303	274	249	227	208	192	177	164	152	142	132	123
(t=3")	1.5VL19	6'-2	8'-3	8'-4	400	400	393	328	296	269	246	226	208	193	179	166	155	145	135
	1.5VL18	6'-8	8'-11	9'-2	400	400	400	378	315	287	262	241	222	206	191	178	166	155	145
45 PSF	1.5VL17	7'-3	9'-6	9'-10	400	400	400	378	345	287	263	241	223	206	191	178	166	155	146
	1.5VL16	7'-9	10'-0	10'-4	400	400	400	377	344	315	262	240	222	205	190	177	165	155	145
	1.5VL22	4'-6	6'-0	6'-1	400	391	347	311	280	254	232	213	195	180	167	155	143	133	124
5"	1.5VL21	4'-11	6'-8	6'-9	400	400	366	328	297	269	246	225	207	191	177	164	153	142	133
	1.5VL20	5'-3	7'-1	7'-2	400	400	382	343	310	281	257	236	217	200	186	172	160	150	140
(t=3 1/2")	1.5VL19	5'-10	7'-11	8'-0	400	400	400	370	335	304	278	255	235	218	202	188	175	163	153
	1.5VL18	6'-4	8'-7	8'-9	400	400	400	394	356	324	297	272	251	233	216	201	187	175	164
51 PSF	1.5VL17	6'-11	9'-1	9'-5	400	400	400	400	357	325	297	273	251	233	216	201	188	176	164
	1.5VL16	7'-4	9'-7	9'-10	400	400	400	400	388	323	295	271	250	232	215	200	187	175	164
	1.5VL22	4'-4	5'-9	5'-10	400	400	388	348	314	285	260	238	219	202	187	173	160	149	139
5 1/2"	1.5VL21	4'-9	6'-5	6'-6	400	400	400	367	332	301	275	252	232	214	198	184	171	159	148
	1.5VL20	5'-1	6'-10	6'-11	400	400	400	383	346	315	287	263	243	224	208	193	179	167	156
(t=4")	1.5VL19	5'-7	7'-7	7'-8	400	400	400	400	374	340	311	286	263	243	226	210	196	183	171
	1.5VL18	6'-1	8'-3	8'-4	400	400	400	400	399	363	332	305	281	260	241	225	210	196	183
57 PSF	1.5VL17	6'-7	8'-9	9'-0	400	400	400	400	399	363	332	305	281	260	242	225	210	196	184
	1.5VL16	7'-1	9'-2	9'-6	400	400	400	400	400	361	330	303	279	259	240	224	209	195	183
	1.5VL22	4'-2	5'-7	5'-8	400	400	400	385	347	315	288	263	242	223	207	191	178	165	154
6"	1.5VL21	4'-7	6'-2	6'-3	400	400	400	400	367	334	304	279	257	237	220	204	189	176	164
	1.5VL20	4'-10	6'-7	6'-8	400	400	400	400	383	348	318	292	269	248	230	214	199	185	173
(t=4 1/2")	1.5VL19	5'-5	7'-4	7'-5	400	400	400	400	400	377	344	316	291	270	250	233	217	202	189
	1.5VL18	5'-10	7'-11	8'-1	400	400	400	400	400	400	367	337	311	288	267	249	232	217	203
63 PSF	1.5VL17	6'-4	8'-5	8'-8	400	400	400	400	400	400	367	337	311	288	267	249	232	217	204
	1.5VL16	6'-9	8'-10	9'-2	400	400	400	400	400	399	365	335	309	286	266	248	231	216	202

Notes:
1. Minimum exterior bearing length required is 1.5 inches. Minimum interior bearing length required is 3.0 inches. If these minimum lengths are not provided, web crippling must be checked.
2. Always contact Vulcraft when using loads in excess of 200 psf. Such loads often result from concentrated, dynamic, or long term load cases for which reductions due to bond breakage, concrete creep, etc. should be evaluated.
3. All fire rated assemblies are subject to an upper live load limit of 250 psf.
4. Inquire about material availability of 17, 19 & 21 gage.

