ZAVRTANJSKE VEZE

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MAŠINSKI FAKULTET KRALJEVO

MAŠINSKI ELEMENTI 1

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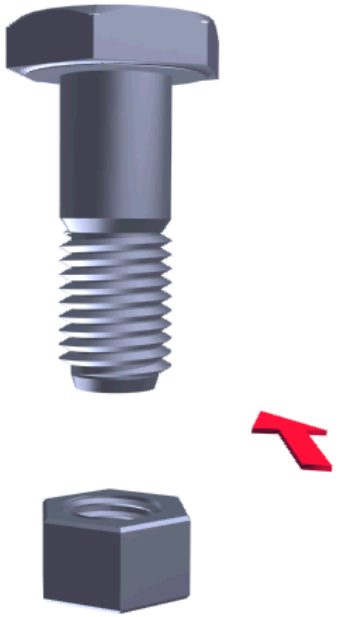
- **Zavrtanjska veza**

- navojni spoj ostvaren posredstvom zavrtnja i navrtke

- **Spojeni delovi,**
- **Zavrtanj,**
- **Navrtka,**
- **Delovi za osiguranje ili zaptivanje.**



Dr Snežana Ćirić Kostić

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DISPONIBILI IN CLASSE 8.8 - ZINCATE


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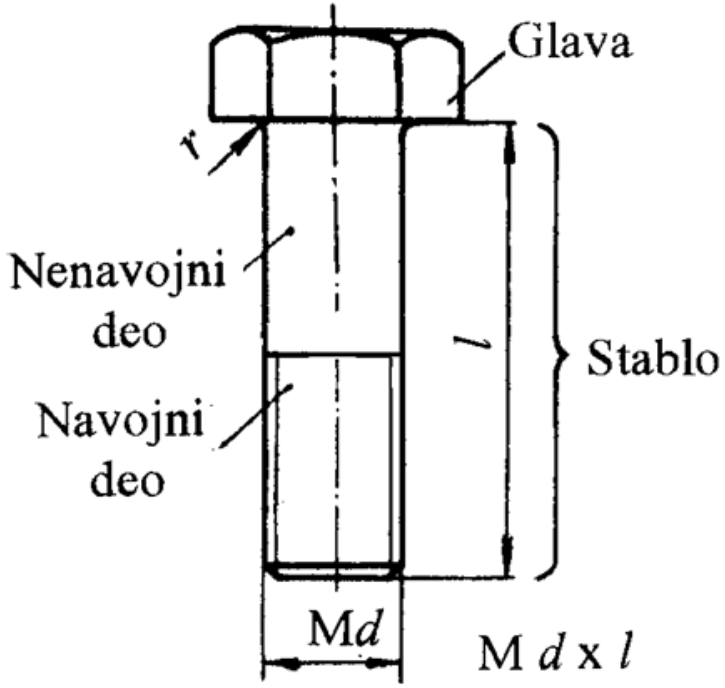
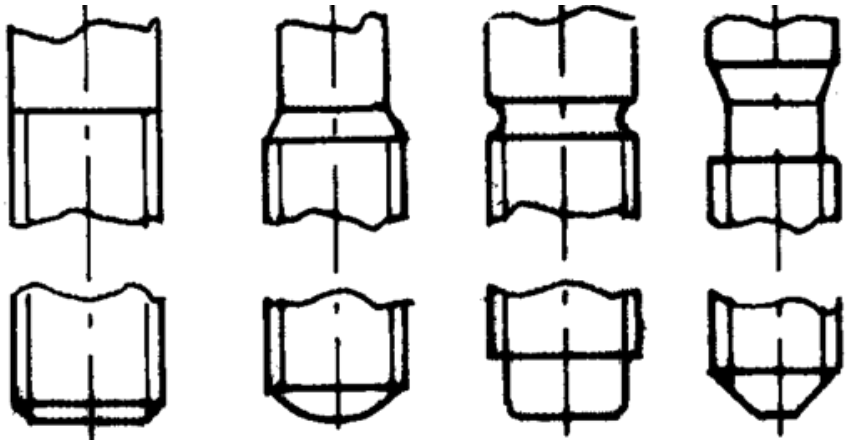
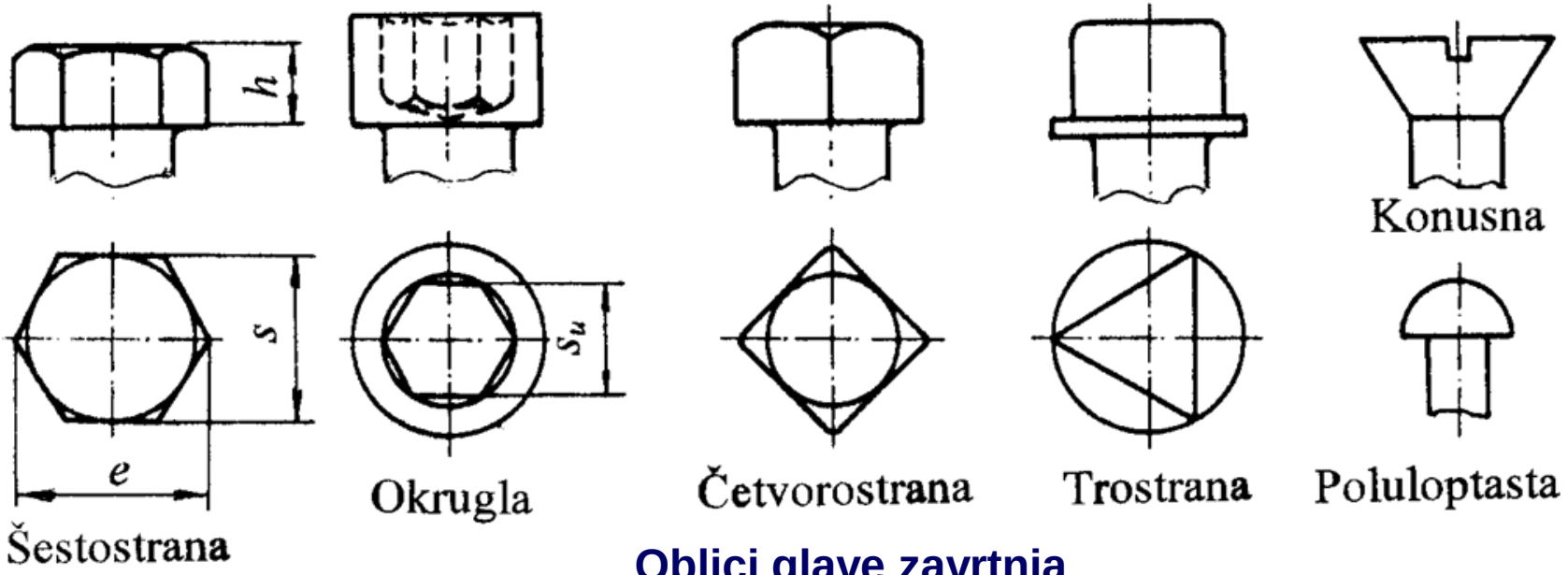


