THICKNESS OF OUTSTANDING PLATES IN COMPRESSION

JAPAN INTERNATIONAL COOPERATION AGENCY

(JICA)

3.2.2 Thickness of Outstanding Plates in Compression

The thickness of plate shall be determiend under the condition that the plate does not buckle locally at least up to the yield Point of the material when the ultimate strength of a member is to be considered.

Taking into account of residual stresses, F. Nishino, L. Tall, H. Fukumoto and F. Ito have derived theoretically the characteristics of plate-buckling as shown by solid lines in Fig. 3.2.1 and Fig. 3.2.2.

The experimental values given in the Figs. by marks scatter in wide range as the actual distribution and/or magnitude of residual stresses vary with the cross-sectional shape and thickness of plates, and the size, sequence and method of welding work.

For the local buckling of plates subject to pure axial compressive force the following equation can be derived under the condition of $\sigma_{cr} = \sigma_y$ in the Figs.

$$\frac{b}{t}\sqrt{\frac{\sigma_y}{E} \cdot \frac{12(1-\mu^2)}{\pi^2 k}} \leqq 0.7 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(Eq. 3.2.1)}$$

Where,

- b: width of plate
- t: thickness of plate
- σ_y: yielding stress (kg/cm^2)
- E: Young's modulus (kg/cm^2)
- μ: Poisson's ratio
- k: buckling coefficient
- σ_{cr}: buckling stress of plate

For the local buckling of plates subject to pure bending the equation can be written in the following form, as the effect of residual stresses could be neglected.

$$\frac{b}{t}\sqrt{\frac{\sigma_y}{E} \cdot \frac{12(1-\mu^2)}{\pi^2 k}} \leqq 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(Eq. 3.2.2)}$$

For the plates subject to both compressive force and bending the maximum allowable value of b/t can be written as following equation, assuming that left terms of both equations vary linearly from 0.7 to 1.0.

$$\frac{b}{t} = R_{cr}\sqrt{\frac{\pi^2 E k}{12(1-\mu^2)^{\nu_B}\sigma_{cao}}} \leqq 1 \quad \ldots\ldots\ldots\ldots\ldots \quad \text{(Eq. 3.2.3)}$$

Where,

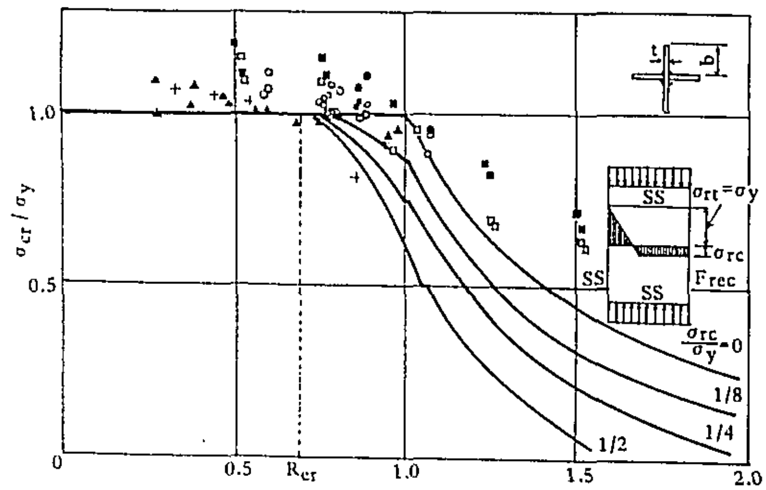
- R_{cr}: buckling parameter ($= 0.70 + 0.15\varphi$)
- ν_B: safety factor ($= 1.7 - 0.15\varphi$)
- σ_{cao}: allowable axial compressive stresses, when slenderness ratio is zero.

$$\varphi = \frac{\sigma_1 - \sigma_2}{\sigma_1}$$

Because in practice it is inconvenient to use the Eq. 3.2.3, it was assumed that the value b/t varies parabolically in the range of stress conditions, namely pure axial compression (φ=0), triangular stress distribution (φ=1) and pure bending (φ=2). Buckling coefficients shown in Fig. 3.2.3 under the various stress and boundary conditions were used in the calculation.

For cantilever plates subject to both bending and compressive force, the minimum thickness was defined to be the same as that subject pure compressive force. Because the former is slightly less than the latter.

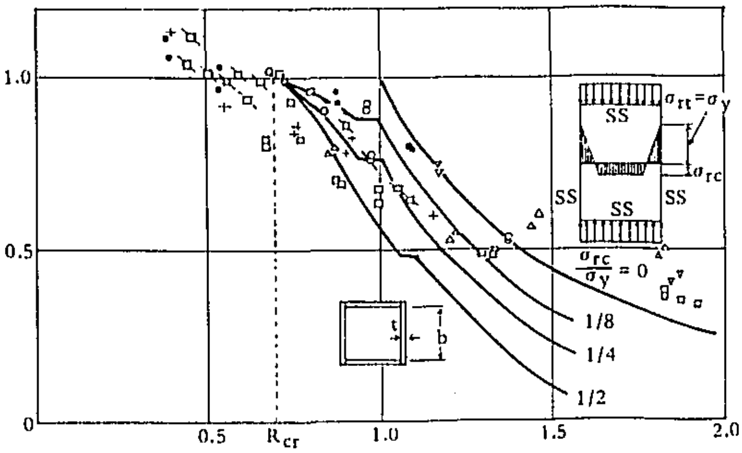
The mitigation shown in Table 3.2.2 was intorduced in the provision of the minimum thickness of plates. The linear relationship $\frac{\sigma_c}{\sigma_{ca}} + \frac{\sigma_b}{\sigma_{bao}} = 1$ was taken into consideration for the case of plates subject to both bending and compressive force.



Marks		σy (kg/mm²)	Reference
▲	Stress released	70.3	(3)
o •	as Weld Stress released	45.7	(4)
+	as Weld	70.3	(5)
□ ■	as Weld Stress released	25.3	(6)

$$R = \frac{b}{t}\sqrt{\frac{\sigma_y}{E} \cdot \frac{12(1-\mu^2)}{\pi^2 k}}$$

Fig. 3.2.1

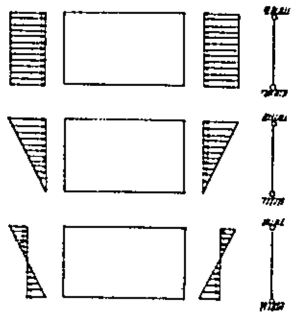


Marks		σ_y (kg/mm²)	Reference
△ ○	as Weld as Weld	27.4 77.2	(7)
□	as Weld	32.6 – 38.5	(8)
+ ●	as Weld Stress released	23.6 – 28.1	(9)
▽ ▲	as Weld Stress released	25.4 – 40.3	(10)
⌀	as Weld Stress released	31.2	(6)
⌑	as Weld	26.9 – 28.1	(11)

$$R = \frac{b}{t}\sqrt{\frac{\sigma_y}{E}\cdot\frac{12\,(1-\mu^2)}{\pi^2\,k}}$$

Fig. 3.2.2

(a) Plate restrained along both edges :



$\varphi = 0 \quad k = 4.0$

$\varphi = 1 \quad k = 7.8$

$\varphi = 2 \quad k = 23.9$

(b) Cantilever plate :

$\varphi = 0 \quad k = 0.43$

Fig. 3.2.3