How to Stiffen a Panel

1. INCREASING PANEL RIGIDITY

The efficient use of materials is the first essential to lower cost designs. One way to achieve such efficiency is to use lighter-gage plate that is easily fabricated and to add stiffeners as necessary for the required rigidity.

Regardless of how flexible or rigid the stiffeners are, they will increase the stiffness of the whole panel by increasing the moment of inertia (I) of the member panel sections.

The usual method is to consider a section of the panel having a width equal to the distance between centers of the stiffeners.* In this manner, just one stiffener will be included in the panel section. The resulting moment of inertia (I) of the stiffener and the section of the panel may be found from the following formula:

$$\boxed{I = I_s + \frac{A_p\, t^2}{12} + \frac{A_s\, A_p\, d^2}{A_s + A_p}} \quad \cdots\cdots\cdots\cdots (1)$$

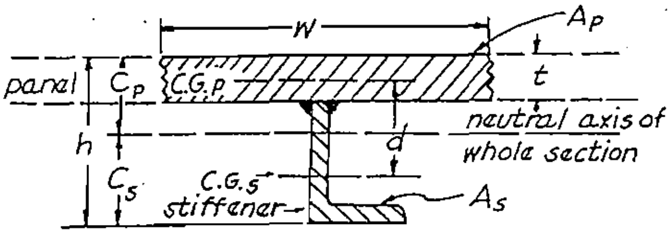


FIGURE 2

where:

- W = distance between stiffeners, in.
- d = distance between center of gravity of panel and that of stiffener, in.
- A_p = cross-sectional area of plate within distance b, in.^{2}
- ** A_s = cross-sectional area of stiffener, in.^{2}
- t = thickness of panel, in.
- ** I_s = moment of inertia of stiffener, in.^{4}

*If there is any question about the distance between stiffeners becoming too great, Section 2.12 will provide some guidance.
**Data obtained from any steel handbook

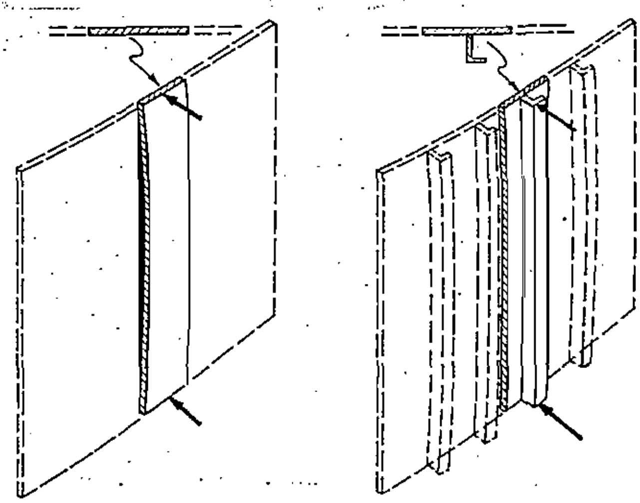


FIGURE 1

In figuring the maximum bending stress in this built-up section, the following distances to the outer fibers must be known.

$$\boxed{c_p = \frac{A_s\, d}{A_s + A_p} + \frac{t}{2}} \quad \cdots\cdots\cdots\cdots (2)$$

$$\boxed{c_s = h - c_p = h - \frac{t}{2} - \frac{A_s\, d}{A_s + A_p}} \quad \cdots\cdots (3)$$

where:

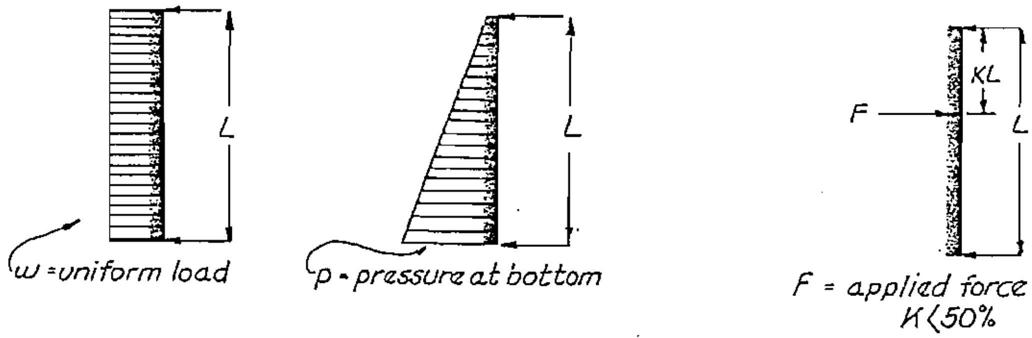
c_p = distance from neutral axis of whole section to outer fiber of plate, in.

