LEGACY REPORT

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Legacy report on the 1997 *Uniform Building Code*™

DIVISION: 05—METALS
Section: 05090—Metal Fastenings

STEEL DECK DIAPHRAGMS ATTACHED WITH TEKS® AND I.C.H. TRAXX® SCREWS

ITW BUILDEX
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1.0 SUBJECT

Steel Deck Diaphragms Attached with TEKS® and I.C.H. TRAXX® Screws.

2.0 DESCRIPTION

2.1 General:

Roof deck diaphragms composed of single sheet steel panels having a depth of $1^1/_2$ inches, flute spacing of 6 inches and nestable-type sidelaps, may be fastened to supporting steel elements and stitched to each other with TEKS and I.C.H. TRAXX self-drilling, self-tapping metal screws. See Figure 1. The steel decking panels must be not less than 24 inches in width and conform to ASTM A 446-76 (81), Grade A or ASTM A 611-82 Grade C steel, with a minimum yield strength of 33,000 pounds per square inch. The panels are No. 16, 18, 20 or 22 gage sheet steel having a standard, narrow intermediate or wide rib configuration. The decking must be designed to support all superimposed loads.

Screws connecting individual panels to the diaphragm perimeter framing and to each interior bearing support are No. 12 24-by-$1^1/_4$-inch-long TEKS 5 and I.C.H. TRAXX 5 hexhead washer or No. 12-24-by-$^7/_8$-inch-long TEKS 4 and I.C.H. TRAXX 4 hexhead washer. TEKS and I.C.H. TRAXX 4 and 5 screws, when applied through minimum No. 22 gage decking into structural steel supports have an uplift resistance of 500 pounds. TEKS 4 or I.C.H. TRAXX 4 is used where structural steel supports are between $^3/_{16}$ and $^1/_4$ inch thick; TEKS 5 and I.C.H. TRAXX 5 are used where structural steel supports are between $^1/_4$ and $^1/_2$ inch thick. Screws connecting individual panels along longitudinal seams are 10-16 by $^3/_4$ TEKS 1; 12-14 by $^3/_4$ TEKS 1; 12-14 by $^7/_8$ I.C.H. TRAXX 1; and 10-14 by $^7/_8$ I.C.H. TRAXX 1. The number and required spacing of screws for various decking spans together with the allowable diaphragm shears per lineal foot of panel are shown in Tables 1 and 2. Diaphragm flexibility limitations for use with the F factors in Tables 1 and 2 are shown in Table 3.

2.2 Concrete Diaphragms with Steel Decks:

Concrete fill over steel decks may be used as diaphragms. Steel decks are $1^1/_2$-inch, 2-inch, or 3-inch deep with cross sections (deck types) as shown in Figures Nos. 4 through 7. The steel is ASTM A 446-76 (81), Grade A or ASTM A 525 with G60 coating. Painted or phosphatized coating systems may also be used. Steel deck thickness ranges from No. 16 to No. 22 gage.

Steel deck panels are fastened to structural steel members with TEKS and I.C.H. TRAXX screws. The minimum structural steel supports are between $^3/_{16}$ and $^1/_4$ inch thick. Fasteners are installed through the steel deck into the supporting structural steel members with tools recommended by Buildex.

The TEKS and I.C.H. TRAXX fasteners are manufactured from steel conforming to AISI 1022 with a minimum tensile strength of 138,000 psi case hardened to a minimum core hardness of 30 Rockwell C. Each fastener has an allowable uplift of 500 pounds in resisting wind uplift forces with no increase permitted.

The deck may be fastened to supports and members parallel to flutes using approved steel shear studs as indicated in Figure 6. Studs may replace the required TEKS and I.C.H. TRAXX screws.

Concrete fill must have a minimum strength of f'_c =3,000 psi with either normal-weight aggregate conforming to ASTM C 33-86 or lightweight coarse aggregate conforming to ASTM C 330-85. Allowable diaphragm shears are shown in Table 4.

