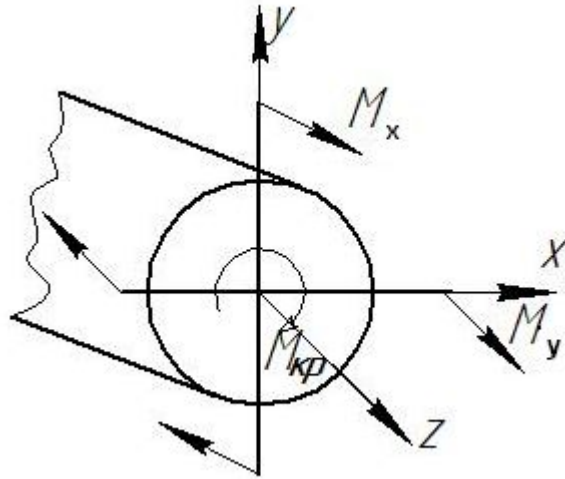
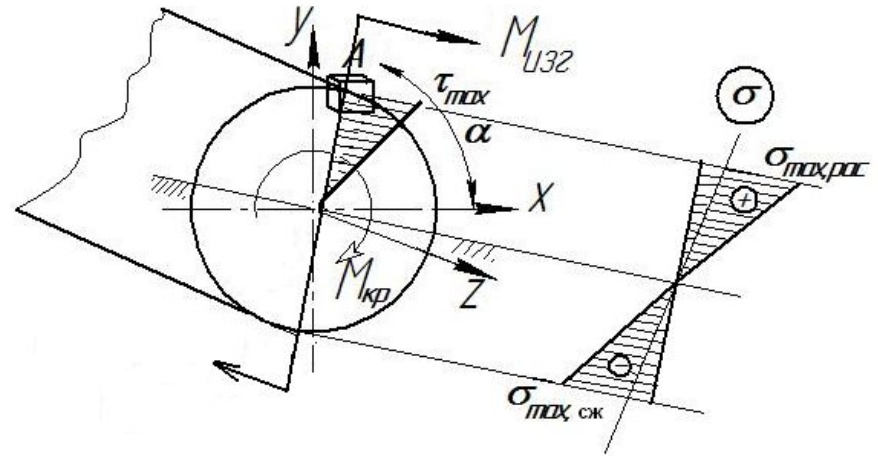


1. Совместное действие изгиба и кручения на брус круглого поперечного сечения. Расчет валов.

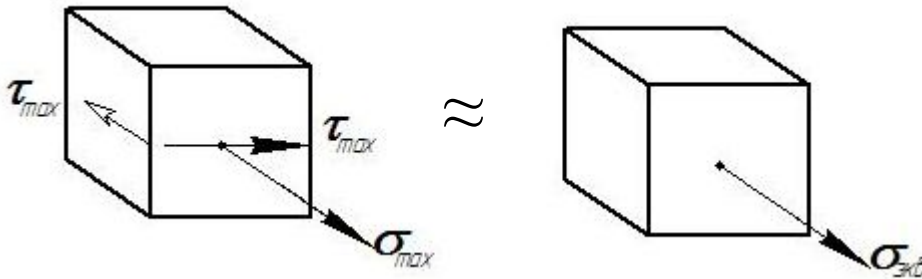


$$M_{изг} = \sqrt{M_x^2 + M_y^2};$$

$$\operatorname{tg} \alpha = \frac{M_x}{M_y}$$



Напряженное состояние опасной т. А.



