

METAL DECKING



ribbed & fluted

H. H. Robertson Co.

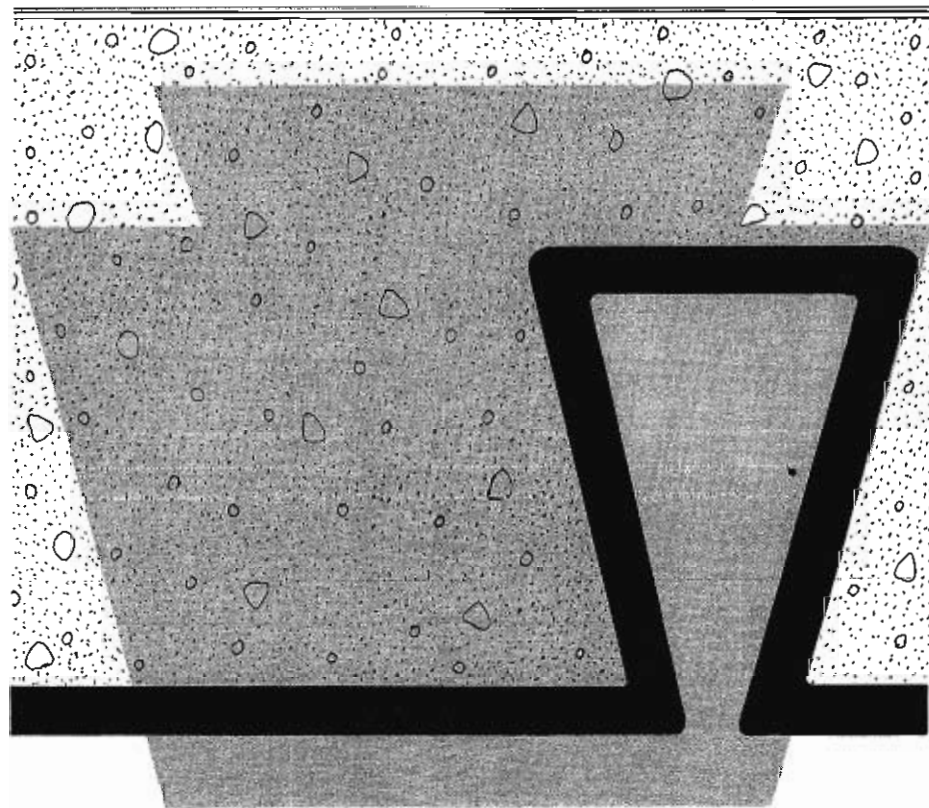
April, 1968

ROBERTSON

Section 69

KEYSTONE

COMPOSITE FLOOR AND BEAM CONSTRUCTION

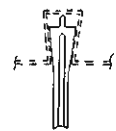
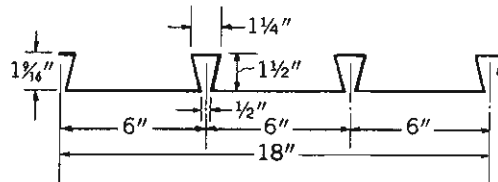
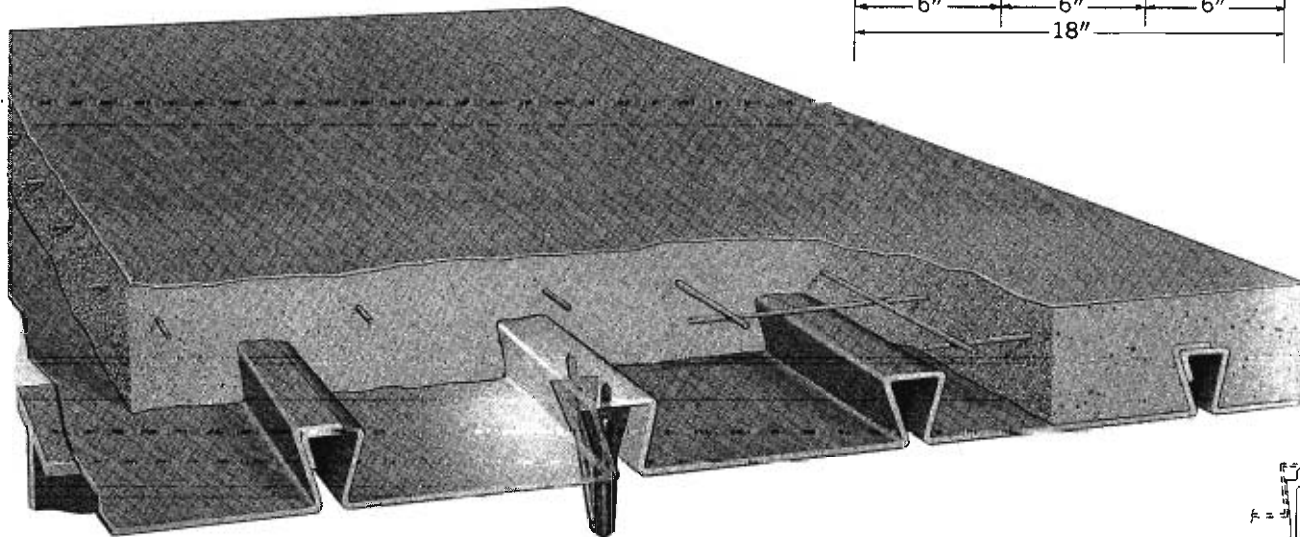


H. H. ROBERTSON COMPANY
PITTSBURGH, PENNSYLVANIA

KEYSTONE DECK

Section 69

COMPOSITE FLOOR SYSTEM



The H-6 Hanger
in place. Other hangers
are available.

The Keystone composite floor system is a combination of steel reinforcing forms and concrete, using the structural qualities of both to the fullest advantage. The bottom plate of the Keystone deck becomes positive reinforcing steel held permanently in place at the lower extremities of the slab by the triangular shaped ribs bonded into the concrete. The compressive strength of concrete is fully utilized at the top surface (compression area) of the slab.

The more efficient use of the concrete and steel results in a decreased slab thickness and a savings in reinforcing steel. (See comparison with conventional slab, page 3.) Besides the savings in concrete, a shallower slab means longer spans without shoring, lighter structural steel,

lighter foundations and a comparable savings in time and labor costs.

Keystone deck provides a rigid, uncluttered working surface for other trades. After the work of the other trades has been completed, the temperature mesh can then be properly installed to occur near the surface of the slab where it has maximum effects in control of shrinkage and also serves as additional reinforcing.

The Keystone composite floor system decreases the cost of fireproofing, since a smaller quantity of material is required to cover the flat underside of Keystone deck than would be needed to cover a fluted or corrugated deck.