Unless noted otherwise, a minimum of 6-inch by 6-inch—W1.4 X W1.4 welded-wire fabric is placed 1 inch from the top of the concrete. If diaphragm concrete thickness is greater than shown in Table 4, the minimum wire fabric must have an area in square inches per foot in each direction of 0.010 times the thickness of fill in inches.

2.3 Diaphragm Design Considerations:

The diaphragm design must take into account the following considerations:

a. Diaphragm classification (flexible or rigid) must comply with Section 1630.6 of the 1997 *Uniform Building Code*™ (UBC); the diaphragm deflection (Δ) must be calculated using the equations noted in Table 3.
b. Diaphragm flexibility limitations shall comply with Table 3.
c. Diaphragm deflection limits shall comply with Section 1633.2.9 of the UBC.
d. Horizontal shears must be distributed in accordance with Sections 1630.6 and 1630.7 of the UBC.

2.4 Special Inspection: Concrete:

Continuous special inspection for concrete and concrete reinforcement complies with Sections 1701.1 and 1701.5 of the code. Inspector responsibilities include sampling and testing, verification of concrete mixes, verification of reinforcement and placement, and concrete placement.

2.5 Identification:

TEKS screws are identified by a BX or BX' marking. I.C.H. TRAXX screws are identified by a cone indentation on the screwhead. Screws are packed in containers with labels noting the screw type and the ITW Buildex name and address.

3.0 EVIDENCE SUBMITTED

Full-scale diaphragm load tests, small-scale fastener shear and tension tests, descriptive details and structural calculations, and a quality control manual.

4.0 FINDINGS

That steel deck diaphragms attached with TEKS and I.C.H. TRAXX screws comply with the 1997 *Uniform Building Code*™, subject to the following conditions:

4.1 Diaphragm construction complies with this report.

4.2 Shear loads on diaphragms do not exceed allowable values in Tables 1 and 2.

4.3 No increase in allowable shear values is permitted for wind and seismic loading.

4.4 Allowable deck spans for vertical loading are limited by sectional properties and allowable stresses of specific panels.

4.5 Special inspection for concrete is provided according to Section 2.3.

This report is subject to re-examination in two years.

TABLE 1—TYPICAL STEEL DECK DIAPHRAGMS FASTENED WITH TEKS OR I.C.H. TRAXX SCREWS $1^1/_2$-INCH DECK WITH FLUTES 6 INCHES ON CENTER[1]