Design Criteria for Concrete Slab in Composite Steel Deck Floors

- Section 5.1 SDI (page 52 Vulcraft catalog)
  - The composite slab shall be designed as a reinforced concrete slab with the steel deck acting as the positive reinforcement. Slabs shall be designed as simple or continuous spans under uniform loads
- Section 5.2 Load determination-Testing. Based on the test information the design rational shall be established by:
  - Elastic Analysis (Allowable Stresses)
  - Strength Analysis

Allowable Stress

- Steel deck:
  - Under the combined stresses caused by the superimposed live load and the tensile stresses in the deck, the tensile stress of the deck shall not exceed $0.6f_y$ or 36 ksi. The allowable load so determined can be increased by 10% if temperature and shrinkage reinforcement conforming to Section 5.5 is provided

Allowable Stress

- Concrete:
  - The compressive stress in the concrete shall not exceed 0.45f’c
  - The minimum concrete cover above the steel deck shall be 2 inches. When additional (negative bending reinforcement) is provided, the minimum cover of concrete above the reinforcing bar shall be ¾ inch.

Additional Requirements- Composite Section

- Section 5.4 (SDI- page 54):
  - Deflection of the composite slab shall not exceed L/360 under the superimposed load

- Section 5.5 (SDI- page 54)
  - Temperature and Shrinkage reinforcement shall have a minimum area of *0.00075*(the area of concrete above the deck per foot of width)* but not less than the area provided by 6x6- W1.4 x W1.4 welded wire fabric

Slab Reinforcement

- The slabs are reinforced with welded wire mesh. It must be noted that the reinforcement shown not always meets temperature and shrinkage requirements in the ACI code. However, based on past experience of performance this deviation is allowed

MATERIAL PROPERTIES
WELDED WIRE FABRIC

Table 8.2.8 Common stock styles of welded wire fabric

Style Designation		Steel Area sq in. per ft		Approx. Weight
Old Designation (By Steel Wire Gage)	New Designation (By W-Number)	Longit.	Trans.	lb per 100 sq ft
6x6-10x10	6x6-W1.4xW1.4	.029	.029	21
4x12-8x12**	4x12-W2.1xW0.9	.062	.009	25
6x6-8x8	6x6-W2.1xW2.1	.041	.041	30
4x4-10x10	4x4-W1.4xW1.4	.043	.043	31
4x12-7x11**	4x12-W2.5xW1.1	.074	.011	31
6x6-6x6*	6x6-W2.9xW2.9	.058	.058	42
4x4-8x8	4x4-W2.1xW2.1	.062	.062	44
6x6-4x4*	6x6-W4.0xW4.0	.080	.080	58
4x4-6x6	4x4-W2.9xW2.9	.087	.087	62
6x6-2x2*	6x6-W5.5xW5.5***	.110	.110	80
4x4-4x4*	4x4-W4.0xW4.0	.120	.120	85
4x4-3x3*	4x4-W4.7xW4.7	.141	.141	102
4x4-2x2*	4x4-W5.5xW5.5***	.165	.165	119

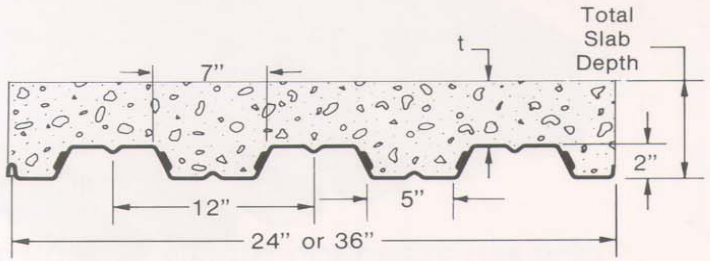
* Commonly available in 8 ft x 12 ft or 8 ft x 15 ft sheets.
** These items may be carried in sheets by various manufacturers in certain parts of the U.S. and Canada.
*** Exact W-Number size for 2 gage is 5.4.

Example- Composite Design

Design composite concrete slab on steel deck floor for 125 psf live load. The steel deck will be used on 8’-6” 3-continuous spans. Shoring will not be used. The concrete is normal weight.