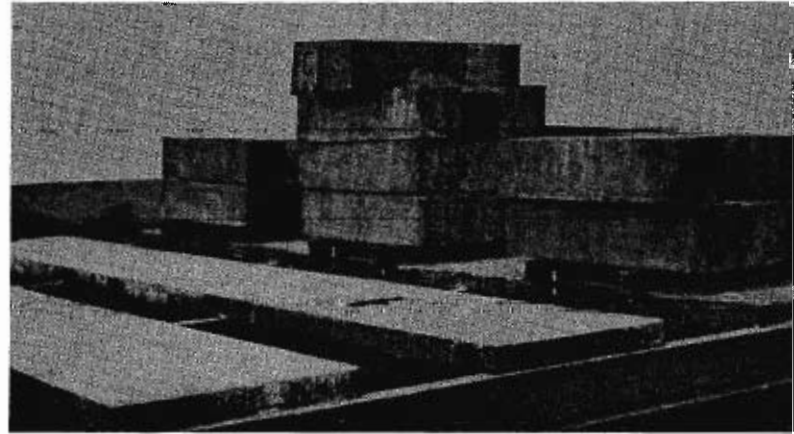
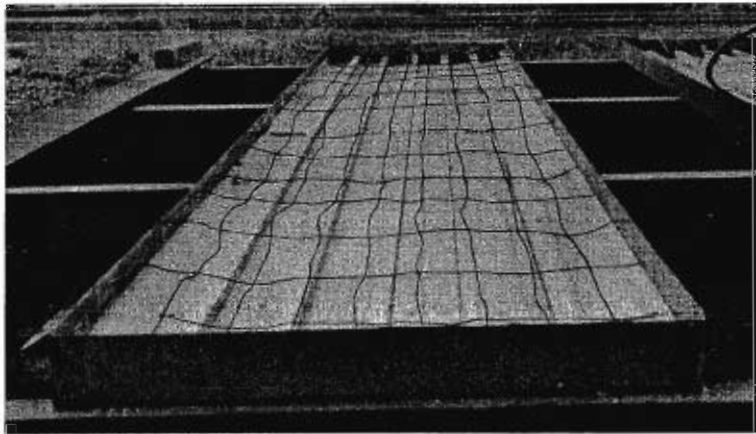
40'-0" sheet lengths

Gauges—16, 18, 20, 22

Coverage—1'-6" per sheet

Robertson's steel Keystone reinforcing forms are available in sheet lengths to 40'-0" and in gauges from 16 to 22. Long sheet length means multiple spanning for greater strength and fast erection. A choice of the gauge which will eliminate shoring often proves to be the most economical.

PAN-AM TEST



20 gauge Keystone deck, 4" Lelite aggregate, 4 x 16-5/10 mesh, 7'-0" beam spacings, triple span Keystone units.

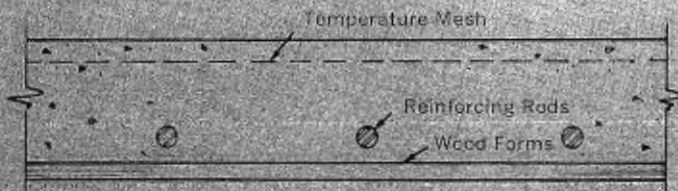
Design Loads: Live Loads—50 and 100 psf

Total Loads—110 and 160 psf

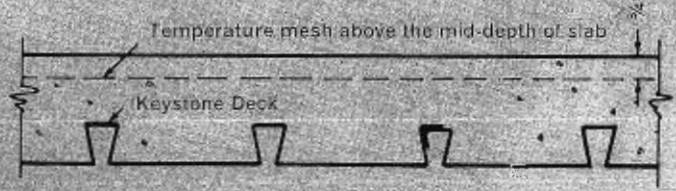
Results:

	Actual	Allowable L/360
Maximum deflection at 110 psf—	.008"	.233"
Maximum deflection at 160 psf—	.013"	.233"
First cracks over supports—	645 psf	
Ultimate load applied—	900 psf	No failure

Tests conducted by Pittsburgh Testing Laboratory. Test No. 660.



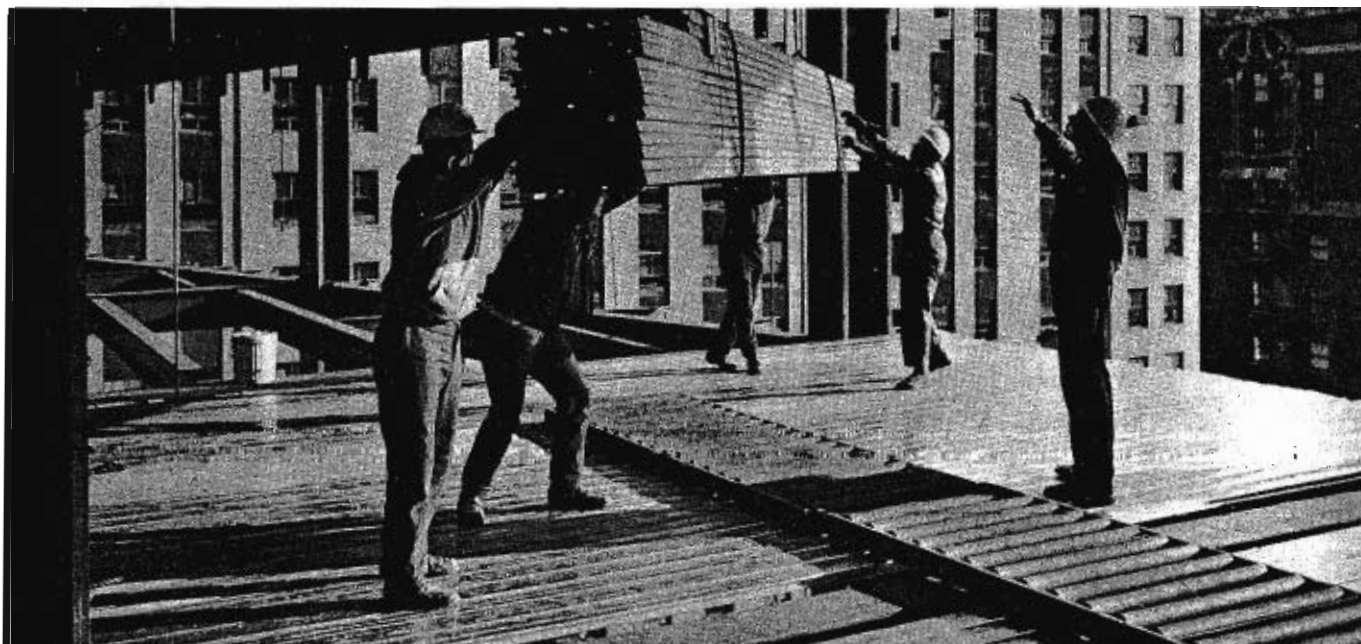
REINFORCED CONCRETE SLAB



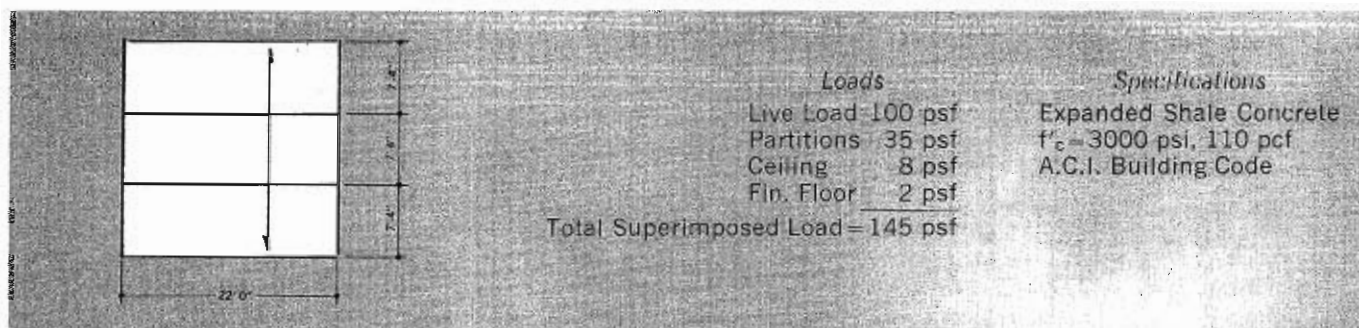
KEYSTONE COMPOSITE SLAB

EXAMPLE	Superimposed Slab				
	Forms	Span	Load	Thickness	Reinforcing
Reinfor. Concrete Slab	Wood	14'-0"	140 PSF	6"	No. 5 bars 10" oc
Keystone Composite Slab	20 ga. Keystone	14'-0"	140 PSF	5½"	None

DESIGN PROCEDURE and EXAMPLE



PROBLEM: To determine the most economical Keystone Composite Slab for a given condition.



