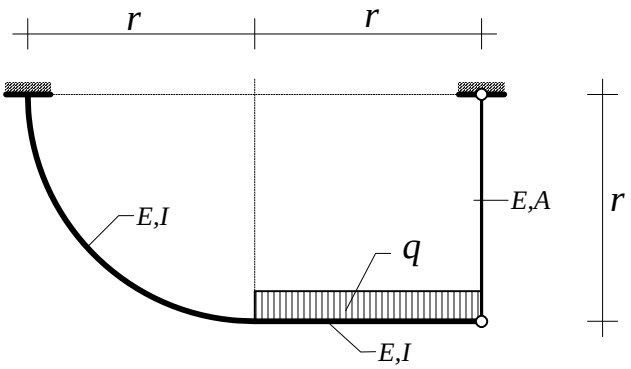
SVEUČILIŠTE U ZAGREBU
GRAĐEVINSKI FAKULTET
ZAVOD ZA TEHNIČKU MEHANIKU

OTPORNOST MATERIJALA 2

2. PRIMJER 2. KOLOKVIJA

1. Za zadani sustav prikazan na slici treba primjenom principa o minimumu potencijalne energije deformacije odrediti i nacrtati dijagrame unutarnjih sila **M**, **T**, **N**.



Zadano je: $E = 2{,}1 \cdot 10^5\ MPa$

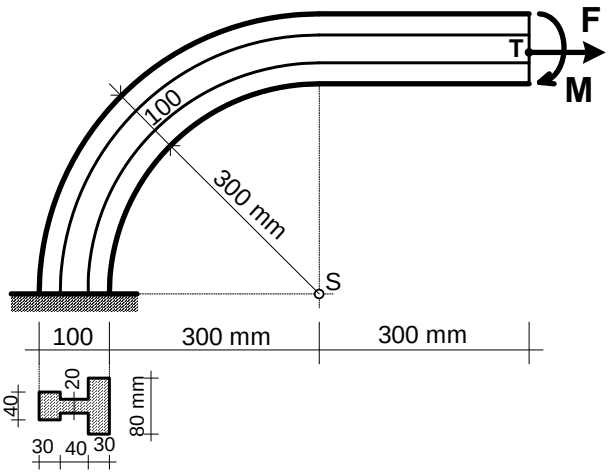
$I = 4 \cdot 10^8\ mm^4$

$A = 800\ mm^2$

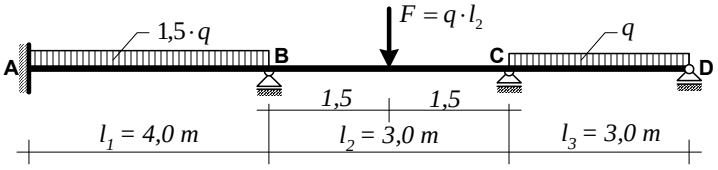
$q = 20\ kN/m'$

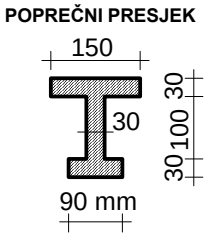
$r = 2{,}0\ m$.

2. Za zakrivljeni štap opterećen prema slici treba izračunati najveća normalna naprezanja i nacrtati dijagram normalnih naprezanja u najviše napregnutom poprečnom presjeku.