DECK GAGE AND THICKNESS		TEKS OR I.C.H. TRAXX PATTERN AT SUPPORTS – 3 (24″ PANEL) OR 4 (30″ OR 36″ PANEL) {2}											
		SPACING OF TEKS OR I.C.H. TRAXX AS SEAMS IN INCHES{3}											
		24"				18"				12"			
		SPAN IN FEET				SPAN IN FEET				SPAN IN FEET			
		4	6	8	10	4	6	8	10	4	6	8	10
16	q	540	470	430	410	660	580	550	530	890	820	780	760
(.0598)	F	5.9+134.6R	5.2+89.8R	4.7+67.3R	4.4+53.9R	5.3+134.6R	4.6+89.8R	4.2+67.3R	3.9+53.9R	4.4+134.6R	3.9+89.8R	3.5+67.3R	3.3+53.9R
18	q	380	340	320	310	470	430	410	400	660	620	600	590
(.0478)	F	8.0+188.4R	6.8+125.6R	6.0+94.2R	5.5+75.4R	6.9+188.4R	5.9+125.6R	5.3+94.2R	4.9+75.4R	5.7+188.4R	4.9+125.6R	4.4+94.2R	4.1+75.4R
20	q	240	230	220	220	310	300	290	290	450	440	430	430
(.0359)	F	11.8+289.4R	9.5+193.0R	8.2+144.7R	7.4+115.8R	9.9+289.4R	8.1+193.0R	7.1+144.7R	6.5+115.8R	7.9+289.4R	6.6+193.0R	5.9+144.7R	5.5+115.8R
22	q	180	180	180	180	240	240	240	230	360	360	350	350
(.0299)	F	15.0+380.8R	11.7+253.9R	10.0+190.4R	9.0+152.3R	12.4+380.8R	9.9+253.9R	8.6+190.4R	7.8+152.3R	9.7+380.8R	8.0+253.9R	7.1+190.4R	6.6+152.3R
DECK GAGE AND THICKNESS		NUMBER OF TEKS OR I.C.H. TRAXX AT SEAMS EQUALLY SPACED BETWEEN SUPPORTS {4}											
		1				2				3			
		SPAN IN FEET				SPAN IN FEET				SPAN IN FEET			
		4	6	8	10	4	6	8	10	4	6	8	10
16	q	540	350	250	200	720	470	340	270	890	580	430	340
(.0598)	F	5.9+134.6R	6.2+89.8R	6.5+67.3R	6.8+53.9R	5.0+134.6R	5.2+89.8R	5.4+67.3R	5.6+53.9R	4.4+134.6R	4.6+89.8R	4.7+67.3R	4.9+53.9R
18	q	380	250	180	140	520	340	250	200	660	430	320	250
(.0478)	F	8.0+183.4R	8.4+125.6R	8.7+94.2R	9.0+75.4R	6.6+188.4R	6.8+125.6R	7.0+94.2R	7.2+75.4R	5.7+188.4R	5.8+125.6R	6.0+94.2R	6.2+75.4R
20	q	240	160	120	90	350	230	170	130	450	300	220	180
(.0359)	F	11.8+289.4R	12.1+193.0R	12.5+144.7R	12.9+115.8R	9.2+289.4R	9.5+193.0R	9.7+144.7R	9.9+115.8R	7.9+289.4R	8.1+193.0R	8.2+144.7R	8.4+115.8R
22	q	180	120	80	70	270	180	130	110	360	240	180	140
(.0299)	F	15.0+380.8R	15.4+253.9R	15.8+190.4R	16.2+152.3R	11.5+380.8R	11.7+253.9R	12.0+190.4R	12.2+152.3R	9.7+380.8R	9.9+253.9R	10.0+190.4R	10.2+152.3R

[1]*q*—Allowable shear on diaphragm in pounds per foot.
F—Flexibility factor: The average microinches a diaphragm web will deflect in a span of 1 foot under a shear of 1 pound per foot. (Refer to Table 3 of this report.)
R—Ratio of vertical load span of deck to length of each deck panel.

[2]Place one screw at the overlapping seams and one at the center flute for 24-inch-wide panels. Place one screw at the overlapping seams and one at each flute closest to the center of the cross section for 30-inch-wide panels. Attachment spacings are typical at all decking interior bearings and perimeter supports normal to the flutes.

[3]The spacing of screws a_s to chords, struts and shear transfer elements parallel to the panel flutes is equal to:
$a_s = 11600\ t/q_a$
a_s = Center-to-center spacing, in feet, of screws
t = Base metal thickness of deck sheet, in inches
q_a = Actual shear on diaphragm, in pounds per foot.
The equation is also applicable for the spacing of fasteners along an overlapping seam in which either adjacent panel is cut to less than 24 inches in width.

[4]The number of screws indicated does not include those in the overlapping seams at the interior bearings and perimeter supports normal to the flutes required by Footnote 2 above.