General Nomenclature

A_s —Cross-sectional area of one foot width of reinforcing form (sq. in.).
 b —Unit width of slab (12 in.).
 d —Effective Depth of Slab (in.).
 E_s —Elastic Modulus of Steel (psi).
 f'_c —28 day Strength of concrete mix in compression (psi).
 f_c —Allowable concrete design stress— $0.45f'_c$ (psi).
 f_s —Allowable design tensile stress in reinforcing bars = 20,000 psi.
 f_t —Allowable design tensile stress in reinforcing form = 20,000 psi.
 I_c —Least Moment of Inertia of composite section transformed into steel (in⁴).
 I_s —Moment of Inertia of reinforcing form section (in⁴).
 jd —Moment arm of composite slab section—see Design Properties (in.).
 K —223 for 3000 psi concrete and $n=9$.
 kd —Effective depth of concrete in compression—See Design Properties (in.).
 L —Length of Span (feet).

M_w —Maximum positive Dead Load Moment from slab weight (ft. lbs.).
 M_2 —Maximum positive moment with superimposed load if no shoring is used; total load if shoring is used (ft. lbs.).
 M_p —Maximum construction load moment (ft. lbs.).
 M_n —Negative Moment at interior supports for continuous spans with superimposed load if no shoring is used and with total load if shored (ft. lbs.).
 S —Section Modulus of deck (in³).
 Σo —Reinforcing Form rib perimeter (= 8 inches).
 t —Total thickness of slab (inches).
 V' —Vertical shear at discontinuous edge of slab with superimposed load without shoring; Total load with shoring. Here referred to as End Shear (lbs./ft.—width).
 V'' —Maximum vertical shear with Live Load without shoring, with Total Load when shoring is used (lbs./ft.—width).
 w_1 —Live Load (psf).
 w_s —Superimposed load for unshored spans—Total Load where shoring is used (psf).
 \bar{y} —Distance of Neutral Axis of reinforcing form section from its bottom fiber (inches).

Design Procedure

Calculations

Preliminary Design

Step 1 Preliminary Selection of Slab from Table 1 (directly or by interpolation).

Table 1:
3" Slab—22 ga. Keystone
7'0" Span—200 psf
8'0" Span—138 psf

Step 2 Check Table 4 for shoring requirements. Check max. stress in Keystone deck with weight of concrete and a construction load of one man (200 lbs.) standing at midspan with his weight distributed over one Keystone deck unit (1'6" wide).

For section properties, (S) see Table 5.

For one time temporary load use $\frac{1}{3}$ stress increase.

Table 4:
Allowable clear span 7'9".
No shoring required.

P W 1'0" wide strip

w = Weight of Slab = 28 psf

$P = 200/1.5 = 133$ lbs.

Moments: (maximum)

$M_w = 0.080 wL^2 = 1444$ in-lbs

$M_P = 0.2042 PL = 2389$ in-lbs

Total: $M = 3833$ in-lbs

Stress:

$$f = \frac{M}{S} = \frac{3833}{.171} = 22,415 \text{ psi} < 20,000 \times 1.33 = 26,600$$

Temporary Load
O.K.

Step 3 Find tensile stress in bottom fiber of Keystone Reinforcing Form from the weight of concrete.

For section properties, (I_s, \bar{y}) see Table 5.

$$f_1 = \frac{M_w \bar{y}}{I_s} = \frac{1444 \times 0.43}{0.189} = 3285 \text{ psi}$$

(for shored spans $f_1 = 0$)

Step 4 Find maximum tensile stress in composite slab from the superimposed load.

For moment coefficients, (M_2) see Table 7.

For slab properties, (jd, kd) see Table 6.

For deck section properties, (A_s) see Table 5.

$$f_2 = \frac{M_2}{jd \times A_s}$$

$$M_2 = \frac{wL^2}{11} = \frac{145 \times 7.33^2}{11} = 708 \text{ ft lbs}$$

$$= 8500 \text{ in lbs}$$

$$f_2 = \frac{8500}{2.2 \times 0.59} = 6545 \text{ psi}$$

Step 5 Check total tensile stress.

$$f_t = f_1 + f_2 = 3285 + 6545 = 9830 \text{ psi}$$

$< 20,000 \text{ psi}$ O.K.

Step 6 Check max. compression stress in concrete.

For slab properties, (jd, kd) see Table 6.

**

$$f_c = \frac{M_2}{\frac{1}{2} kd \times jd \times b} = \frac{8496}{\frac{1}{2} \times 1.13 \times 2.2 \times 12} = 570 \text{ psi} < 1350 \text{ psi}$$

O.K.

Step 7 Check max. bond stress.

Allowable values:

16 ga. Keystone 60 psi

18 ga. Keystone 60 psi

20 ga. Keystone 60 psi

22 ga. Keystone 40 psi

Perimeter of Keystone

$\Sigma_o = 8$ inches

For shear coefficient, (V') see Table 7.

$$u = \frac{V'}{\Sigma_o \times jd} =$$

$$V' = \frac{2}{5} wL = \frac{2}{5} \times 145 \times 7.33 = 425 \#$$

$$u = \frac{425}{8 \times 2.2} = 24.1 \text{ psi} < 40 \text{ psi}$$

O.K.

*For shored spans use w =total load. For unshored spans use w =total load less weight of slab.

**Example is based on 3000 psi concrete, however any structural concrete can be used.

Design Procedure

Calculations

Step 8 Check shear stress in concrete.

Allowable value $0.03 f'_c$

For shear coefficients, (V'') see Table 7.

$$v = \frac{V''}{12 \times jd}$$

$$V'' = \frac{1.15}{2} wL = \frac{1.15}{2} \times 145 \times 7.33 = 611 \text{ lbs.}$$

$$v = \frac{611}{12 \times 2.2} = 23.14 < 90 \text{ psi O.K.}$$

Step 9 Select least required negative reinforcing for the maximum negative moment from Table 8 or by calculating the required cross-section of reinforcing steel.

$$\text{Max. negative moment} = M_n = \frac{wL^2}{12}$$

$$M_n = \frac{145 \times 7.33^2}{12} = 649 \text{ ft lbs}$$

Table 9: #3 Bars 6"-o.c.

$$\text{or: } A_n = \frac{12 \times M_n}{f_s \times 0.874(2'')^{***}} = 0.22 \text{ in}^2$$

Step 10 Check negative moment capacity of slab with negative reinforcing.

$K = 223$ for 3000 psi concrete.

$$M_n (\text{allowable}) = K (d)^2 = 223 \times 2^2 = 892 \text{ ft lbs}$$

$$649 < 892 \text{ O.K.}$$

From the result obtained in Step #5 it can be seen that the allowable steel stress of 20,000 psi was not reached. To realize a possible saving by eliminating negative reinforcing, a simple span analysis follows.

Step 11 Bottom fiber stress in Keystone form from weight of concrete remains as in Step #3.

$$f_1 = 3285 \text{ psi}$$

Step 12 Maximum tensile stress in composite slab from superimposed load. For moment coefficient see Table 7.

$$M_2 = \frac{w \cdot L^2}{8}$$

$$M_2 = \frac{145 \times 7.33^2}{8} \times 12 = 11686 \text{ in-lbs}$$

$$f_2 = \frac{M_2}{jd \times A_s} = \frac{11686}{2.2 \times 0.59} = 9003 \text{ psi}$$

Step 13 Check total tensile stresses.

$$f_t = f_1 + f_2 = 3285 + 9003 = 12,288 \text{ psi}$$

$$< 20,000 \text{ psi O.K.}$$

Step 14 Check max. compression stress in concrete.

$$f_c = \frac{M_2}{\frac{1}{2} kd \times jd \times b} = \frac{11,686}{\frac{1}{2} \times 1.13 \times 2.2 \times 12}$$

$$= 783 \text{ psi} < 1350 \text{ psi O.K.}$$

Step 15 Check max. bond stress.

$$v' = \frac{wL}{2} = \frac{145 \times 7.33}{2} = 531 \#$$

$$u = \frac{v'}{\sum o \times jd} = \frac{531}{8 \times 2.2} = 30.2 \text{ psi} < 40 \text{ psi O.K.}$$

Step 16 Check shear stress in concrete.

$$V'' = V' = 531 \#$$

$$v = \frac{V''}{12 \times jd} = \frac{531}{12 \times 2.2} = 20.1 \text{ psi} < 90 \text{ psi O.K.}$$

Since simple span assumptions produce adequate results negative steel is not required unless other considerations require it.

