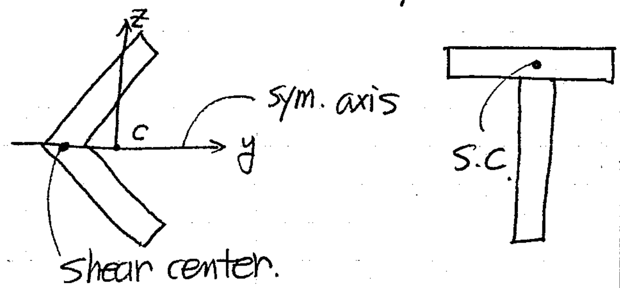
★ Simple rule for S.C.

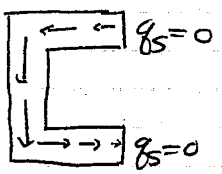
- Shear center is on the sym. axis.



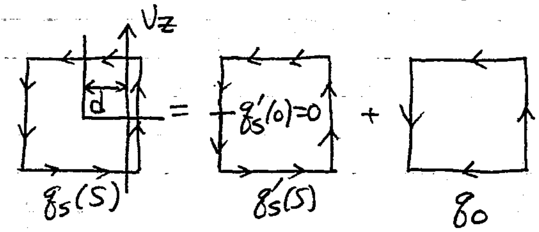
- If all walls meet at a single location, S.C. is the intersection point.

5.3. Closed Thin-Walled Section

Open section



Closed section (no free edge)



$$q_s = q_s' + q_0$$

↳ assuming a free edge

$V_z \cdot d = 2\bar{A} q_0 +$ moment from q_s' — (a)

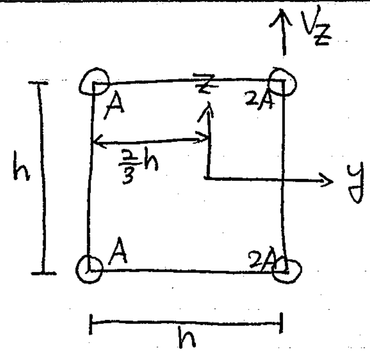
1. Shear Center

Apply V_z at shear center ⇒ no twist

$$\theta = 0 = \frac{1}{2G\bar{A}} \oint \frac{q}{t} ds$$

Use (a) to calculate shear center

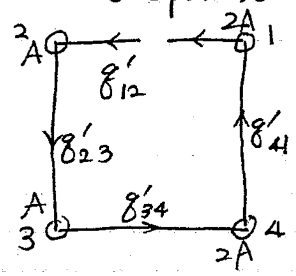
Ex)



thickness = t

$I_y = \frac{3}{2}Ah^2, \quad I_z = \frac{4}{3}Ah^2$

① Assumed open section



$q_{12}' = 0$

$q_{23}' = -\frac{V_z A \cdot \frac{h}{2}}{\frac{3}{2}Ah^2} = -\frac{V_z}{3h}$

$q_{34}' = 0$

$q_{41}' = -\frac{V_z A(-\frac{h}{2})}{\frac{3}{2}Ah^2} = \frac{2V_z}{3h}$

② moment by $q = q' + q_0$ = moment by V_z.

$V_z \cdot 0 = q_{23}' \cdot h^2 + 2\bar{A} q_0$

$\Rightarrow -\frac{V_z}{3h} \cdot h^2 + 2h^2 q_0 = 0$

$\therefore q_0 = \frac{V_z}{6h}$ //

∴ shear flow

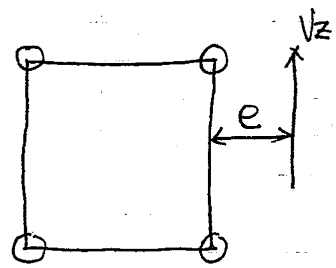
$q_{12} = q_{12}' + q_0 = \frac{V_z}{6h}$

$q_{23} = q_{23}' + q_0 = -\frac{V_z}{6h}$

$q_{34} = q_{34}' + q_0 = \frac{V_z}{6h}$

$q_{41} = q_{41}' + q_0 = \frac{5V_z}{6h}$

③ shear center



Moment equil.

$$V_z e = q_{23}' h^2 + 2h^2 q_0$$

$$= -\frac{V_z}{3h} h^2 + 2h^2 q_0$$

$$\Rightarrow \underline{q_0 = \frac{V_z}{6h^2}(h+3e)}$$ ※ q_0 varies according to e

$$\Rightarrow q_{12} = q_0 = \frac{V_z}{6h^2}(h+3e)$$

$$q_{23} = \frac{V_z}{6h^2}(-h+3e)$$

$$q_{34} = \frac{V_z}{6h^2}(h+3e)$$

$$q_{41} = \frac{V_z}{6h^2}(5h+3e)$$

- calculate e from zero twist cond.

$$\theta = \frac{1}{2G\bar{A}}\left(q_{12}\frac{h}{t} + q_{23}\frac{h}{t} + q_{34}\frac{h}{t} + q_{41}\frac{h}{t}\right) = 0$$

$$\Rightarrow q_{12} + q_{23} + q_{34} + q_{41} = 0$$

$$\Rightarrow \underline{e = -\tfrac{1}{2}h}$$ // inside of section

$$y_{sc} = \frac{h}{3} + e = -\frac{h}{6}.$$

$$z_{sc} = 0 \quad (\text{sym.})$$