TABLE 2—TYPICAL STEEL DECK DIAPHRAGMS FASTENED WTH TEKS OR I.C.H. TRAXX SCREWS $1^1/_2$-INCH DECK WITH FLUTES 6 INCHES ON CENTER[1,3]

DECK GAGE AND THICKNESS		TEKS OR I.C.H. TRAXX PATTERN AT SUPPORTS – 6″ O.C. {2}											
		SPACING OF TEKS AT SEAMS IN INCHES											
		24"				18"				12"			
		SPAN IN FEET				SPAN IN FEET				SPAN IN FEET			
		4	6	8	10	4	6	8	10	4	6	8	10
16	q	620	520	470	430	740	630	580	550	970	870	820	790
(.0598)	F	5.5+16.8R	5.0+11.2R	4.6+8.4R	4.3+6.7R	5.0+16.8R	4.5+11.2R	4.1+8.4R	3.9+6.7R	4.3+16.8R	3.8+11.2R	3.5+8.4R	3.3+6.7R
18	q	430	370	340	320	520	470	440	420	710	650	630	610
(.0478)	F	7.4+23.6R	6.5+15.7R	5.9+11.8R	5.5+9.4R	6.6+23.6R	5.7+15.7R	5.2+11.8R	4.8+9.4R	5.5+23.6R	4.8+15.7R	4.4+11.8R	4.2+9.4R
20	q	270	250	240	230	340	320	310	300	480	460	440	440
(.0359)	F	10.9+36.2R	9.1+24.1R	8.1+18.1R	7.4+14.5R	9.4+36.2R	7.9+24.1R	7.0+18.1R	6.5+14.5R	7.7+36.2R	6.5+24.1R	5.9+18.1R	5.5+14.5R
22	q	200	190	190	180	260	250	250	240	380	370	360	360
(.0299)	F	13.9+47.6R	11.3+31.7R	9.9+23.8R	8.9+19.0R	11.8+47.6R	9.6+31.7R	8.5+23.8R	7.9+19.0R	9.4+47.6R	7.9+31.7R	7.1+23.8R	6.6+19.0R
DECK GAGE AND THICKNESS		NUMBER OF TEKS OR I.C.H. TRAXX AT SEAMS EQUALLY SPACED BETWEEN SUPPORTS {4}											
		1				2				3			
		SPAN IN FEET				SPAN IN FEET				SPAN IN FEET			
		4	6	8	10	4	6	8	10	4	6	8	10
16	q	620	400	290	220	800	520	380	300	970	630	470	370
(.0598)	F	5.5+16.8R	5.8+11.2R	6.1+8.4R	6.5+6.7R	4.8+16.8R	5.0+11.2R	5.2+8.4R	5.4+6.7R	4.3+16.8R	4.5+11.2R	4.6+8.4R	4.8+6.7R
18	q	430	280	200	160	570	370	270	220	710	470	340	270
(.0478)	F	7.4+23.6R	7.8+15.7R	8.2+11.8R	8.5+9.4R	6.3+23.6R	6.5+15.7R	6.7+11.8R	7.0+9.4R	5.5+23.6R	5.7+15.7R	5.9+11.8R	6.1+9.4R
20	q	270	180	130	100	380	250	180	140	480	320	240	190
(.0359)	F	10.9+36.2R	11.3+24.1R	11.8+18.1R	12.2+14.5R	8.8+36.2R	9.1+24.1R	9.4+18.1R	9.6+14.5R	7.7+36.2R	7.9+24.1R	8.1+18.1R	8.3+14.5R
22	q	200	130	100	80	290	190	140	110	380	250	190	140
(.0299)	F	13.9+47.6R	14.4+31.7R	14.9+23.8R	15.3+19.0R	11.0+47.6R	11.3+31.7R	11.6+23.8R	11.9+19.0R	9.4+47.6R	9.6+31.7R	9.9+23.8R	10.0+19.0R

[1] *q*—Allowable shear on diaphragm in pounds per foot.
F—Flexibility factor: The average microinches a diaphragm web will deflect in a span of 1 foot under a shear of 1 pound per foot. (Refer to Table 3 of this report.)
R—Ratio of vertical load span of deck to length of each deck panel.

[2] Place one screw at the overlapping seam and in each flute at all interior bearings and perimeter supports normal to the flutes.