Step 17 Check maximum deflection under superimposed load.

See Table 6 for composite moment of Inertia " I_c ."

$$\Delta = \frac{5}{384} \left(\frac{wL^4}{E_s I_c} \right) =$$

$$\frac{5}{384} \left(\frac{145 \times 7.33^4 \times 12^3}{30 \times 10^6 \times 2.08} \right) = 0.15 \text{ inches} < L/360 = 0.24$$

*For shored spans use w =total load. For unshored spans use w =total load less weight of slab.

***Effective depth for slab with negative reinforcing " d ."

ALLOWABLE LOAD TABLES (FOR 20,000 PSI DESIGN STRESS)

Total Superimposed Load Lbs. Per Sq. Ft.

Sand and Gravel Concrete—3000 psi strength
Lightweight concrete—see footnote.

Table 1 — Without Negative Reinforcement

Span (Ft.)	Over-all Slab Depth (In.)	Gauge			
		16	18	20	22
5	2½	314	314	314	223
	3	398	398	398	281
6	2½	262	262	262	186
	3	332	332	332	234
	3½	403	403	403	282
7	3	284	284	284	200
	3½	345	345	345	242
	4	407	407	372	284
	4½	468	468	398	271
8	3	238	228	197	138
	3½	302	302	222	169
	4	356	356	235	199
	4½	410	410	355	230
	5	464	464	403	261
9	3½	259	226	189	145
	4	316	316	252	172
	4½	353	309	309	199
	5	363	352	352	226
	5½	394	394	394	253
	6	426	213	195	150
10	4½	273	273	249	173
	5	310	310	309	197
	5½	348	348	348	221
	6	386	386	386	245
	6½	424	424	424	268
	4	178	167	152	132
	4½	231	216	196	152
11	5	271	271	245	173
	5½	310	310	279	194
	6	344	344	309	216
	6½	379	379	340	237
	7	413	413	370	268
	4½	186	173	156	135
	5	234	217	196	154
12	5½	273	265	224	173
	6	310	310	248	192
	6½	334	330	273	210
	7	371	371	297	230
	5	190	176	158	127
	5½	234	217	181	142
	6	274	260	201	158
13	6½	306	306	221	173
	7	335	335	241	190
	5½	192	178	147	113
	6	232	214	163	125
	6½	275	253	179	139
	7	300	284	196	152
	5½	159	146	119	90
14	6	193	177	133	100
	6½	229	210	146	111
	7	268	236	160	121
	6	161	147	108	79
	6½	192	175	119	88
	7	225	197	120	96
	6½	161	146	96	69
15	7	190	165	106	76
	6	161	147	108	79
	6½	192	175	119	88
	7	225	197	120	96
	6½	161	146	96	69
	7	190	165	106	76
	6	161	147	108	79
16	6½	192	175	119	88
	7	225	197	120	96
	6½	161	146	96	69
	7	190	165	106	76
	6	161	147	108	79
	6½	192	175	119	88
	7	225	197	120	96
17	6½	161	146	96	69
	7	190	165	106	76
	6	161	147	108	79
	6½	192	175	119	88
	7	225	197	120	96
	6½	161	146	96	69
	7	190	165	106	76
18	6	161	147	108	79
	6½	192	175	119	88
	7	225	197	120	96
	6½	161	146	96	69
	7	190	165	106	76
	6	161	147	108	79
	6½	192	175	119	88

Table 2 — With Negative Reinforcement

Span (Ft.)	Over-all Slab Depth (In.)	16 Gauge		18 Gauge		20 Gauge		22 Gauge	
		2-Span	3-Span	2-Span	3-Span	2-Span	3-Span	2-Span	3-Span
5	2½	314	314	314	314	314	314	261	261
	3	398	398	398	398	398	398	374	351
6	2½	262	262	262	262	262	262	186	186
	3	332	332	332	332	332	332	312	292
	3½	488	488	488	488	488	488	377	353
7	3	284	284	284	284	284	284	232	232
	3½	358	358	358	358	358	358	323	260
	4	498	498	498	498	498	498	329	306
	4½	624	585	624	585	624	585	379	302
8	3	238	238	228	228	197	197	143	143
	3½	302	302	302	302	222	222	231	222
	4	392	392	392	392	353	353	282	262
	4½	531	512	531	512	476	457	325	301
	5	619	580	619	580	558	519	369	342
9	3½	259	259	226	226	189	189	145	145
	4	316	316	267	267	267	267	245	227
	4½	419	419	364	364	364	364	283	262
	5	484	455	484	455	484	455	321	297
	5½	548	507	548	507	548	507	359	333
	6	624	585	624	585	624	585	379	302
10	4½	285	285	285	285	285	285	249	240
	5	381	381	381	381	381	381	283	261
	5½	487	452	487	452	487	452	317	293
	6	539	501	539	501	539	501	350	324
	6½	592	550	592	550	592	550	384	355
	4	178	178	167	167	152	152	132	132
	4½	231	231	216	216	196	196	152	179
11	5	271	271	271	271	245	245	213	232
	5½	310	310	310	310	279	279	278	260
	6	352	399	352	399	352	399	312	288
	6½	434	491	434	491	434	491	342	316
	7	525	537	525	537	525	537	373	344
	4½	186	186	173	173	156	156	122	141
	5	234	234	217	217	196	196	165	194
12	5½	273	273	265	265	224	255	223	232
	6	303	324	303	324	284	324	280	256
	6½	352	400	352	400	352	400	307	283
	7	427	484	427	484	427	484	334	308
	5	190	190	176	176	158	158	135	157
	5½	234	234	217	217	191	207	180	207
	6	274	274	260	260	231	265	231	232
13	6½	306	329	306	329	288	329	277	255
	7	351	400	351	400	351	364	293	278
	5½	192	192	178	178	146	170	146	170
	6	232	232	214	214	189	218	189	201
	6½	275	275	253	273	238	246	221	221
	7	300	333	291	333	291	302	239	239
	5½	159	159	146	146	119	139	119	139
14	6	193	193	177	181	156	181	156	165
	6½	229	229	210	228	197	228	182	182
	7	268	279	243	279	243	252	199	199
	6	161	161	147	150	128	150	128	137
	6½	192	192	175	190	163	190	151	151
	7	225	235	203	235	203	211	164	164
	6½	161	161	146	160	136	160	124	124
15	7	190	198	170	198	170	177	136	136
	6	161	161	147	150	128	150	128	137
	6½	192	192	175	190	163	190	151	151
	7	225	235	203	235	203	211	164	164
	6½	161	161	146	160	136	160	124	124
	7	190	198	170	198	170	177	136	136
	6	161	161	147	150	128	150	128	137
16	6½	192	192	175	190	163	190	151	151
	7	225	235	203	235	203	211	164	164
	6½	161	161	146	160	136	160	124	124
	7	190	198	170	198	170	177	136	136
	6	161	161	147	150	128	150	128	137
	6½	192	192	175	190	163	190	151	151
	7	225	235	203	235	203	211	164	164
17	6½	161	161	146	160	136	160	124	124
	7	190	198	170	198	170	177	136	136
	6	161	161	147	150	128	150	128	137
	6½	192	192	175	190	163	190	151	151
	7	225	235	203	235	203	211	164	164
	6½	161	161	146	160	136	160	124	124
	7	190	198	170	198	170	177	136	136
18	6	161	161	147	150	128	150	128	137
	6½	192	192	175	190	163	190	151	151
	7	225	235	203	235	203	211	164	164
	6½	161	161	146	160	136	160	124	124
	7	190	198	170	198	170	177	136	136
	6	161	161	147	150	128	150	128	137
	6½	192	192	175	190	163	190	151	151