2 VLI

Maximum Sheet Length 42'-0
Extra Charge for Lengths Under 6'-0
ICBO Approved (No. 3415)



STEEL SECTION PROPERTIES — Fy= 40 KSI

Deck Type	Design Thick.	Weight PSF	Ip in^4/ft	In in^4/ft	Sp in^3/ft	Sn in^3/ft
2VLI22	0.0295	1.62	0.332	0.329	0.274	0.277
2VLI21	0.0329	1.81	0.378	0.375	0.317	0.321
2VLI20	0.0358	1.97	0.418	0.415	0.355	0.360
2VLI19	0.0418	2.30	0.493	0.492	0.435	0.443
2VLI18	0.0474	2.61	0.557	0.557	0.512	0.518
2VLI17	0.0538	2.96	0.633	0.633	0.589	0.589
2VLI16	0.0598	3.29	0.704	0.704	0.653	0.653

Check

- From Table for normal weight concrete (page 46), t = 2 inches and overall depth, D = 4 inches:
  - Use a 2VLI 20 with a maximum construction span of 10’-3” and superimposed live load capacity of 130 psf for t= 2 inches. The weight of the concrete plus deck is W_1 is 39 psf
    - Check deflection of steel deck under construction loads
    - Check steel deck stress under construction loads
    - Check composite concrete slab steel deck section for superimposed live load
      - Temperature and Shrinkage steel
      - If major cracking over the supports is unacceptable design negative moment steel
      - Maximum tensile stress (formwork stress plus composite section stress) in the steel deck for the given table load of 130 psf
      - Check concrete stresses for the same superimposed load of 130 psf

(N=9) NORMAL WEIGHT CONCRETE (145 PCF)