[3] The spacing of screws a_s to chords, struts and shear transfer elements parallel to the panel flutes is equal to:
$a_s = 11600\ t/q_a$
a_s = Center-to-center spacing, in feet, of screws
t = Base metal thickness of deck sheet, in inches
q_a = Actual shear on diaphragm, in pounds per foot.

The equation is also applicable for the spacing of fasteners along an overlapping seam in which either adjacent panel is cut to less than 24 inches in width.

[4] The number of screws indicated does not include those in the overlapping seams at the interior bearings and perimeter supports normal to the flutes required by Footnote 2 above.

TABLE 3—DIAPHRAGM FLEXIBILITY LIMITATION[1,2,3,5]

F	MAXIMUM SPAN IN FEET FOR MASONRY OR CONCRETE WALLS	SPAN-DEPTH LIMITATION			
		ROTATION NOT CONSIDERED IN DIAPHRAGM		ROTATION CONSIDERED IN DIAPHRAGM	
		MASONRY OR CONCRETE WALLS	FLEXIBLE WALLS{4}	MASONRY OR CONCRETE WALLS	FLEXIBLE WALLS{4}
More than 150	Not used	Not used	2:1	Not used	1-1/2:1
70-150	200	2:1 or as required for deflection	3:1	Not used	2:1
10-70	400	2-1/2:1 or as required for deflection	4:1	As required for deflection	2-1/2:1
1-10	No limitation	3:1 or as required for deflection	5:1	As required for deflection	3:1
Less than 1	No limitation	As required for deflection	No limitation	As required for deflection	3-1/2:1

[1]Roof diaphragms are to be investigated regarding their flexibility and recommended span-depth limitations. Refer to above tables for determination of value of "F".

[2]Roof diaphragms supporting masonry or concrete walls are to have their deflections limited to the following amount:

$$\Delta wall = \frac{H^2 f c}{0.01 E t}$$

Where:

H = Unsupported height of wall, in feet.

t = Thickness of wall, in inches.

E = Modulus of elasticity of wall material for deflection determination in pounds per square inch.

f_c = Allowable compressive strength of wall material in flexure in pounds per square inch.
For concrete: $fc = 0.45 f'_c$. For masonry: $fc = Fb = 0.33 f'm$.

[3]The total deflection of the diaphragm may be computed from the equation:

$$\Delta = \Delta_f + \Delta_w$$

Where:

Δ_f = Flexural deflection of the diaphragm determined in the same manner as the deflection of beams.

Δ_w = The web deflection may be determined by the equation:

$$\Delta_w = \frac{q_{ave} L_t F}{10^6}$$

Where:

L_t = Distance in feet between vertical resisting element (such as shear wall) and the point to which the deflection is to be determined.

q_{ave} = Average shear in diaphragm in pounds per foot over length.

F = Flexibility factor: The average microinches a diaphragm web will deflect in a span of 1 foot under a shear of 1 pound per foot.

[4]When applying these limitations to cantilevered diaphragms, the allowable span-depth ratio will be half that shown.

[5]Diaphragm classification (flexible or rigid) and deflection limits shall comply with Section 2.3 of this report.

TABLE 4—ALLOWABLE DIAPHRAGM SHEARS[1,2,3,4] (IN POUNDS PER FOOT)

CONCRETE TYPE[5]	CONCRETE THICKNESS[6] (in inches)	SPACING OF $^{1}/_{2}$-INCH-DIAMETER STUDS (IN INCHES)				(*G′*)[7]
		16	18	24	32	
NW	2	3,780	3,780	3,400	2,550	2,500
LW	2	3,540	3,540	2,900	2,175	1,786
NW	$2^{1}/_{2}$	4,730	4,530	3,400	2,550	3,125
LW	$2^{1}/_{2}$	4,350	3,860	2,900	2,180	2,222
LW	$3^{1}/_{4}$	4,350	3,860	2,900	2,180	2.941

[1]The values given in the table are for slabs reinforced with wire mesh having an area of at least 0.0025 times the gross area of concrete. This requirement is satisfied by welded-wire fabric, 6 x 6—W4 x W4 for 2 inch and $2^{1}/_{2}$-inch-thick slabs. For $3^{1}/_{4}$-inch-thick slabs, the requirement is satisfied by welded-wire fabric 4 x 4—W4 x W4.