The above loads may be used with the floor units on simple or continuous spans. Composite slab design to be based upon simple span analysis. Shoring requirements are based on 200 lb. concentrated construction load at midspan plus the

MAXIMUM SPANS WITHOUT SHORING
TABLE 3 Sand and gravel concrete (145 pcf)

Span	Gage	2½"	3"	3½"	4"	4½"	5"	5½"	6"	6½"	7"
Simple	16	9'-0"	8'-6"	8'-3"	7'-9"	7'-6"	7'-3"	7'-3"	6'-9"	6'-9"	6'-6"
	18	8'-6"	8'-0"	7'-6"	7'-3"	7'-0"	6'-9"	6'-6"	6'-6"	6'-3"	6'-0"
	20	7'-9"	7'-3"	7'-0"	6'-9"	6'-6"	6'-3"	5'-9"	5'-9"	5'-6"	5'-6"
	22	7'-3"	6'-9"	6'-6"	6'-3"	6'-0"	5'-9"	5'-9"	5'-6"	5'-6"	5'-3"
Double and Contin.	16	11'-0"	10'-6"	10'-0"	9'-6"	9'-3"	9'-0"	8'-9"	8'-6"	8'-3"	8'-0"
	18	10'-6"	9'-6"	9'-0"	8'-9"	8'-6"	8'-3"	8'-0"	7'-9"	7'-6"	7'-3"
	20	9'-0"	8'-6"	8'-0"	7'-9"	7'-6"	7'-3"	7'-0"	6'-9"	6'-9"	6'-6"
	22	8'-0"	7'-6"	7'-3"	7'-0"	6'-9"	6'-6"	6'-3"	6'-0"	6'-0"	5'-9"

No shoring is required up to the spans listed.

Shoring tables are based on 200# concentrated construction load plus the weight of wet concrete. Deflection under weight of concrete does not exceed 1/240 of the span. To speed concrete placement, runways for concrete buggies are recommended.

MAXIMUM SPANS WITHOUT SHORING
TABLE 4 Lightweight Concrete (110 pcf)

Span	Gage	2½"	3"	3½"	4"	4½"	5"	5½"	6"	6½"	7"
Simple	16	10'-0"	9'-3"	8'-9"	8'-6"	8'-3"	8'-0"	7'-9"	7'-6"	7'-6"	7'-3"
	18	9'-3"	8'-9"	8'-6"	8'-0"	8'-0"	7'-9"	7'-6"	7'-3"	7'-0"	6'-9"
	20	8'-6"	8'-0"	7'-9"	7'-6"	7'-3"	7'-0"	6'-9"	6'-6"	6'-3"	6'-0"
	22	8'-0"	7'-6"	7'-3"	7'-0"	6'-9"	6'-6"	6'-3"	6'-3"	6'-0"	5'-9"
Double and Contin.	16	11'-0"	11'-0"	10'-9"	10'-6"	10'-3"	10'-0"	9'-6"	9'-3"	9'-0"	8'-9"
	18	10'-6"	10'-3"	10'-0"	9'-9"	9'-3"	9'-0"	8'-9"	8'-6"	8'-3"	8'-0"
	20	9'-9"	9'-3"	9'-0"	8'-6"	8'-3"	8'-0"	7'-9"	7'-6"	7'-3"	7'-3"
	22	8'-0"	7'-9"	7'-6"	7'-3"	7'-0"	6'-9"	6'-6"	6'-6"	6'-3"	6'-3"

TABLE 5 Section Properties—Keystone Deck.

Gage	A _s In. ²	\bar{y} (To Bottom) In.	Weight Lbs.	I _s In. ⁴	S In. ³
16	1.18	0.51	4.17	0.372	0.333
18	0.95	0.49	3.19	0.300	0.270
20	0.71	0.46	2.47	0.226	0.206
22	0.59	0.43	2.06	0.189	0.171

Properties computed in accordance with A.I.S.I. specifications for the design of light gauge cold-formed steel structural members, 1962 Edition.

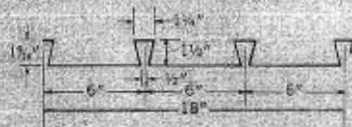


TABLE 6 Section Properties of Concrete Slab.

Slab t	Gage	d	kd	jd	I _c [*]	Weight of Slab	
		In.	In.	In.	In. ⁴	Sand and Gravel Concrete (145 pcf)	Light-weight (110 pcf)
2 ½	16	2.05	1.21	1.64	2.00	31 psf	23 psf
	18	2.05	1.14	1.67	1.77		
	20	2.06	1.04	1.71	1.48		
	22	2.08	.98	1.75	1.33		
3	16	2.55	1.41	2.07	3.16	37 psf	28 psf
	18	2.56	1.32	2.11	2.78		
	20	2.56	1.20	2.15	2.32		
	22	2.58	1.13	2.20	2.08		
3 ½	16	3.05	1.60	2.51	4.68	43 psf	32 psf
	18	3.05	1.49	2.56	4.11		
	20	3.06	1.35	2.61	3.41		
	22	3.08	1.27	2.65	3.04		
4	16	3.55	1.77	2.95	6.58	49 psf	37 psf
	18	3.55	1.65	3.00	5.76		
	20	3.56	1.48	3.06	4.74		
	22	3.58	1.39	3.11	4.22		
4 ½	16	4.05	1.93	3.40	8.87	55 psf	41 psf
	18	4.05	1.79	3.45	7.74		
	20	4.06	1.61	3.52	6.34		
	22	4.08	1.51	3.57	5.62		
5	16	4.55	2.09	3.85	11.56	61 psf	46 psf
	18	4.55	1.93	3.91	10.05		
	20	4.56	1.73	3.98	8.21		
	22	4.58	1.62	4.04	7.25		
5 ½	16	5.05	2.23	4.30	14.67	67 psf	50 psf
	18	5.05	2.06	4.37	12.72		
	20	5.08	1.85	4.44	10.35		
	22	5.08	1.72	4.50	9.11		
6	16	5.55	2.37	4.73	18.21	73 psf	55 psf
	18	5.55	2.19	4.82	15.74		
	20	5.56	1.96	4.90	12.77		
	22	5.58	1.82	4.97	11.20		
6 ½	16	6.05	2.50	5.21	22.17	79 psf	60 psf
	18	6.05	2.31	5.28	19.11		
	20	6.06	2.06	5.37	15.46		
	22	6.08	1.92	5.44	13.54		
7	16	6.55	2.63	5.67	26.57	85 psf	64 psf
	18	6.55	2.43	5.74	22.85		
	20	6.56	2.16	5.83	18.44		
	22	6.58	2.01	5.91	16.11		

TABLE 7 Moment and Shears for uniform loads.

	Units	Simple Span	Double Span	Continuous Span
*Max. Pos. Moment	+M	$\frac{WL^2}{8}$ ft-lbs	$\frac{WL^2}{11}$ ft-lbs	$\frac{WL^2}{11}$ ft-lbs
*Max. Negative Moment	Spans to 10 ft	-M	0	$\frac{WL^2}{12}$ ft-lbs
	Spans over 10 ft	-M	0	$\frac{WL^2}{10}$ ft-lbs
End Shear	V'	$\frac{WL}{2}$ lbs	$\frac{3 WL}{8}$ lbs	$\frac{2 WL}{5}$ lbs
*Max. Shear	V''	$\frac{WL}{2}$ lbs	$\frac{1.15 WL}{2}$ lbs	$\frac{1.15 WL}{2}$ lbs

*ACI Building Code—June 1963

$$jd = d - \frac{kd}{3}$$

$$I_c = \frac{4 (kd)^3}{n} + A_s (d - kd)^2 + I_s$$

$$n = 9$$

$$f_c = 3000 \text{ psi}$$

$$\frac{(kd)^2}{2} \times b = n \cdot A_s \cdot (d - kd)$$

$$d = t - y$$

*For deflection calculation of sand and gravel concrete slab.