$$\sigma_{\max} = \frac{M_{изг}}{W_x} = \frac{M_{изг}}{0,1d^3}$$

$$\tau_{\max} = \frac{M_{кр}}{W_p} = \frac{M_{кр}}{0,2d^3}$$

$$W_p = 2W_x \text{ для круглых тел.}$$

Определение эквивалентных напряжений

$$\underline{\underline{\sigma_{\text{эkv}}^{\text{III}} = ?}} \quad \sigma_{\text{эkv}}^{\text{III}} = \sqrt{\sigma^2 + 4\tau^2} = \sqrt{\left(\frac{M_{\text{изг}}}{0,1d^3}\right)^2 + 4\left(\frac{M_{\text{кр}}}{0,2d^3}\right)^2} = \sqrt{\left(\frac{M_{\text{изг}}}{0,1d^3}\right)^2 + 4\left(\frac{M_{\text{кр}}}{2 \cdot 0,1d^3}\right)^2} =$$

$$= \frac{\sqrt{M_{\text{изг}}^2 + M_{\text{кр}}^2}}{0,1d^3} = \frac{\sqrt{M_x^2 + M_y^2 + M_{\text{кр}}^2}}{0,1d^3} = \frac{M_{\text{эkv}}^{\text{III}}}{0,1d^3}; \quad M_{\text{эkv}}^{\text{III}} = \sqrt{M_x^2 + M_y^2 + M_{\text{кр}}^2}.$$

$$\boxed{\sigma_{\text{эkv}}^{\text{III}} = \frac{M_{\text{эkv}}^{\text{III}}}{0,1d^3} \leq [\sigma]_{\text{уд}}}$$

$$\text{а } d \geq \sqrt[3]{\frac{M_{\text{эkv}}^{\text{III}}}{0,1 \cdot [\sigma]}} = \sqrt[3]{\frac{\sqrt{M_{\text{кр}}^2 + M_y^2 + M_x^2}}{0,1 \cdot [\sigma]}}$$

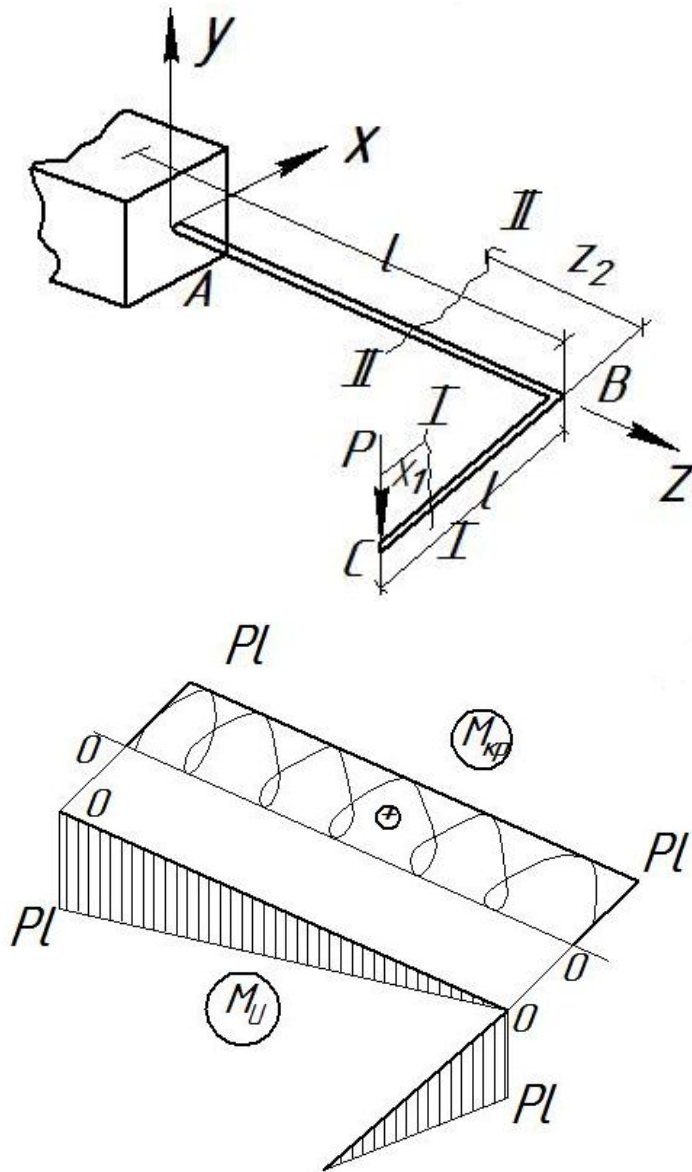
$$\underline{\underline{\sigma_{\text{эkv}}^{\text{IV}} = ?}} \quad \sigma_{\text{эkv}}^{\text{IV}} = \sqrt{\sigma^2 + 3\tau^2} = \sqrt{\left(\frac{M_{\text{изг}}}{0,1d^3}\right)^2 + 3\left(\frac{M_{\text{кр}}}{0,2d^3}\right)^2} = \sqrt{\left(\frac{M_{\text{изг}}}{0,1d^3}\right)^2 + 3\left(\frac{M_{\text{кр}}}{2 \cdot 0,1d^3}\right)^2} =$$