[2]Deck-types A, B, C and D shall use $^{1}/_{2}$-inch-diameter studs. Deck-types F and G shall use $^{5}/_{8}$-inch-diameter studs. Deck-type E shall use $^{3}/_{4}$-inch-diameter studs and the tabular shears shall be reduced by a factor of 0.74.

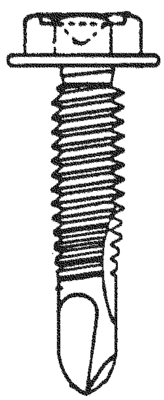
[3]See Figures 4 through 7 for qualifying deck types.

[4]For local shear transfer within the field of the diaphragm, $^{1}/_{2}$-inch-diameter studs having shear values of 6.8K per stud for normal-weight concrete fills and 5.8K per stud for lightweight concrete, except as noted hereafter, shall be used. For deck-types F and G, $^{5}/_{8}$-inch-diameter studs with values of 8.6K and 7.4K, respectively shall be used. For deck-type A, values of 5.7K and 4.9K, respectively, shall be used. For deck-type E, $^{3}/_{4}$-inch-diameter studs with values of 3.5K and 3.0K, respectively, shall be used.

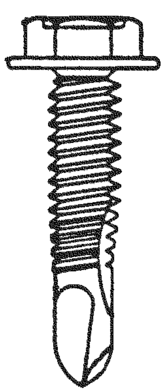
[5] NW = Normal weight (145 pcf).
LW = Lightweight (115± pcf).

[6]Concrete is measured from top flute of metal deck.

[7]*G′* = Diaphragm shear stiffness (kips/inch)