c_s = distance from neutral axis of whole section to outer fiber of stiffener, in.

The panel section may then be treated as a simply supported beam and designed with sufficient moment of inertia (I) to withstand whatever load is applied. Use a 1" wide strip of this panel, and use uniform load of (w) lbs per linear inch; if entire width of panel (b), use uniform pressure of (p) psi.

Figure 3 illustrates the technique of treating a panel section as a beam under three different conditions. Formulas for finding maximum deflection, bending moment, and vertical shear are given, with p being the pressure in psi against the panel.

FIGURE 3—Properties of Panel Section Treated as a Beam



Condition A

$$\boxed{\Delta_{max} = \frac{5\ p\ b\ L^4}{384\ E\ I}} \quad \ldots (4)$$

$$\boxed{M_{max} = \frac{p\ b\ L^2}{8}} \quad \ldots (5)$$

$$\boxed{V_{max} = \frac{p\ b\ L}{2}} \quad \ldots (6)$$

Condition B

$$\boxed{\Delta_{max} = 0.00652\ \frac{p\ b\ L^4}{E\ I}} \quad (7)$$

$$\boxed{M_{max} = 0.0642\ p\ b\ L^2} \quad \ldots (8)$$

$$\boxed{V_{max} = \frac{p\ b\ L}{3}} \quad \ldots\ldots (9)$$

Condition C

$$\boxed{\Delta_{max} = \frac{F\ L^3\ K}{27\ E\ I}\ \sqrt{3\ (1 - K^2)^3}} \quad (10)$$

$$\boxed{M_{max} = F\ L\ K\ (1 - K)} \quad \ldots\ldots (11)$$

$$\boxed{V_{max} = F\ (1 - K)} \quad \ldots\ldots (12)$$

(With reference to Figure 3)
If due to weight of liquid or granular material:

$$p = h\ d = .006944\ H\ D$$
$$p = .0361\ h\ s = .4335\ H\ s$$

where:

h = height of liquid or material, in.
H = height of liquid or material, ft
s = specific gravity of liquid or material, lbs/cu in.
d = density of liquid or material, lbs/cu. in.
D = density of liquid or material, lbs/cu ft.

The maximum stress in the outer fibers of either the panel or the stiffener may be found by using the corresponding value of c and the maximum moment (M_{max}) in the following formulas:

for the panel

$$\boxed{\sigma_p = \frac{M_{max}\ c_p}{I}} \quad \ldots\ldots (13)$$

for the stiffener

$$\boxed{\sigma_s = \frac{M_{max}\ c_s}{I}} \quad \ldots\ldots (14)$$

2. RESISTING TORSION

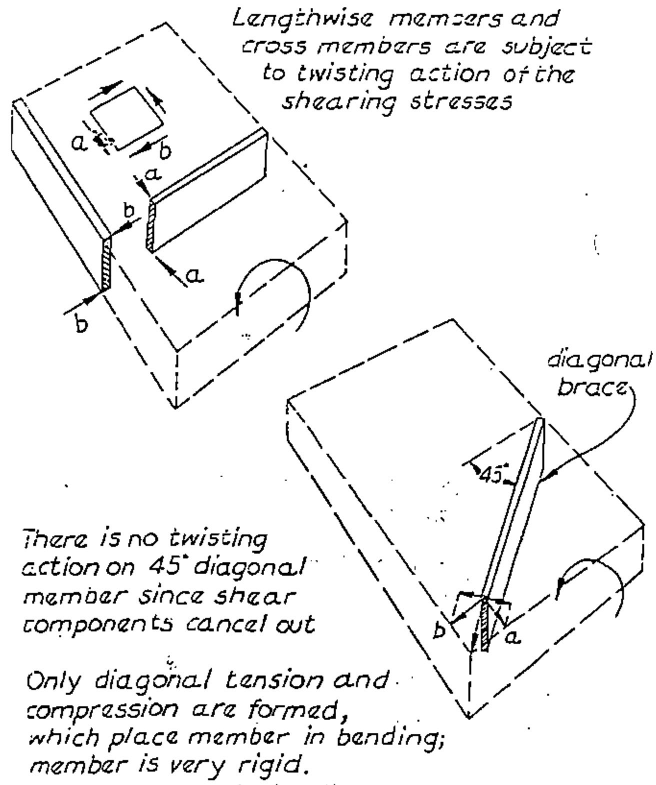


FIGURE 4

Conventional cross stiffeners on a panel do not offer any resistance to twisting. However, if these stiffeners are placed at 45°, they will greatly increase the torsional resistance of a panel. There is no twisting action on the 45° stiffeners because the two components from the longitudinal and transverse shear stresses are equal and opposite and, therefore, cancel out.

3. WELD SIZE

The leg size of the continuous fillet weld required to join a stiffener to the panel may be found from the following formula:

$$\omega = \frac{V\ a\ y}{11{,}200\ I\ n} \quad \text{(E70 welds)}$$

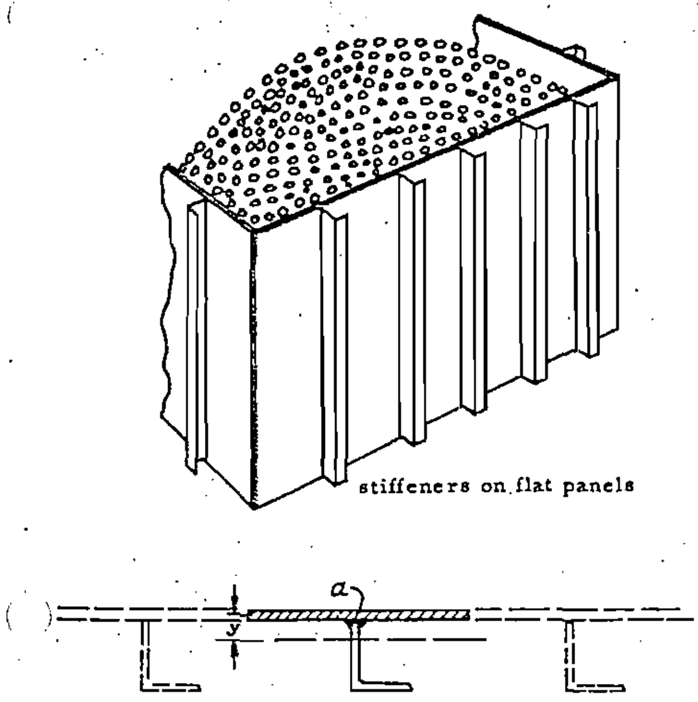


FIGURE 5

where:

ω = leg size of continuous fillet weld, in.

V = total shear on section at a given position along the beam, lbs

a = area held by weld, $in.^2$

y = distance between center of gravity of the area and neutral axis of whole section, in. $= c_p - \frac{1}{2} t$