$$= \frac{\sqrt{M_{\text{изг}}^2 + 0,75M_{\text{кр}}^2}}{0,1d^3} = \frac{\sqrt{M_x^2 + M_y^2 + 0,75M_{\text{кр}}^2}}{0,1d^3} = \frac{M_{\text{эkv}}^{\text{IV}}}{0,1d^3}; \quad M_{\text{эkv}}^{\text{IV}} = \sqrt{M_{\text{кр}}^2 + M_y^2 + 0,75M_x^2}.$$

$$\boxed{\sigma_{\text{эkv}}^{\text{IV}} = \frac{M_{\text{эkv}}^{\text{IV}}}{0,1d^3} \leq [\sigma]_{\text{уда}}}$$

$$d \geq \sqrt[3]{\frac{M_{\text{эkv}}^{\text{IV}}}{0,1 \cdot [\sigma]}} = \sqrt[3]{\frac{\sqrt{M_{\text{кр}}^2 + M_y^2 + 0,75M_x^2}}{0,1 \cdot [\sigma]}}$$

2. Статически определимые плоско-пространственные рамы.



Сечение I-I $0 \leq x_1 \leq l$

$$M_{кр} = 0$$

$$M_{узг} = P \cdot x_1 \text{ (сжатое волокно внизу)}$$

$$1. x_1 = 0 \quad M_{узг} = 0$$

$$2. x_1 = l \quad M_{узг} = P \cdot l$$

Сечение II-II $0 \leq z_2 \leq l$

$$M_{кр} = P \cdot l \text{ (const)}$$

$$M_{узг} = P \cdot z_2 \text{ (нижнее)}$$

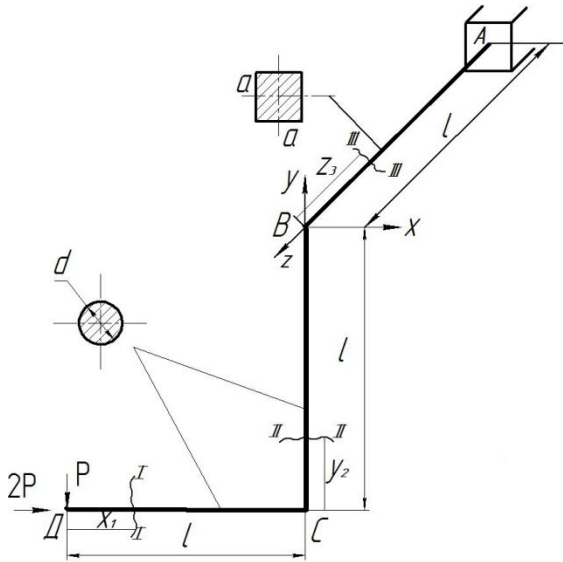
$$1. z_2 = 0 \quad M_{узг} = 0$$

$$2. z_2 = l \quad M_{узг} = P \cdot l$$

Сечение "А"-опасное сечение: $M_{кр} = P \cdot l \quad M_u = P \cdot l$

$$\sigma_{экр}^{III} = \frac{\sqrt{M_u^2 + M_{кр}^2}}{0,1d^3} = \frac{\sqrt{(Pl)^2 + (Pl)^2}}{0,1d^3} = \frac{Pl\sqrt{2}}{0,1d^3}; \sigma_{экр}^{III} \leq [\sigma].$$

4. Расчет пространственного ломаного бруса.