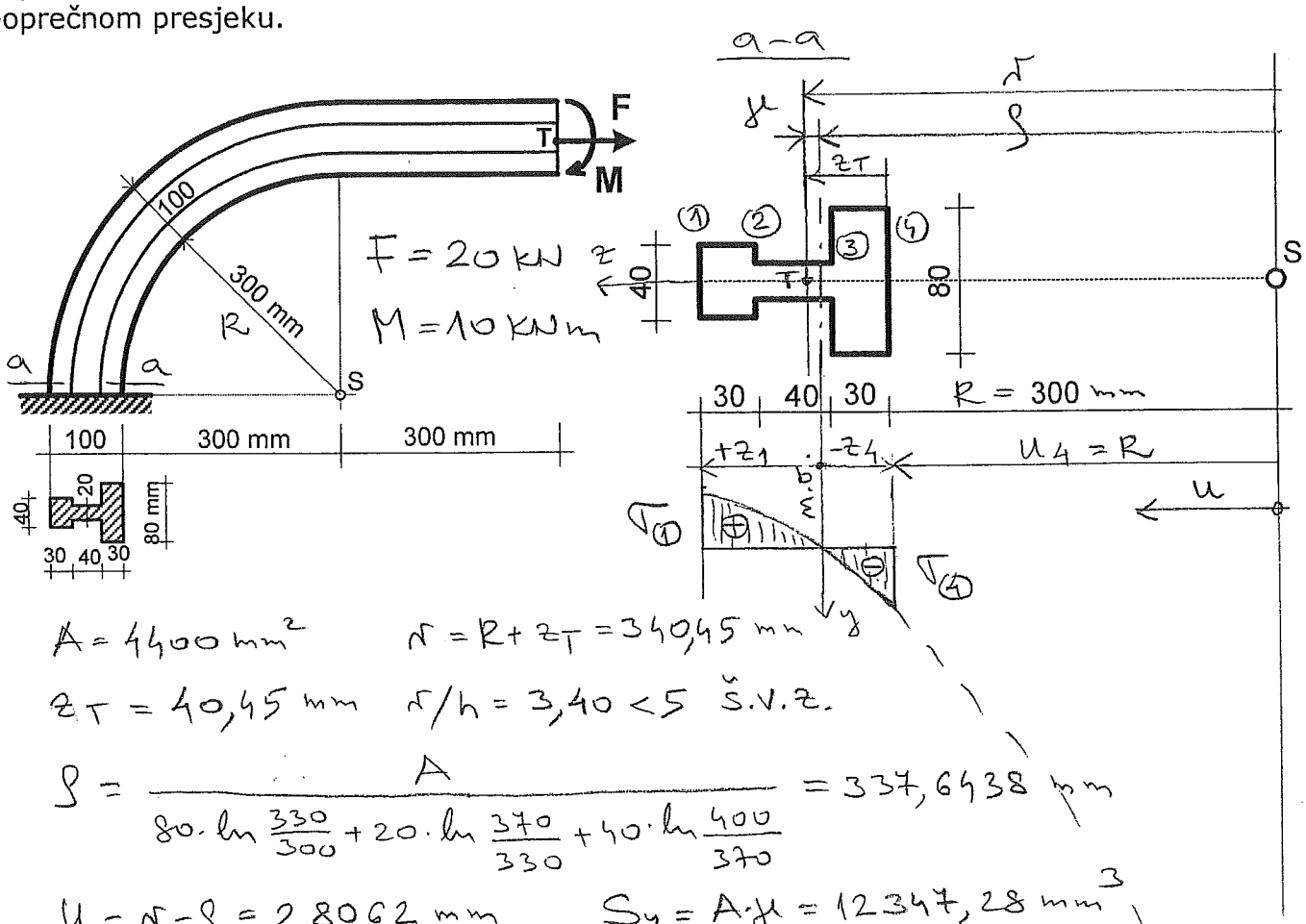


3. Za zadani sistem prikazan na slici treba po teoriji plastičnosti odrediti dopušteno opterećenje q, ako je granica tečenja materijala $\sigma_T = 220\ MPa$ i koeficijent sigurnosti $k = 1{,}8$.





2. Za zakrivljeni štap opterećen prema slici treba izračunati najveća normalna naprezanja i nacrtati dijagram normalnih naprezanja u najviše napregnutom poprečnom presjeku.



$A = 4400\ mm^2$ $\quad r = R + z_T = 340{,}45\ mm$

$z_T = 40{,}45\ mm$ $\quad r/h = 3{,}40 < 5$ Š.V.Z.

$$\rho = \frac{A}{80 \cdot \ln\frac{330}{300} + 20 \cdot \ln\frac{370}{330} + 40 \cdot \ln\frac{400}{370}} = 337{,}6438\ mm$$

$e = r - \rho = 2{,}8062\ mm$ $\quad S_y = A \cdot e = 12347{,}28\ mm^3$

$M_{a-a} = F \cdot r + M = +16{,}809\ kNm$

$z_1 = +62{,}36\ mm$

$z_2 = +32{,}36\ mm$

$z_3 = -7{,}64\ mm$

$z_4 = -37{,}64\ mm$

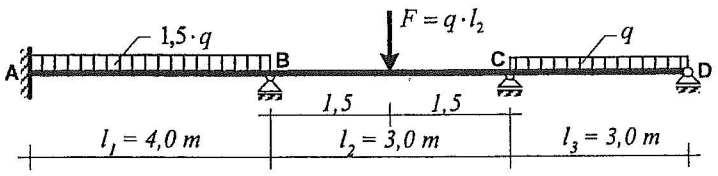
$$\sigma_{①} = \frac{M}{S}\,\frac{z_1}{u_1} = \underline{+212{,}23\ MPa}$$

$\sigma_{②} = \underline{+119{,}06\ MPa}$

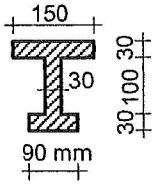
$\sigma_{③} = \underline{-31{,}52\ MPa}$

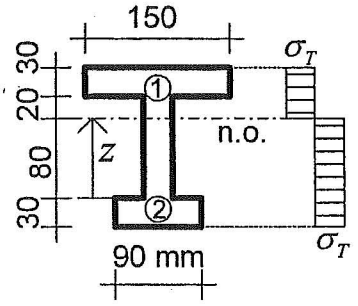
$\sigma_{④} = \underline{-170{,}80\ MPa}$

3. Za zadani sistem prikazan na slici treba po teoriji plastičnosti odrediti dopušteno opterećenje q, ako je granica tečenja materijala $\sigma_T = 220\ MPa$ i koeficijent sigurnosti $k = 1{,}8$.