TABLE 8 Moment Resistance of Slab with negative reinforcing. (ft. lbs.)

Slab Depth in Inches										Bar Size and Spacing
2½	3	3½	4	4½	5	5½	6	6½	7	
									7530	No. 6 @ 6"
								6408	6992	No. 4 @ 3"
									6434	No. 5 @ 5"
							5352	5892	5826	No. 3 @ 2"
						4386	4866	5346	5826	No. 5 @ 6"
						4008	4460	4910	5362	No. 4 @ 4"
					3495	3933	4371	4806	5244	No. 6 @ 9"
					3312	3738	4165	4593	5020	No. 5 @ 7"
					3048	3435	3823	4209	4596	No. 4 @ 5"
				2448	2796	3146	3497	3845	4195	No. 5 @ 8"
				2328	2667	3006	3345	3682	4021	No. 3 @ 3"
			1964	2284	2604	2924	3244	3564	3884	No. 5 @ 9"
			1768	2069	2370	2672	2973	3273	3575	No. 4 @ 6"
			1748	2040	2330	2622	2914	3204	3496	No. 5 @ 10"
		1321	1591	1862	2134	2405	2676	2946	3217	No. 4 @ 7"
		1248	1498	1748	1997	2247	2498	2746	2996	No. 3 @ 4"
		1230	1473	1713	1953	2193	2433	2673	2913	No. 5 @ 12"
			1326	1552	1778	2004	2230	2455	2681	No. 4 @ 8"
	874	1092	1311	1530	1747	1966	2185	2403	2662	No. 6 @ 18"
	801	1015	1229	1442	1656	1869	2083	2298	2510	No. 3 @ 5"
	792	984	1178	1370	1562	1754	1946	2138	2330	No. 5 @ 15"
		881	1061	1242	1422	1603	1784	1964	2145	No. 4 @ 10"
	700	837	1049	1224	1398	1573	1748	1922	2098	No. 5 @ 16"
			994	1164	1333	1503	1672	1841	2011	No. 3 @ 6"
500	660	820	982	1142	1302	1462	1622	1782	1942	No. 5 @ 18"
			884	1035	1185	1336	1488	1637	1787	No. 4 @ 12"
437	583	728	874	1020	1165	1311	1457	1602	1748	No. 3 @ 7"
		703	842	979	1116	1253	1390	1527	1664	No. 4 @ 13"
403	538	672	807	941	1075	1210	1345	1479	1613	No. 4 @ 14"
374	500	624	749	874	998	1123	1249	1373	1498	No. 4 @ 15"
350	466	582	699	816	932	1049	1166	1282	1398	No. 4 @ 16"
328	437	546	655	765	874	983	1093	1201	1311	No. 4 @ 17"
308	411	514	617	720	822	925	1029	1131	1234	No. 3 @ 10"
300	396	492	589	685	781	877	973	1069	1165	No. 3 @ 11"
273	360	447	536	623	710	797	885	972	1059	

- Capacities are based on 3000 psi concrete and ¾" of concrete cover over bars.
- Most efficient combination of bar size and spacing is shown.
- Bar lengths should extend ¼ of the span each way from the center of the support. (Based on A.C.I. code, section 918e.)

TABLE 9 Minimum Requirements for Shrinkage Mesh (Sand and Gravel Concrete)

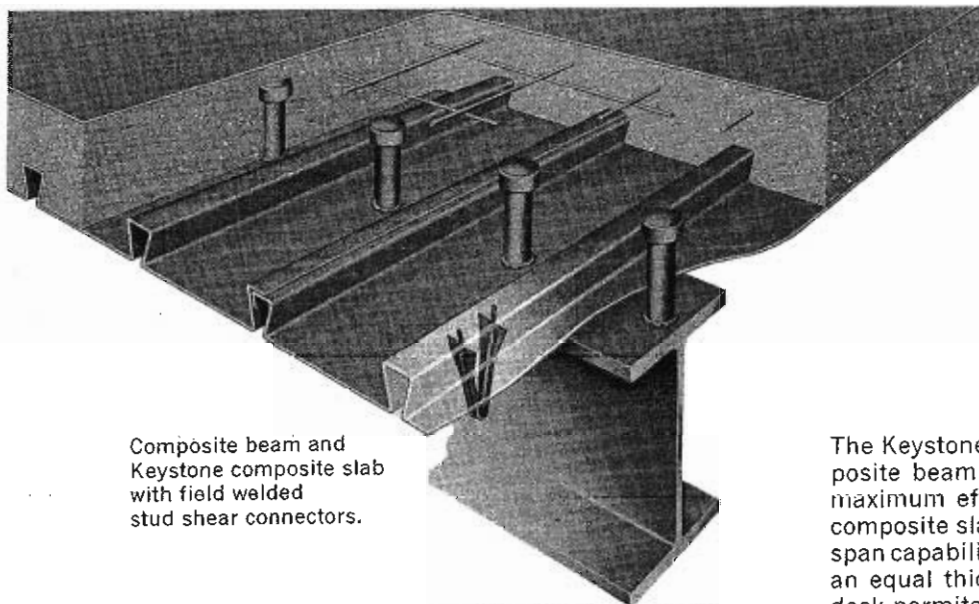
Depth of Slab	Suggested 6 x 6 Welded Wire Fabric
2½"	10/10
3"	9/9
3½"	9/9
4"	8/8
4½"	7/7
5"	6/6
5½"	6/6
6"	5/5
6½"	5/5
7"	4/4

