include("公共函数库.sm") = 34

输入数据

截面尺寸:

$b := 300\ mm$

$h := 6000\ mm$

混凝土等级 C50

混凝土轴心抗压强度设计值

$f_{cd} := f_{cd}(Conc) = 22.4\ MPa$

钢筋等级 HRB400

普通钢筋抗拉强度设计值

$f_{sd} := f_{sd}(Rebar) = 330\ MPa$

$f'_{sd} := f_{sd}(Rebar) = 330\ MPa$

主筋直径

$d_L := 20\ mm$

$d_Y := 14\ mm$

主筋根数

$n_L := 4$

$n_Y := 3$

配筋面积

$$A_s := n_L \cdot \pi \cdot \frac{d_L^2}{4} = 1256.6\ mm^2$$

$$A'_s := n_Y \cdot \pi \cdot \frac{d_Y^2}{4} = 461.8\ mm^2$$

主筋净保护层厚度

$a_s := 45\ mm$

$a'_s := 45\ mm$

注意：静力计算用设计值，抗震计算用标准值。

结构重要性系数

$\gamma_0 := 1.0$

构件长度

$L := 10\ m$

截面有效高度

$h_0 := h - a_s = 5955\ mm$

偏心受压构件正截面抗压承载力验算

弯矩设计值

$M_d := 210\ \text{kN m}$

轴力设计值

$N_d := 315\ \text{kN}$

构件计算长度

$l_0 := L \cdot 1.0 = 10\ \text{m}$

偏心距

$e_0 := \frac{M_d}{N_d} = 666.7\ \text{mm}$

荷载偏心率对截面曲率的影响系数

$\zeta_1 := \text{Min}\left(1.0,\ 0.2 + 2.7 \cdot \frac{e_0}{h_0}\right) = 0.5023$

构件长细比对截面曲率的影响系数

$\zeta_2 := \text{Min}\left(1.0,\ 1.15 - 0.01 \cdot \frac{l_0}{h}\right) = 1$

截面积

$A := b \cdot h = 1.8 \cdot 10^{6}\ \text{mm}^2$

截面惯性矩

$I := \frac{b \cdot h^3}{12} = 5.4 \cdot 10^{12}\ \text{mm}^4$

截面回转半径

$\text{i} := \sqrt{\frac{I}{A}} = 1732.1\ \text{mm}$

偏心距增大系数

$$\eta := \begin{cases} \text{if } \frac{l_0}{\text{i}} > 17.5 \\ \quad \eta := 1 + \frac{1}{1400 \cdot \frac{e_0}{h_0}} \cdot \left(\frac{l_0}{h}\right)^2 \cdot \zeta_1 \cdot \zeta_2 \\ \text{else} \\ \quad 1 \end{cases} = 1$$

$e_s := \eta \cdot e_0 + \frac{h}{2} - a_s = 3621.7\ \text{mm}$

$$e'_s := \begin{cases} \text{if } e_s > h_0 - a'_s \\ \quad \frac{h}{2} - \eta \cdot e_0 - a'_s \\ \text{else} \\ \quad \left|\frac{h}{2} - \eta \cdot e_0 - a'_s\right| \end{cases} = 2288.33\ \text{mm}$$

截面受压区矩形高度与实际受压区高度比

$\beta := 0.8$

混凝土极限压应变

$$\varepsilon_{cu} := \begin{bmatrix} \text{if } Conc \le C50 \\ \quad 0.0033 \\ \text{else} \\ \quad \text{if } Conc = C80 \\ \quad\quad 0.003 \\ \quad \text{else} \\ \quad\quad 0.0033 + \frac{0.003 - 0.0033}{C80 - C50} \cdot (Conc - C50) \end{bmatrix} = 0.0033$$

普通钢筋弹性模量

$E_s := E_s(Rebar) = 2 \cdot 10^5$ MPa

大小偏心受压构件判定

假定为大偏心受压构件：

$$x := \text{solve}\left(f_{cd} \cdot b \cdot x \cdot \left(e_s - h_0 + \frac{x}{2}\right) = f_{sd} \cdot A_s \cdot e_s + f'_{sd} \cdot A'_s \cdot e'_s, x, 0, h\right)$$