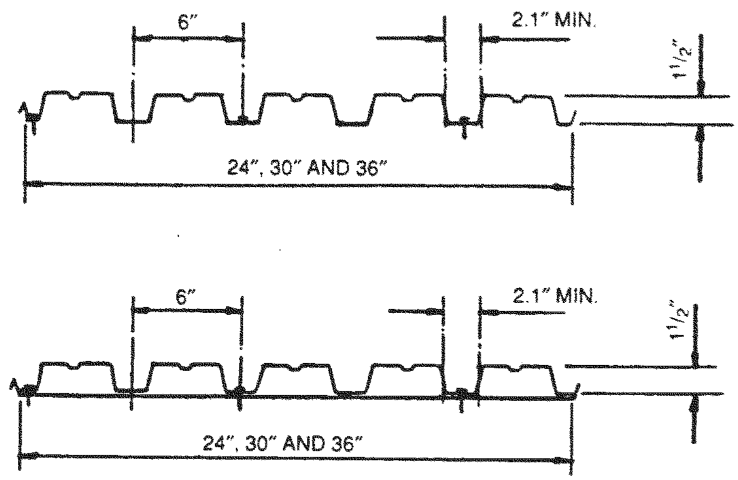


I.C.H. TRAXX SCREW

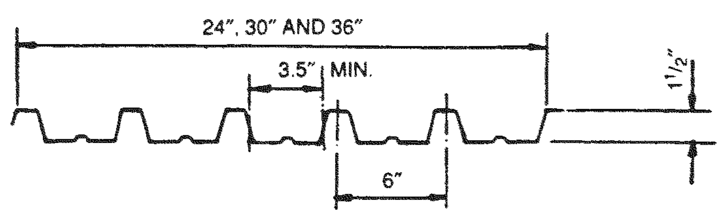


TEKS SCREW

FIGURE 1

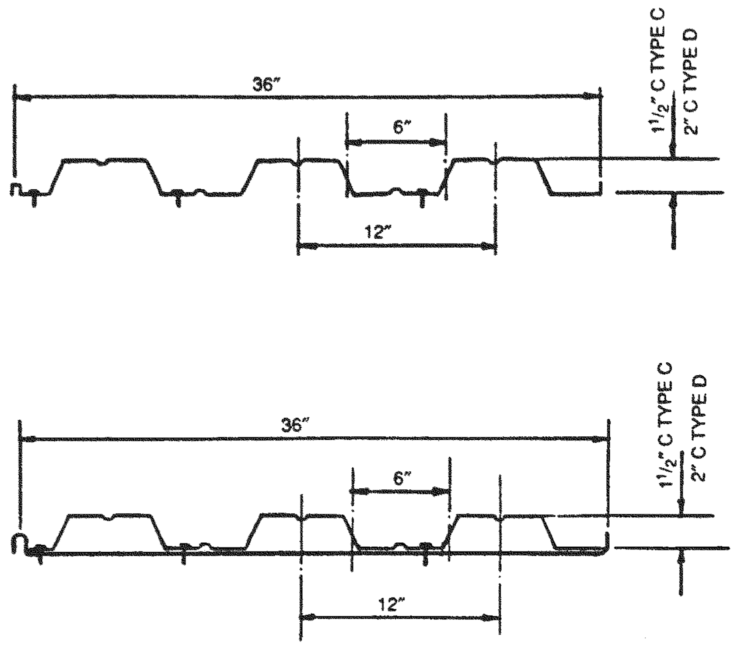


TYPE A



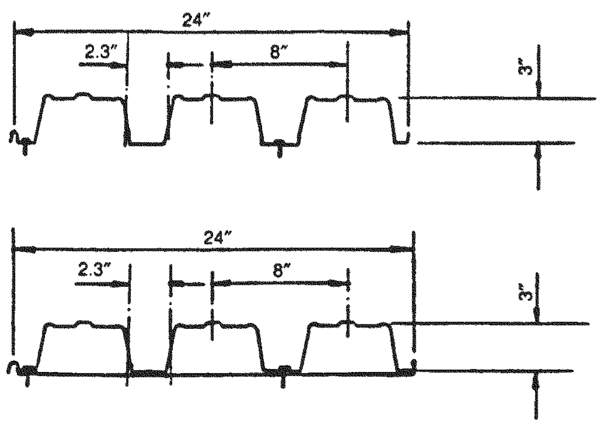
TYPE B

FIGURE 2

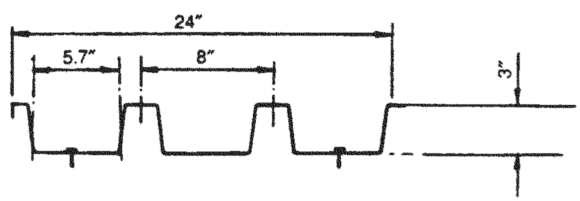


TYPE C AND TYPE D

FIGURE 3

