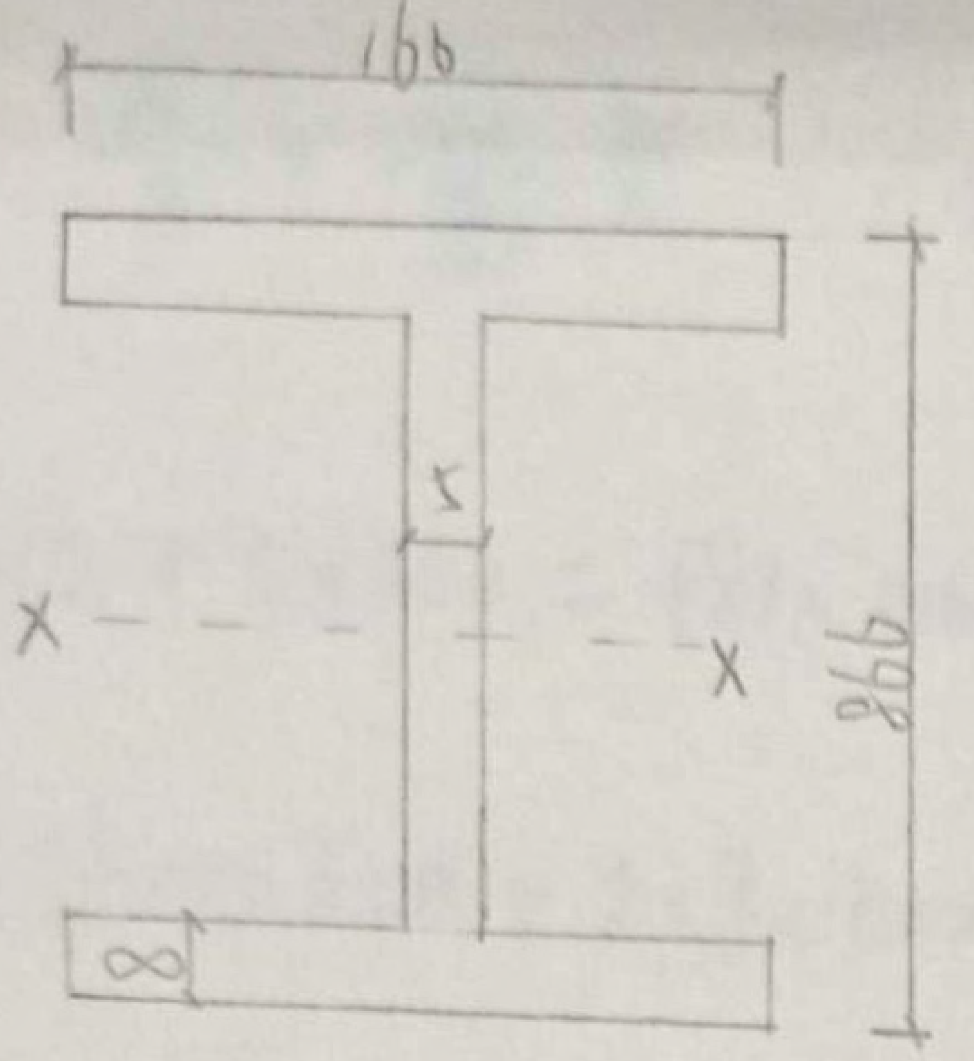
作业1:



$M_x = 185 kN\cdot m$

$N = 55 kN.$

$V = 19 kN$

$f = 215 N/mm^2$ (Q235)

$f_v = 125 N/mm^2$

$a = 850 mm$ (腹板加劲肋间距)

试对该截面进行强度验算。(利用屈曲后强度)

解：

① 求腹板屈曲后受剪承载力设计值 V_d. $V_d = h_w t_w f_v'$.