$x := \max(x)$ m $= 4781.8$ mm

$$\begin{bmatrix} \text{if } \frac{x}{h_0} \le \xi_b(Conc, Rebar) \\ \quad \text{"大偏心，假设成立"} \\ \text{else} \\ \quad \text{"小偏心"} \end{bmatrix} = \text{"小偏心"}$$

大偏心受压构件计算

受压区高度验算：

$$\begin{bmatrix} \text{if } x \ge 2 \cdot a'_s \\ \quad \text{"受压区高度满足"} \\ \text{else} \\ \quad \text{"受压区高度不满足"} \end{bmatrix} = \text{"受压区高度满足"}$$

正截面抗压承载力验算：

$\gamma_0 \cdot N_d = 315$ kN

$N_{ud} := f_{cd} \cdot b \cdot x + f'_{sd} \cdot A'_s - f_{sd} \cdot A_s = 31871.7$ kN

$\gamma_0 \cdot N_d \cdot e_s = 1140.825$ kN m

$M_{ud} := f_{cd} \cdot b \cdot x \cdot \left(h_0 - \frac{x}{2}\right) + f'_{sd} \cdot A'_s \cdot (h_0 - a'_s) = 1.2 \cdot 10^5$ kN m

$$\begin{bmatrix} \text{if } (\gamma_0 \cdot N_d < N_{ud}) \wedge (\gamma_0 \cdot N_d \cdot e_s < M_{ud}) \\ \quad \text{"正截面抗压承载力计算通过"} \\ \text{else} \\ \quad \text{"NG"} \end{bmatrix} = \text{"正截面抗压承载力计算通过"}$$

正截面抗弯承载力验算：

$\gamma_0 \cdot N_d \cdot e_s = 1140.8$ kN m

$M_{ud} := f_{cd} \cdot b \cdot x \cdot \left(h_0 - \frac{x}{2}\right) + f'_{sd} \cdot A'_s \cdot (h_0 - a'_s) = 1.2 \cdot 10^5$ kN m

$$\begin{pmatrix}\text{if } \gamma_0 \cdot N_d \cdot e_s < M_{ud} \\ \quad \text{"正截面抗弯承载力计算通过"} \\ \text{else} \\ \quad \text{"NG"}\end{pmatrix} = \text{"正截面抗弯承载力计算通过"}$$

小偏心受压构件计算

再次假设为小偏心受压构件:

$$f(x) := f_{cd} \cdot b \cdot \frac{x^3}{2} + \left(f_{cd} \cdot b \cdot e_s - f_{cd} \cdot b \cdot h_0\right) \cdot x^2 + \left(\varepsilon_{cu} \cdot E_s \cdot A_s \cdot e_s - f'_{sd} \cdot A'_s \cdot e'_s\right) \cdot x - \varepsilon_{cu} \cdot E_s \cdot \beta \cdot h_0 \cdot A_s \cdot$$

$$x := \text{solve}\left(f(x) = 0, x, 0, h\right)$$

$$x := \max(x)\ \text{m} = 4691.7\ \text{mm}$$

再次判别:

$$\begin{pmatrix}\text{if } \frac{x}{h_0} \le \xi_b(Conc, Rebar) \\ \quad \text{"小偏心，假设成立"} \\ \text{else} \\ \quad \text{"大偏心"}\end{pmatrix} = \text{"小偏心，假设成立"}$$

受压区高度验算:

$$\begin{pmatrix}\text{if } x \ge 2 \cdot a'_s \\ \quad \text{"受压区高度满足"} \\ \text{else} \\ \quad \text{"受压区高度不满足"}\end{pmatrix} = \text{"受压区高度满足"}$$

钢筋应力验算:

$$\sigma_s := \varepsilon_{cu} \cdot E_s \cdot \left(\frac{\beta \cdot h_0}{x} - 1\right) = 10.2\ \text{MPa}$$

$$\begin{pmatrix}\text{if } \left(\sigma_s > f_{sd}\right) \wedge \left(\sigma_s < -f'_{sd}\right) \\ \quad \text{"钢筋应力不符合规定"} \\ \text{else} \\ \quad \text{"钢筋应力符合规定"}\end{pmatrix} = \text{"钢筋应力符合规定"}$$