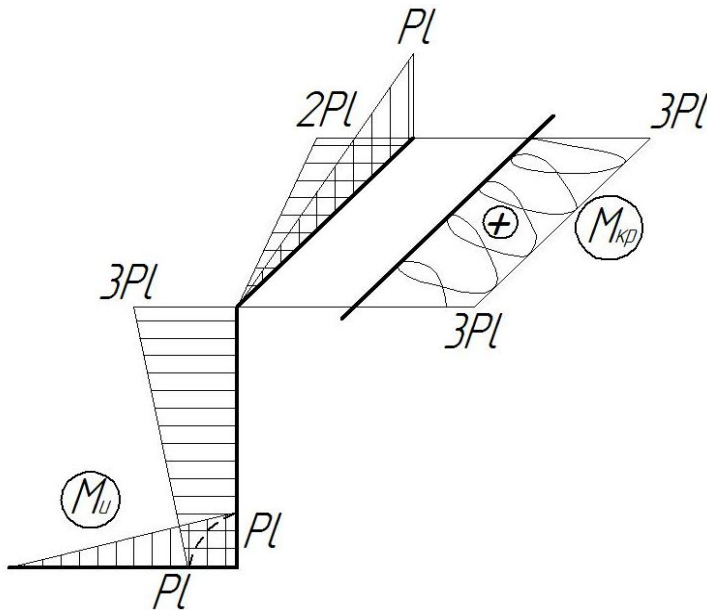
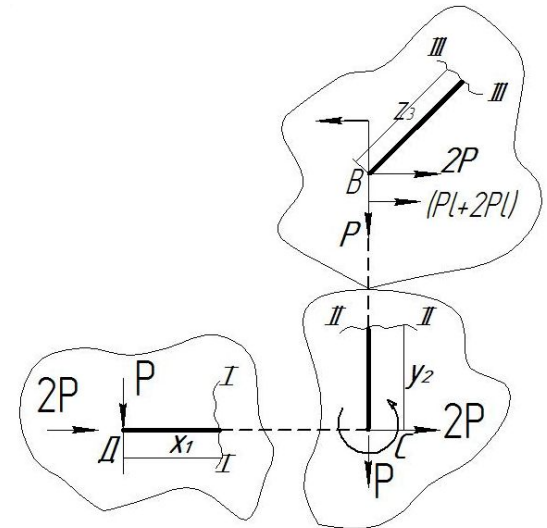
Дано:

$$P = 1 \text{ кН}$$

$$l = 0.5$$

$$\sigma_{T.P.} = \sigma_{T.C.} = 100 \text{ Па}$$

Определить размеры поперечных сечений бруса, используя III теорию прочности.



Участок BC : $P \cdot x M_{kp} = 0 \quad u = \dots \cdot 1$

$$0 \leq x_1 \leq l$$

Участок BC : $Pl \quad M_{kp} \neq 0 \quad u = \dots + 2 \cdot \dots \cdot 2$

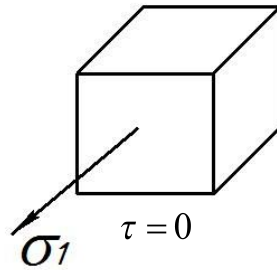
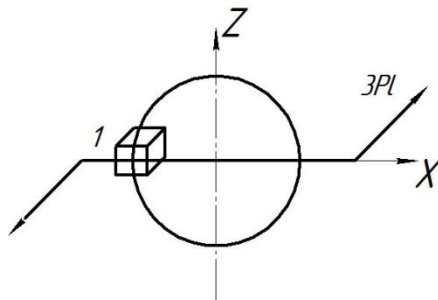
$$0 \leq y_2 \leq l$$