由于 $\frac{a}{h_0} = \frac{850}{850} = 1.$ $\Rightarrow k_\tau = 5.34 + \frac{4}{(\frac{a}{h_0})^2} = 9.34.$

$\Rightarrow \lambda_w = \frac{h_w/t_w}{37\sqrt{k_\tau}\sqrt{\frac{235}{f_y}}} = \frac{\frac{850}{5}}{37\sqrt{9.34}\cdot\sqrt{\frac{235}{235}}} = 1.50 > 1.4.$

$\Rightarrow f_v' = (1-0.275\lambda_w) f_v = (1-0.275\times1.501)\times125 = 73.44 N/mm^2.$

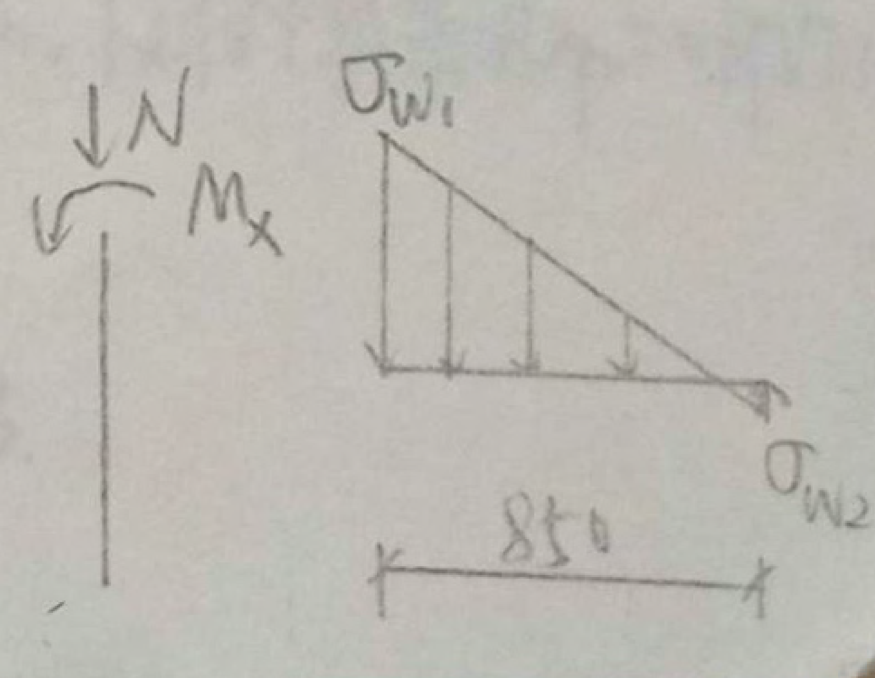
故 $V_d = h_w t_w f_v' = 850\times5\times73.44 = 312.12 kN.$

由于 $V = 19kN \le 0.5V_d = 156.06 kN.$ 故需验算：$\frac{N}{A_e} + \frac{M}{W_e} \le f.$

② 求腹板的有效宽度.

1°. 先判断腹板是否全部受压：记腹板边缘最大压应力为 σ_{w1}.

另一边压应力为 σ_{w2}. 如右图所示.



则 $\sigma_{w1} = \frac{N}{A} + \frac{M_x}{I_x} \cdot \frac{h_w}{2}$，$\sigma_{w2} = \frac{N}{A} - \frac{M_x}{I_x} \cdot \frac{h_w}{2}$.

$A = 8 \times 160 \times 2 + 5 \times 850 = 6810\ mm^2$.

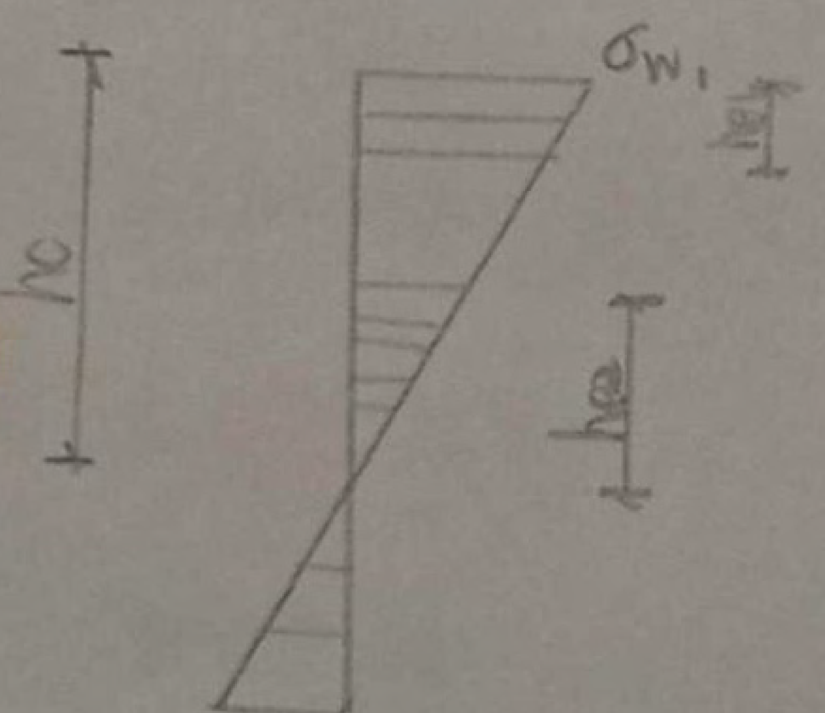
$I_x = \frac{1}{12} \times 5 \times 850^3 + 2 \times 8 \times 160 \times \left(\frac{850}{2} + 4\right)^2$ （忽略翼缘对自身惯性矩）