SPECIFICATIONS

Keystone Composite Slab

- GENERAL**—All areas noted on the plans or specifications shall be covered with composite slabs, using Keystone deck as manufactured by H. H. Robertson Company. The Keystone deck shall serve as form, total positive reinforcement and temperature reinforcement for the lower half of the slab. Full scale tests by independent laboratory substantiating composite ability shall be submitted prior to approval.
- MATERIAL**—Keystone composite deck shall be formed of (select gauge) 16, 18, 20 or 22 USS Gauge Steel sheets conforming to ASTM A-242-64. The steel shall have received before being formed, a metal protective coating of zinc conforming to ASTM A-525-65T (wiped coating) and to Federal Specification QQ-S-775c, Type I, class e.
- CONSTRUCTION**—To provide a positive key bond with the concrete the Keystone deck shall have integral pyramidal shaped ribs, all continuous and complete in cross-section, and spaced not more than 6" on center. Ribs shall be formed to a depth of not less than 1½" with an opening of not more than ¼" at the base and a width of not less than 1½" at the apex. Side laps shall be positive registering full depth side lap ribs placed in a manner to prevent the flow of concrete through the joints. The area of steel provided as positive reinforcement shall not be less than 0.50 sq. in./ft. The bottom of the sheets shall form a substantially flat and continuous surface.
- DESIGN**—Keystone composite slab construction shall be capable of supporting the specified uniform loads in accordance with the allowable live load table and design factors shown in the manufacturer's catalog for this product.
- ERECTION**—Keystone composite deck units shall be laid in strict accordance with the manufacturer's instructions and as shown on a layout prepared for the erector's use. At the end laps of the units attach the unit to the supporting members with puddle welds, one adjacent to each of the outside ribs. At intermediate supports, attach the unit to the supporting member with one puddle weld adjacent to the center rib. Deck units shall span 3 or more supports wherever practical. Concrete dams shall be provided and installed at ends of deck units by manufacturer where area of rib between top of beam exceeds 1½ square inches. Side joints shall be joined by welding with ½" fillet welds at supports and at midspan for spans 4' 0" to 6' 0". For spans over 6' 0" weld joints at supports and at third points of the span.
- WORK TO BE INCLUDED IN OTHER CONTRACT**—Concrete for Keystone composite slab construction shall conform to the following specifications.
 - Base Preparation**—Prior to concreting, the surface of the sheets shall be cleaned of all debris, grease, oil and other deleterious substances to the satisfaction of the contractor and/or architect's representative.
 - Materials and Mixture**—(Architect shall provide specifications for cement, fine and coarse aggregates, water-cement ratio and mixing for concrete providing an ultimate compressive strength of 3,000 psi or other strength required). It is recommended that the specified mixture shall have a slump of from 4 to 5 inches, insuring sufficient moisture in the concrete to allow optimum bonding of the concrete to the deck surface and minimize shrinkage. Concrete with admixtures containing chloride salts is not to be used with Keystone Composite Deck.
 - Reinforcement**—Shrinkage and thermal stress reinforcement in the form of welded wire mesh and type suitable for the depth of the slab as called for in the manufacturer's catalog, shall be placed above the mid-depth of the slab and at least 1" below the top surface. This mesh is placed in the top part of the slab in order to provide optimum control of shrinkage at the exposed surface.
 - Placement of Concrete**—Concrete shall be mixed and placed in accordance with the American Concrete Institute's "Building Code Requirements for Reinforced Concrete" (ACI 318-63) Chapter 6.
 - Curing**—After placement, the concrete shall be allowed to cure, without being loaded, until it reaches 70% of the specified ultimate compressive strength. Curing shall be done in accordance with good concrete curing practice.
 - Construction Joints**—Construction joints shall be placed at midspan in accordance with the provisions of Section 704 of the above ACI Code.
 - Shoring**—When required, in conformance with the allowable shoring tables on page 4, the Keystone composite slab shall be temporarily shored. The design of the shoring shall be in accordance with local building code provisions. The shoring shall be left in place until the concrete attains 70% design compressive strength.

COMPOSITE BEAM DESIGN



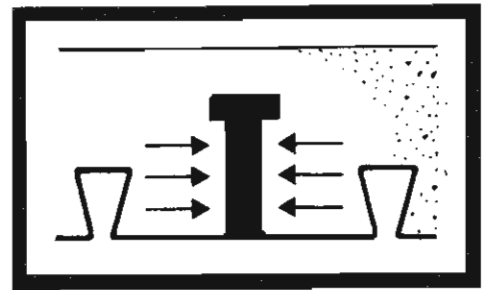
Composite beam and Keystone composite slab with field welded stud shear connectors.

The unrestricted use of composite design in building construction is a relatively recent occurrence. Architects and engineers considering the use of composite design find that they must also investigate the compatibility of related materials with the composite system. A critical look at all available concrete forming methods is imperative.

Composite beam design is accomplished by welding structural shear connectors to the top flange of a floor beam through single thickness of Keystone metallic coated deck so that the shear resistance of the connectors will cause the floor slab and the beam to act as a unit.

A composite beam will deflect only $\frac{1}{3}$ to $\frac{1}{6}$ as much as a non-composite beam under identical conditions. In practice this means lighter, shallower beams, reduced building height, and savings in all related material and labor.

The economy of composite design is best realized when each component is designed for maximum effectiveness. Girders and beams should be spaced as far apart as practicable. The maximum value of shear connectors is obtained when the concrete form system allows the slab to be in contact with the top flange of the beam around the roots of the shear connectors. The forms should also be capable of providing lateral support for the compression flange of the beams during construction.

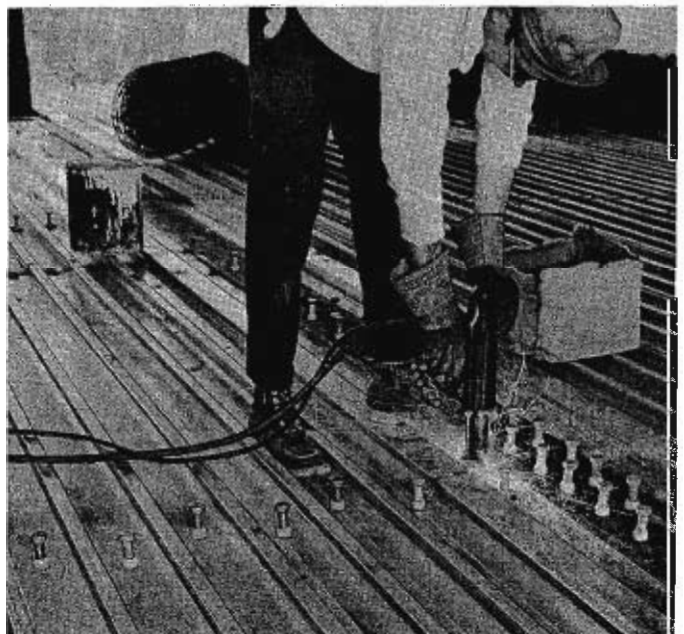
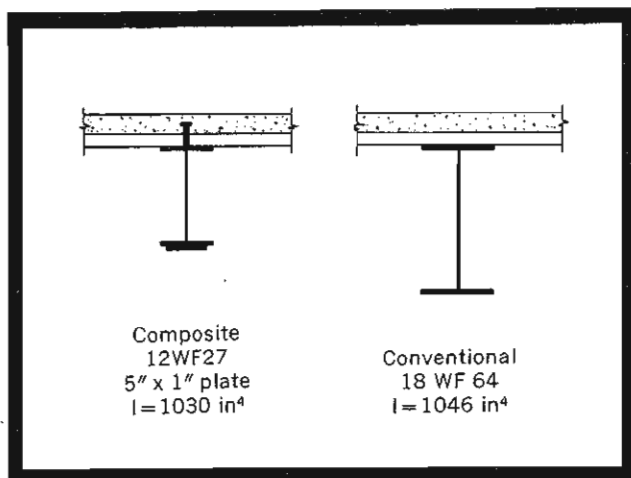


Use standard A.I.S.C. procedure for composite beam design.

The Keystone system combines composite slab with composite beam construction to fulfill the requirements for maximum efficiency in composite design. The Keystone composite slab has, in independent tests, proven its long-span capabilities to be greater than any other system using an equal thickness of concrete. The design of Keystone deck permits the slab to be in full contact with the shear connectors. The ample slab space between the ribs assures the total effectiveness of the composite action between the beam and the slab. Standard A.I.S.C. Composite Design Procedure may be used. Refer to the section on "Composite Design for Building Construction" in your A.I.S.C. Manual.

Besides efficient structural design, economical construction demands efficient handling and installation of materials. The multiple span metallic coated Keystone sheets (up to 40'-0" long) mean fast erection of a rigid, convenient working surface. Shear connectors, temperature mesh, and negative steel (when required) are installed last, so that they will not impede the work of other trades.

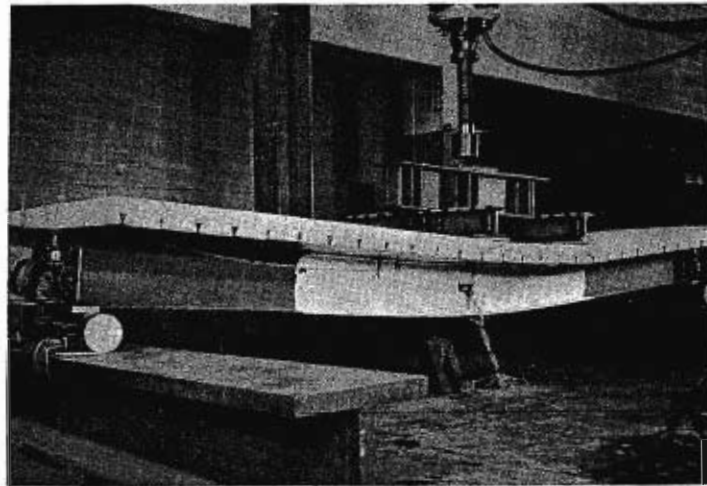
Complete information and details are available through your Robertson Representative. Robertson engineers are at your service.