Участок AB : $M_{kp} = Pl + 2Pl = 3Pl$

$$0 \leq z_3 \leq l \quad M_u^V = P \cdot z_3$$

$$M_u^I = 2P \cdot z_3$$

Сечение «В»



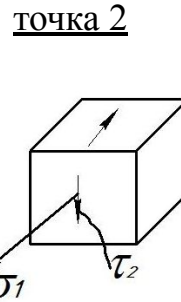
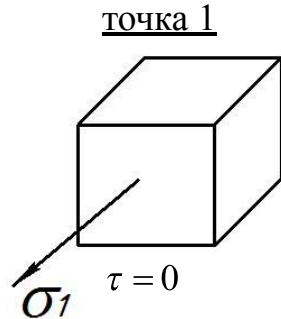
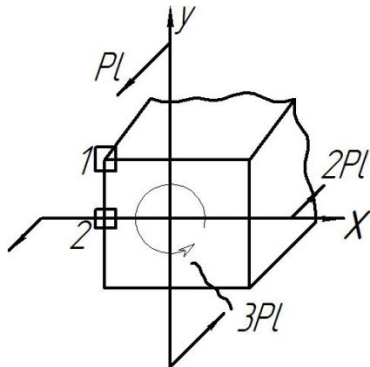
$$\sigma_1 = \sigma_{\text{ЭКВ}}^{\text{III}} \quad \sigma_1 = \frac{M_{\text{изг}}}{W_x} = \frac{3Pl}{0,1d^3} = \frac{\sigma_{\text{Т.Р.}}}{n_T} = [\sigma];$$

$$W_{\text{изг}} = W = \frac{\pi d^3}{32} \approx 0,1d^3$$

Откуда:

$$d = \sqrt[3]{\frac{3Pl n_T}{0,1 \cdot \sigma_{\text{Т.Р.}}}} = \sqrt[3]{\frac{3 \cdot 1000 \cdot 0,5 \cdot 2}{0,1 \cdot 200 \cdot 10^6}} = 5,3 \cdot 10^{-2} \text{ м} = 5,3 \text{ см}$$

Сечение «А»



$$\sigma_{1(\text{ЭКВ})}^{\text{III}} = \frac{M_x}{W_x} + \frac{M_y}{W_y} = \frac{Pl}{\frac{a^3}{6}} + \frac{2Pl}{\frac{a^3}{6}} = \frac{18Pl}{a^3}$$

$$\text{где } W_x = W_y = \frac{J_x}{y_{\text{max}}} = \frac{a^4 \cdot 2}{12 \cdot a} = \frac{a^3}{6}$$

$$G_2 = \frac{M_y}{W_y} = \frac{2Pl}{\frac{a^3}{6}} = \frac{12Pl}{a^3}$$

$$\tau_2 = \frac{M_{\text{КР}}}{W_{\text{КР}}} = \frac{3Pl}{\alpha \cdot a^3} = \frac{3Pl}{0,208a^3}$$

($\alpha = 0,208$ из таблиц)

$$\sigma_{2(\text{ЭКВ})}^{\text{III}} = \sqrt{\sigma^2 + 4\tau^2} = \sqrt{\left(\frac{12Pl}{a^3}\right)^2 + 4\left(\frac{3Pl}{0,208a^3}\right)^2} = \frac{31,2Pl}{a^3}$$

Получим: $\sigma_{2(\text{ЭКВ})}^{\text{III}} > \sigma_{1(\text{ЭКВ})}^{\text{III}} \quad \sigma_{2(\text{ЭКВ})}^{\text{III}} \leq \frac{\sigma_{\text{Т.Р.}}}{n_T} \quad \frac{31,2Pl}{a^3} \leq \frac{\sigma_{\text{Т.Р.}}}{n_T} \quad \text{Откуда } a \geq \sqrt[3]{\frac{31,2 \cdot 1000 \cdot 0,5 \cdot 2}{200 \cdot 10^6}} = 5,4 \cdot 10^{-2} \text{ м} = 5,4 \text{ см}$