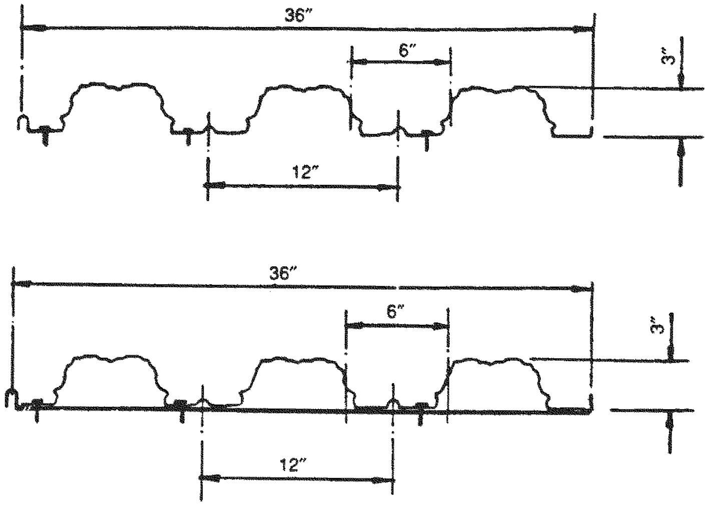


TYPE E



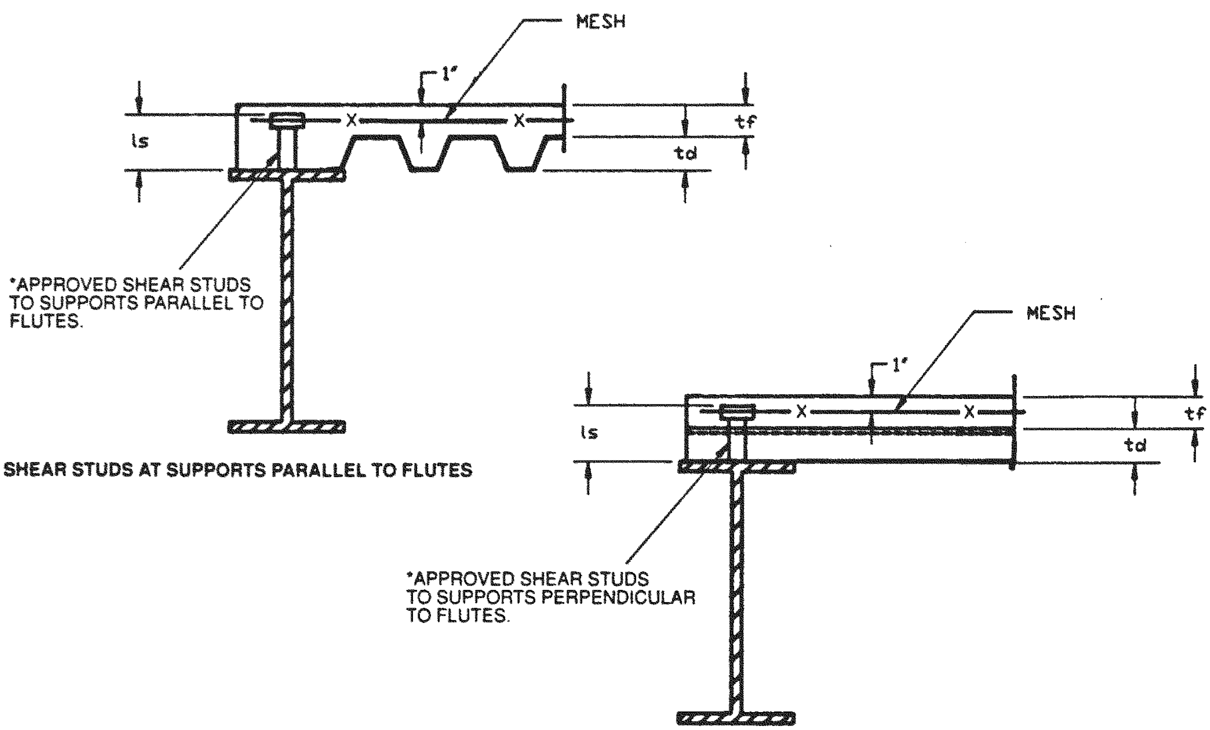
TYPE F

FIGURE 4



TYPE G

FIGURE 5



SHEAR STUDS AT SUPPORTS PARALLEL TO FLUTES

SHEAR STUDS AT SUPPORTS PERPENDICULAR TO FLUTES

t_d	STUD LENGTH l_S
$1^1/_2$"	3"
2"	$3^1/_2$"
3"	$4^1/_2$"

TYPICAL EXTERIOR OR INTERIOR SHEAR TRANSFER STUDS

FIGURE 6