$= 7.27 \times 10^8\ mm^4$.

$\Rightarrow \sigma_{w1} = \frac{55 \times 10^3}{6810} + \frac{185 \times 10^6 \times 425}{7.27 \times 10^8} = 116.2\ mpa$.　$\sigma_{w2} = \frac{55 \times 10^3}{6810} - \frac{185 \times 10^6 \times 425}{7.27 \times 10^8} = -100.1\ mpa$.

$\sigma_{w2} < 0$，说明腹板部分受拉，故腹板受压区高度 $h_c = \frac{\sigma_{w1}}{\sigma_{w1} + |\sigma_{w2}|} \cdot h_w = 456.6\ mm$.

2°. 求简单腹板有效宽度 h_e.



由于腹板部分受拉，$h_e = \rho h_c$.　$\beta = \frac{\sigma_{w2}}{\sigma_{w1}} = \frac{-100.1}{116.2} = -0.861$

$\Rightarrow k_\sigma = \frac{16}{\sqrt{(1+\beta)^2 + 0.112(1-\beta)^2} + (1+\beta)} = \frac{16}{\sqrt{(1-0.861)^2 + 0.112 \times 1.861^2} + 1 - 0.861} = 20.59$.

$\lambda_p = \frac{h_w / t_w}{28.1\sqrt{k_\sigma}\sqrt{\frac{235}{f_y}}} = \frac{\frac{850}{5}}{28.1 \times \sqrt{20.59} \times \sqrt{\frac{235}{235}}} = 1.33$.

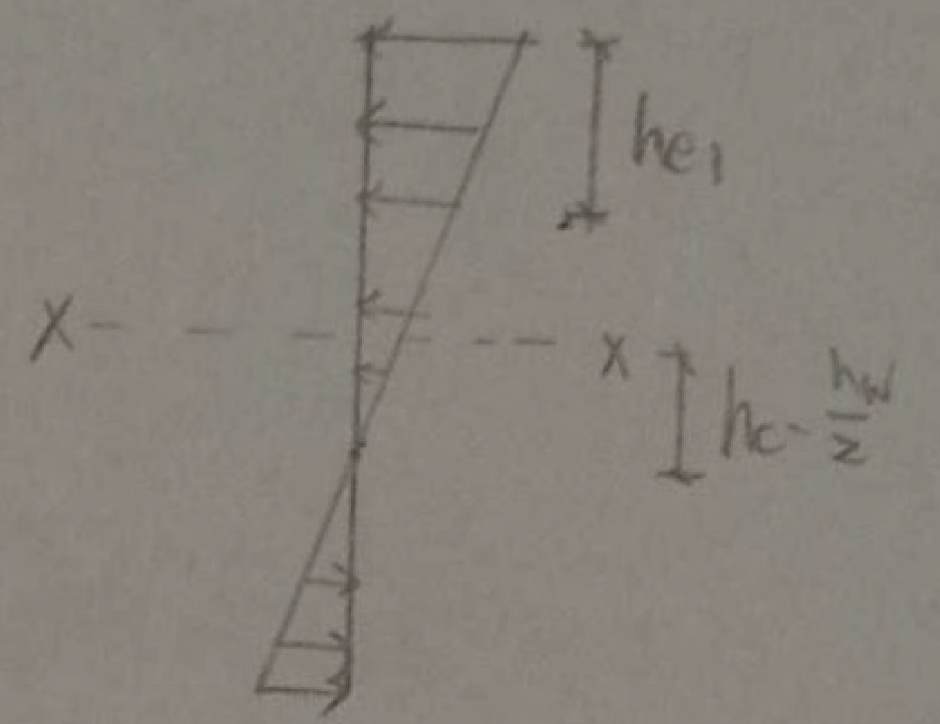
（另计算 λ_p 时用 $1.1\sigma_1$ 代替式中的 f_y，$\Rightarrow \lambda_p = \frac{850/5}{28.1 \times \sqrt{20.59} \times \sqrt{\frac{235}{1.1 \times 116.2}}} = 0.983$，下面计算采用 $\lambda_p = 0.983$）