POPREČNI PRESJEK





$$A = 10200\ mm^2$$

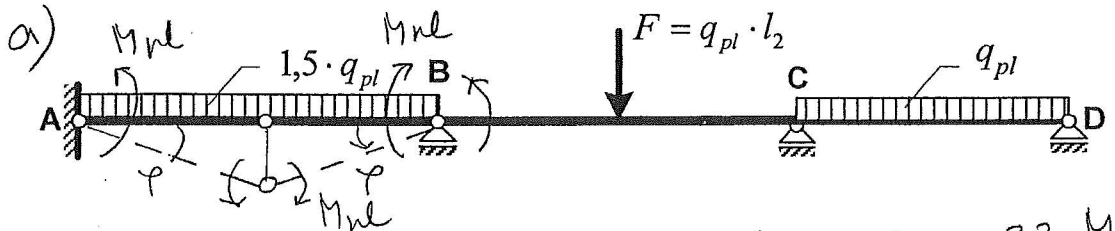
$$\frac{A}{2} = 30 \cdot 90 + z \cdot 30 \quad \Rightarrow \quad z = 80\ mm$$

$$W_{pl} = S_1 + S_2 = 163500 + 352500 = 516000\ mm^3$$

$$M_{pl} = \sigma_T \cdot W_{pl} = 220 \cdot 516000 = 113{,}52\ kNm$$

$$q_{pl} = \frac{2}{3} \cdot M_{pl} = 75{,}68\ kN/m' \quad \Rightarrow \quad \boxed{q_{dop} = \frac{q_{pl}}{k} = 42{,}04\ kN/m'}$$

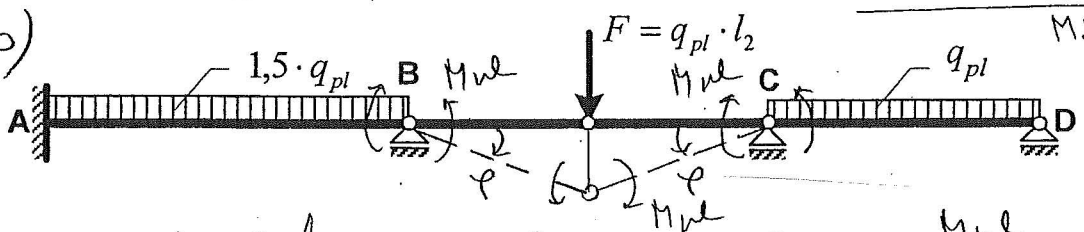
a)



$$1{,}5 \cdot q_{pl} \cdot \frac{l_1}{2} \cdot \varphi \cdot \frac{l_1}{4} \cdot 2 - 4 M_{pl} \cdot \varphi = 0 \rightarrow q_{pl} = \frac{32}{3} \frac{M_{pl}}{l_1^2} = \frac{2}{3} M_{pl}$$

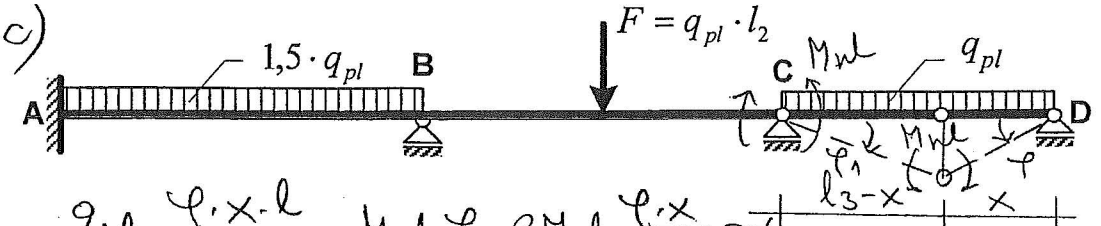
MJERODAVNO !

b)



$$q_{pl} \cdot l_2 \cdot \varphi \cdot \frac{l_2}{2} - 4 M_{pl} \cdot \varphi = 0 \rightarrow q_{pl} = 8 \frac{M_{pl}}{l_2^2} = \frac{8}{9} M_{pl}$$

c)



$$\varphi_1 = \varphi \frac{x}{l_3 - x}$$

$$q_{pl} \frac{\varphi \cdot x \cdot l}{2} - M_{pl} \cdot \varphi - 2 M_{pl} \frac{\varphi \cdot x}{l_3 - x} = 0$$

$$q_{pl} = \frac{2 M_{pl}}{l} \frac{l_3 + x}{x(l_3 - x)} \qquad \frac{d q_{pl}}{dx} = 0 \rightarrow x = 0{,}414 \cdot l_3$$

$$q_{pl} = 11{,}6 \frac{M_{pl}}{l_3^2} = \frac{11{,}6}{9} M_{pl}$$