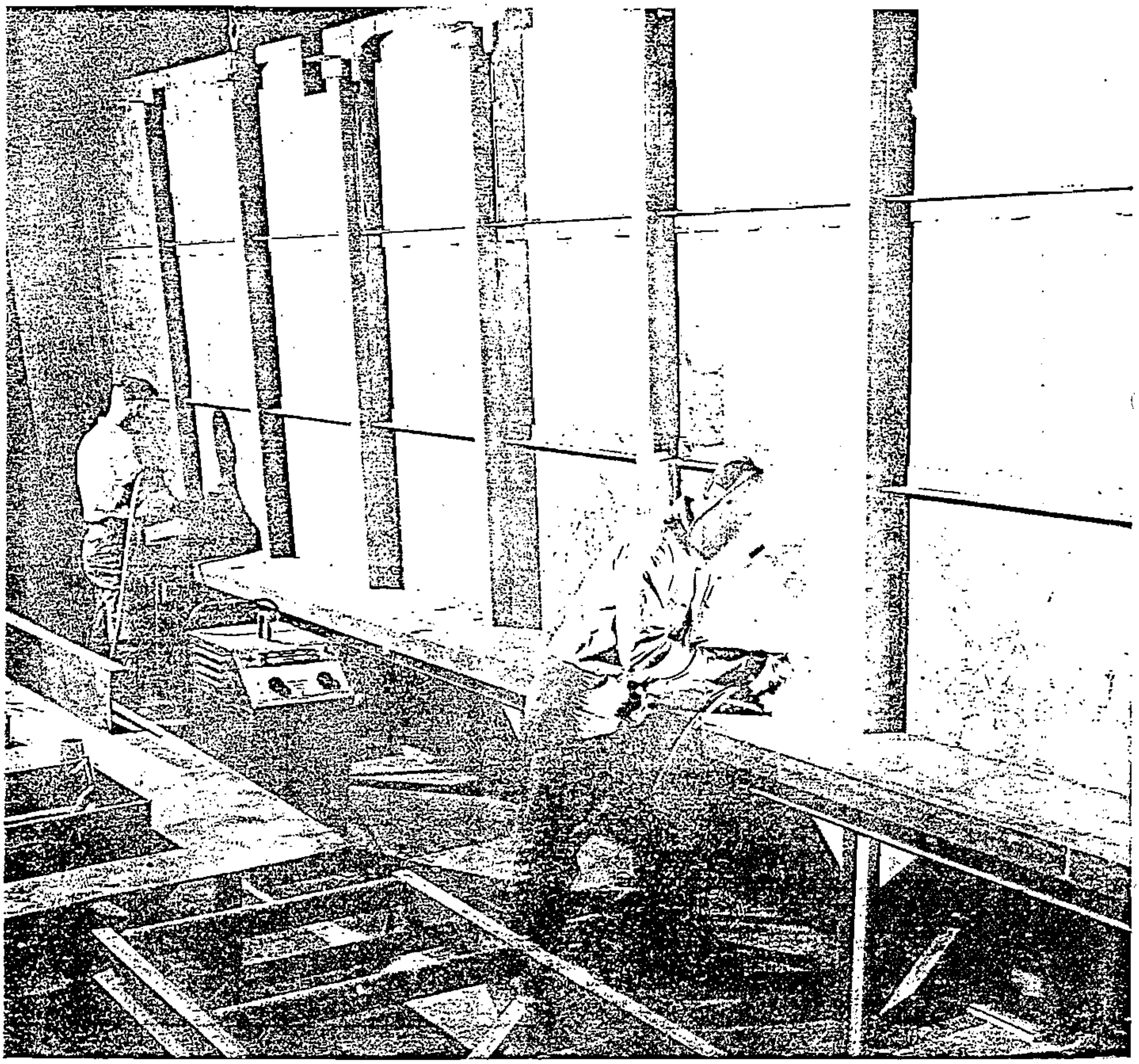
I = moment of inertia of whole section, $in.^4$

n = number of continuous welds joining the stiffener to the panel

If intermittent fillet welds are to be used, calculate the continuous fillet weld leg size expressed as a decimal, and divide this by the actual leg size of intermittent fillet weld used. When expressed as a percentage this will give the amount of intermittent weld to be used per unit length. For convenience, Table 1 has various intermittent weld lengths and distance between centers for a given percentage of continuous weld.

TABLE 1—Intermittent Welds

Percent of Continuous Weld	Length of Intermittent Welds and Distance Between Centers		
75%		3 - 4	
66			4 - 6
60		3 - 5	
57			4 - 7
50	2 - 4	3 - 6	4 - 8
44			4 - 9
43		3 - 7	
40	2 - 5		4 - 10
37		3 - 8	
33	2 - 6	3 - 9	4 - 12
30		3 - 10	
25	2 - 8	3 - 12	
20	2 - 10		
16	2 - 12		



Weld fabrication of large panels, using proper stiffeners, provides required strength and rigidity, while keeping weight to a minimum.