Total Slab Depth	Deck Type	SDI Max. Unshored Clear Span			Superimposed Live Load, PSF														
					Clear Span (ft.-in.)														
		1 Span	2 Span	3 Span	5'-6	6'-0	6'-6	7'-0	7'-6	8'-0	8'-6	9'-0	9'-6	10'-0	10'-6	11'-0	11'-6	12'-0	12'-6
4" (t=2") 39 PSF	2VLI22	6'-6	8'-9	8'-10	274	239	211	164	145	129	115	104	94	85	78	71	65	59	54
	2VLI21	7'-2	9'-5	9'-8	294	255	224	200	155	138	123	111	100	91	83	76	69	64	58
	2VLI20	7'-8	9'-11	10'-3	310	269	236	210	188	146	130	117	106	96	87	80	73	67	62
	2VLI19	8'-8	11'-0	11'-4	344	298	261	231	207	186	169	130	117	106	97	88	81	74	68
	2VLI18	9'-6	11'-10	12'-3	373	324	285	253	228	206	188	172	159	122	112	103	95	87	81
	2VLI17	10'-4	12'-7	13'-0	400	351	308	273	245	221	201	184	170	157	120	111	102	94	87
	2VLI16	10'-11	13'-2	13'-5	400	376	330	292	261	235	214	195	180	166	154	118	109	100	93
4 1/2" (t=2 1/2") 45 PSF	2VLI22	6'-2	8'-4	8'-5	319	278	217	190	168	150	134	121	109	99	90	83	76	69	63
	2VLI21	6'-9	8'-11	9'-3	341	297	261	204	180	160	144	129	117	106	97	88	81	74	68
	2VLI20	7'-3	9'-5	9'-9	361	313	275	244	190	169	152	136	123	112	102	93	85	78	72
	2VLI19	8'-2	10'-5	10'-10	400	346	303	268	240	216	168	151	136	124	113	103	94	86	79
	2VLI18	9'-0	11'-3	11'-8	400	376	331	295	264	239	218	200	156	142	130	119	110	102	94
	2VLI17	9'-9	12'-0	12'-5	400	400	358	318	284	257	234	214	197	153	140	129	118	109	101
	2VLI16	10'-4	12'-7	13'-0	400	400	383	339	303	274	248	227	209	193	150	137	126	117	108
5" (t=3") 51 PSF	2VLI22	5'-11	7'-9	8'-0	364	285	247	217	192	171	153	138	125	113	103	94	86	79	72
	2VLI21	6'-5	8'-6	8'-10	389	338	266	233	206	183	164	147	133	121	110	101	92	84	78
	2VLI20	6'-11	9'-0	9'-4	400	356	313	246	217	193	173	156	141	128	116	106	97	89	82
	2VLI19	7'-9	10'-0	10'-4	400	394	345	306	273	214	192	172	156	141	128	117	107	99	91
	2VLI18	8'-7	10'-9	11'-2	400	400	377	336	301	273	249	195	178	162	148	136	126	116	107
	2VLI17	9'-3	11'-6	11'-10	400	400	400	362	324	293	266	244	192	175	160	147	135	125	116
	2VLI16	9'-10	12'-1	12'-5	400	400	400	386	346	312	283	259	238	187	171	157	144	133	123
5 1/2" (t=3 1/2") 57 PSF	2VLI22	5'-8	7'-2	7'-4	400	320	278	244	216	192	172	155	140	127	116	106	97	89	81
	2VLI21	6'-2	8'-2	8'-5	400	379	298	261	231	205	184	166	150	136	124	113	104	95	87
	2VLI20	6'-7	8'-8	8'-11	400	400	351	276	244	217	194	175	158	143	131	119	109	100	92
	2VLI19	7'-5	9'-7	9'-11	400	400	388	343	271	241	215	193	175	159	144	132	121	111	102
	2VLI18	8'-2	10'-4	10'-8	400	400	400	377	338	306	243	219	199	182	167	153	141	130	121
	2VLI17	8'-10	11'-0	11'-5	400	400	400	400	364	329	299	237	215	196	180	165	152	140	130
	2VLI16	9'-4	11'-7	12'-0	400	400	400	400	388	350	318	290	230	210	192	176	162	150	138
6" (t=4") 63 PSF	2VLI22	5'-5	6'-8	6'-10	400	355	308	270	239	213	191	172	156	141	129	118	108	99	90
	2VLI21	5'-11	7'-11	8'-1	400	381	331	290	256	228	204	184	166	151	137	126	115	105	97
	2VLI20	6'-4	8'-4	8'-7	400	400	350	306	271	241	215	194	175	159	145	132	121	111	102
	2VLI19	7'-2	9'-3	9'-7	400	400	400	381	301	267	239	215	194	176	160	146	134	123	113
	2VLI18	7'-10	10'-0	10'-4	400	400	400	400	375	299	269	243	221	202	185	170	157	145	134
	2VLI17	8'-6	10'-7	11'-0	400	400	400	400	400	364	331	263	239	218	199	183	169	156	144
	2VLI16	9'-0	11'-2	11'-6	400	400	400	400	400	388	352	322	255	233	213	195	180	166	154
6 1/2" (t=4 1/2") 69 PSF	2VLI22	5'-1	6'-2	6'-4	400	390	339	297	263	234	210	189	171	155	141	129	118	108	99
	2VLI21	5'-9	7'-6	7'-6	400	400	363	318	281	250	224	202	183	166	151	138	126	116	106
	2VLI20	6'-1	8'-1	8'-4	400	400	385	337	297	264	237	213	193	175	159	145	133	122	112
	2VLI19	6'-10	8'-11	9'-3	400	400	400	375	330	293	262	236	213	193	176	161	147	135	124
	2VLI18	7'-7	9'-8	9'-11	400	400	400	400	400	329	296	268	243	222	203	187	172	159	147
	2VLI17	8'-2	10'-3	10'-7	400	400	400	400	400	400	320	289	262	239	219	201	185	171	158
	2VLI16	8'-8	10'-9	11'-2	400	400	400	400	400	400	387	309	280	256	234	215	198	183	169

NOTES:

1. Minimum exterior bearing length required is 2.0 inches. Minimum interior bearing length required is 4.0 inches. If these minimum lengths are not provided, web crippling must be checked.
2. Always contact Vulcraft when using loads in excess of 200 psf. Such loads often result from concentrated, dynamic, or long term load cases for which reductions due to bond breakage, concrete creep, etc. should be evaluated.
3. All fire rated assemblies are subject to an upper live load limit of 250 psf.
4. Inquire about material availability of 17, 19 & 21 gage.