A composite design floor using Keystone deck—section 69—and Stud Shear Connectors.

COMPOSITE BEAM TESTS

Purpose To check the performance of Keystone Composite Slabs used in conjunction with Composite Beam Design.



Test A Keystone Composite Slab—Composite Beam Design.
12 WF 27 on a 15'0" span, Keystone deck, $\frac{1}{4}$ " diameter headed studs, 6 x 6—10/10 mesh, and 4" sand-gravel concrete slab.

Test B Identical to Test A except expanded shale concrete replaced the sand-gravel concrete.

	Test A	Test B
Actual Test Failure Moment (kip-in)	2927	2920
Calculated Ultimate Failure Moment (kip-in)	2750	2685

Conclusions

Based on the above and test load-deflection curves the concrete slab can be considered as though it were solid concrete in computing elastic section properties for calculation of stresses and deflections. The Keystone composite deck section provides adequate concrete cover around headed studs to develop the full shear capacity of the studs. The composite beam design procedure published by A.I.S.C. may be used.

Tests conducted at Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa.

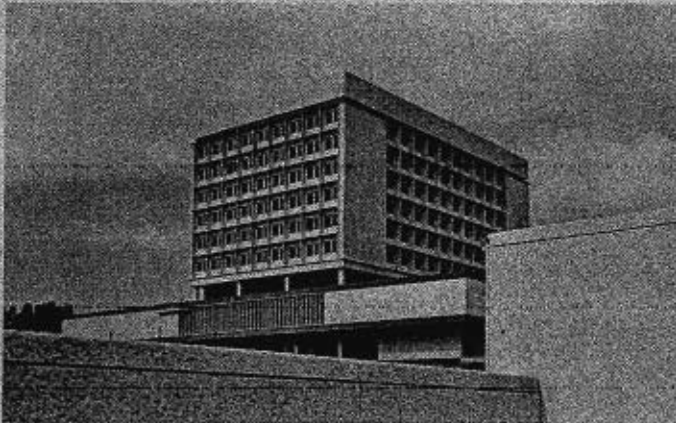


Keystone deck—section 69—used with composite beam design.

Headed Stud Shear Connectors	Allowable Horizontal Shear Load (kips) (Applicable only to concrete made with A.S.T.M. C33 aggregates)		
	$f'_c = 3,000$	$f'_c = 3,500$	$f'_c = 4,000$
$\frac{1}{2}$ " dia. x 2"	5.1	5.5	5.9
$\frac{3}{8}$ " dia. x 2 $\frac{1}{2}$ "	8.0	8.6	9.2
$\frac{3}{4}$ " dia. x 3"	11.5	12.5	13.3
$\frac{7}{8}$ " dia. x 3 $\frac{1}{2}$ "	15.6	16.8	18.0

f'_c —Specified compression strength of concrete at 28 days.

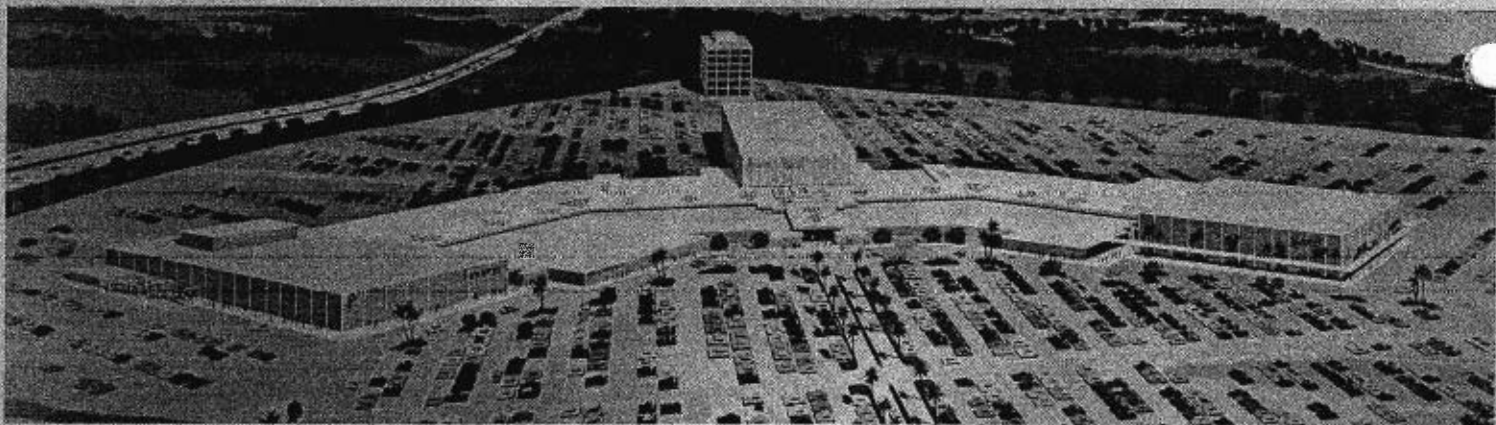
Typical Keystone Composite Floor Installations



HOSPITAL—NEBRASKA METHODIST HOSPITAL, OMAHA, NEB.
Hennington, Durham and Richardson, Designers
Mead and Mount Construction Co., Contractor
KEYSTONE COMPOSITE FLOOR



SCHOOL—SHARON SCHOOL BOARD AUTHORITY, SHARON, PA.
Hunter-Heiges & Associates, Architects and Structural Engineers
Mellon Stuart, Contractor
KEYSTONE COMPOSITE FLOOR



SHOPPING CENTER—PALM BEACH MALL, WEST PALM BEACH, FLA.
Edward J. DeBarto Corp., Designer and Contractor
KEYSTONE COMPOSITE FLOOR

The information contained herein is not intended to be used for design purposes, and the H. H. Robertson Company reserves the right to change or withdraw such information, or the designs and details of the products upon which it is based, either wholly or in any portion thereof, without further notice. Specific information required for design and detailing of specific jobs is available upon request and should be obtained from your Robertson sales representative.

H. H. ROBERTSON COMPANY



PITTSBURGH, PA.

PLANTS IN AMBRIDGE & ZELIENOPLE, PA., CONNERSVILLE, IND., ST. LOUIS, MO., LOS ANGELES & STOCKTON, CAL.

SUBSIDIARIES, PLANTS OR SALES OFFICES IN THESE COUNTRIES: AUSTRALIA, AUSTRIA, BELGIUM, CANADA, DENMARK, FINLAND, FRANCE, GERMANY, HOLLAND, IRELAND, ITALY, NORWAY, SOUTH AFRICA, SWITZERLAND, SPAIN, SWEDEN, UNITED KINGDOM.

AGENTS IN ADEN, ARGENTINA, BAHAMAS, BAHRAIN, BARBADOS, BRAZIL, CEYLON, CHILE, COLOMBIA, FIJI ISLANDS, GREECE, GRENADA, GUAM, GUYANA, HONG KONG, ICELAND, INDIA, IRAN, IRAQ, JAMAICA, KUWAIT, LEBANON, LIBYA, MADAGASCAR, MALAYSIA (WESTERN), MAURITIUS, NEW ZEALAND, OKINAWA, PAKISTAN, PHILIPPINES, PORTUGAL, SAUDI ARABIA, SINGAPORE, SUDAN, THAILAND, TRINIDAD, TURKEY, VENEZUELA, VIETNAM.