正截面抗压承载力验算:

$$\gamma_0 \cdot N_d = 315\ \text{kN}$$

$$N_{ud} := f_{cd} \cdot b \cdot x + f'_{sd} \cdot A'_s - f_{sd} \cdot A_s = 31266.1\ \text{kN}$$

$$\begin{pmatrix}\text{if } \gamma_0 \cdot N_d < N_{ud} \\ \quad \text{"正截面抗压承载力计算通过"} \\ \text{else} \\ \quad \text{"NG"}\end{pmatrix} = \text{"正截面抗压承载力计算通过"}$$

正截面抗弯承载力验算:

$$M_{ud1} := f_{cd} \cdot b \cdot x \cdot \left(h_0 - \frac{x}{2}\right) + f'_{sd} \cdot A'_s \cdot \left(h_0 - a'_s\right) = 1.1 \cdot 10^5\ \text{kN m}$$

$$e' := \begin{pmatrix}\text{if } e_s > h_0 - a'_s \\ \quad 0 \\ \text{else} \\ \quad \frac{h}{2} - e_0 - a'_s\end{pmatrix} = 2.2883\ \text{m}$$

$$M_{ud2} := f_{cd} \cdot b \cdot h \cdot \left(h - a'_s - \frac{h}{2}\right) + f'_{sd} \cdot A_s \cdot \left(h - a'_s - a'_s\right) = 1.2 \cdot 10^5\ \text{kN m}$$

$$\left(\begin{array}{l}\text{if } \left(\gamma_0 \cdot N_d \cdot e_s < M_{ud1}\right) \wedge \left(\gamma_0 \cdot N_d \cdot e' < M_{ud2}\right) \\ \quad \text{"正截面抗弯承载力计算通过"} \\ \text{else} \\ \quad \text{"NG"}\end{array}\right) = \text{"正截面抗弯承载力计算通过"}$$

裂缝宽度计算（JTG3362-2018 第6.4条)

作用长期效应组合内力值

$N_L := 702\ \text{kN}$

作用短期效应组合内力值

$N_S := 702\ \text{kN}$

作用短期效应组合内力值

$M_S := 5928\ \text{kN m}$

偏心距

$$e_0 := \frac{M_S}{N_S} = 8.4444\ \text{m}$$

轴向压力的正常使用极限状态偏心距增大系数(6.4.4-8)

$$\eta_s := \left(\begin{array}{l}\text{if } \frac{l_0}{h} < 14 \\ \quad 1.0 \\ \text{else} \\ \quad 1 + \frac{1}{4000 \cdot \frac{e_0}{h_0}} \cdot \left(\frac{l_0}{h}\right)^2\end{array}\right) = 1$$

$$\rho_{te} := \frac{A_s}{2 \cdot a_s \cdot b} = 4.6542\ \%$$

$$y_s := \frac{h}{2} - a_s = 2.955\ \text{m}$$

$$e_s := \eta_s \cdot e_0 + y_s = 11.3994\ \text{m}$$

$\gamma'_f := 0$

$$z := \left(0.87 - 0.12 \cdot \left(1 - \gamma'_f\right) \cdot \left(\frac{h_0}{e_s}\right)^2\right) \cdot h_0 = 4.9858\ \text{m}$$

钢筋应力

$$\sigma_{ss} := \frac{N_S \cdot \left(e_s - z\right)}{A_s \cdot z} = 718.6\ \text{MPa}$$

裂缝宽度计算

$C_1 := 1.0$

$$C_2 := 1 + 0.5 \cdot \frac{N_L}{N_S} = 1.5$$

$C_3 := 0.9$

$E_s = 2 \cdot 10^5$ MPa

$c := a_s - 0.5 \cdot d_L = 35$ mm

$$W_{cr} := C_1 \cdot C_2 \cdot C_3 \cdot \frac{\sigma_{ss}}{E_s} \cdot \left(\frac{c + d_L}{0.36 + 1.7 \cdot \rho_{te}} \right) = 0.61 \text{ mm}$$