由于 $0.8 < \lambda_p \le 1.2$，$\Rightarrow \rho = 1 - 0.9(\lambda_p - 0.8) = 1 - 0.9 \times (0.983 - 0.8) = 0.8353$.

进而 $h_e=\rho h_c=0.8353\times456.6=381.4mm$.

$\beta=-0.861$, $\Rightarrow h_{e1}=0.4h_e=152.6mm$, $h_{e2}=0.6h_e=228.8mm$.

3° 计算有效截面的几何特性.



$A_e=t_w\cdot(h_w-(h_c-h_{e1}))+2\times b\times t=6434mm^2$.

$h_c-\frac{h_w}{2}=456.6-425=31mm$.

$I_{xe}=I_e-[\frac{1}{12}\times t_w\times(h_c-h_{e1})^3+t_w\times(h_c-h_{e1})\times[h_{e2}+\frac{h_c-h_e}{2}-(h_c-\frac{h_w}{2})]^2]$

$=6.93\times10^8mm^4$.

形心改变了.

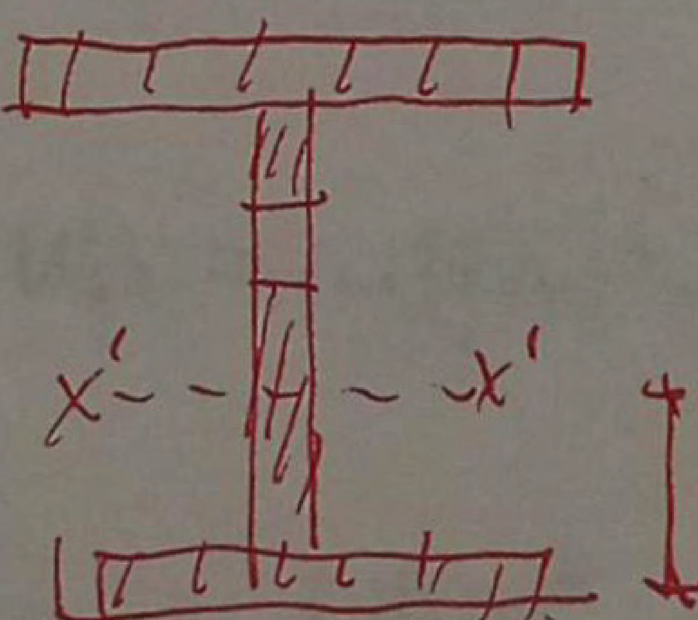
$W_e=\frac{I_{xe}}{\frac{h_w}{2}+t}=\frac{6.93\times10^8}{425+8}=1.6\times10^6mm^3$.

因为 $\sigma=\frac{My}{I_z}$，式中I_z为形心主轴惯性矩。

故要先计算有效截面的形心!!!

$\Rightarrow \frac{N}{A_e}+\frac{M_x}{W_e}=\frac{55\times10^3}{6434}+\frac{185\times10^6}{1.6\times10^6}=124.2mpa<f=215mpa$.

故该截面强度满足要求。



$y_0=\frac{\int y\,ds}{\int ds}=419.28mm$.

$I_x'=7.05\times10^8mm^4$.

$\Rightarrow \frac{N}{A_e}+\frac{M_x y}{I_x'}=\frac{655\times10^3}{6810-752.15}+\frac{185\times10^6\times(866-419.28)}{7.05\times10^8}=125.77mpa<f=215mpa$

(t=8mm (16mm)