Prelaz glave u stablo



Prelaz nenavojnog u navojni deo i završetak zavrtnja



Oblici glave zavrtnja

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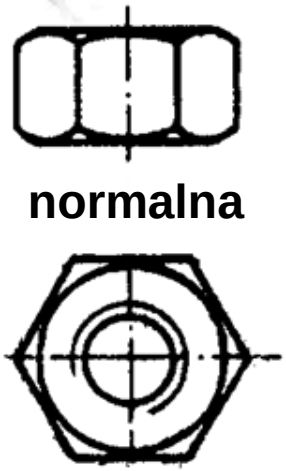
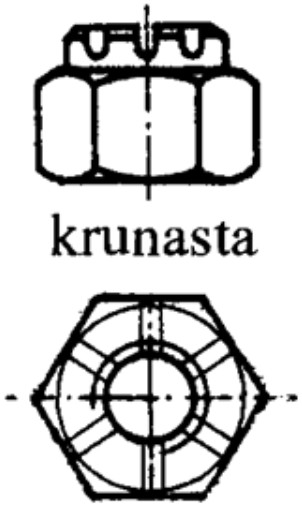
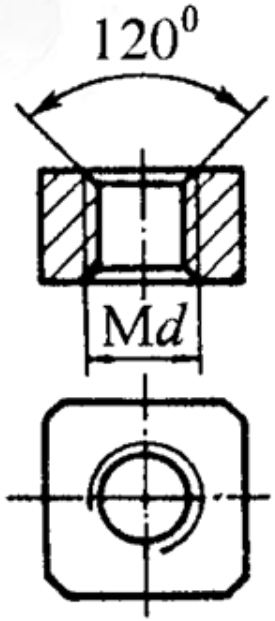
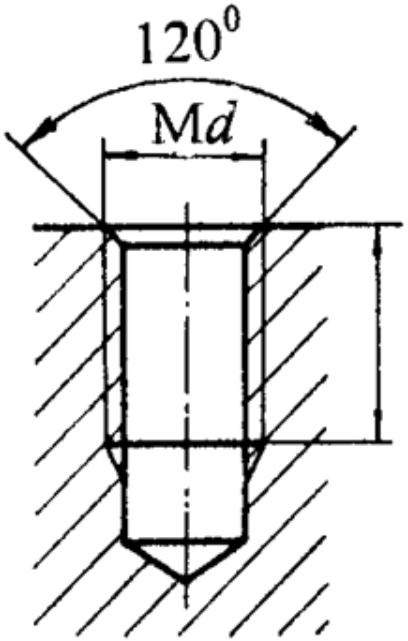
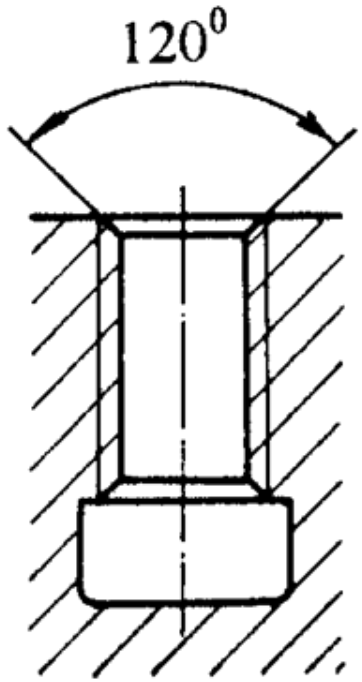
- **Oblici navrtke**











- **šestougaone navrtke**
- **krilaste navrtka**
- **navrtke posebnog oblika**
- **četvorougaone navrtka**
- **Izgled navojne rupe**

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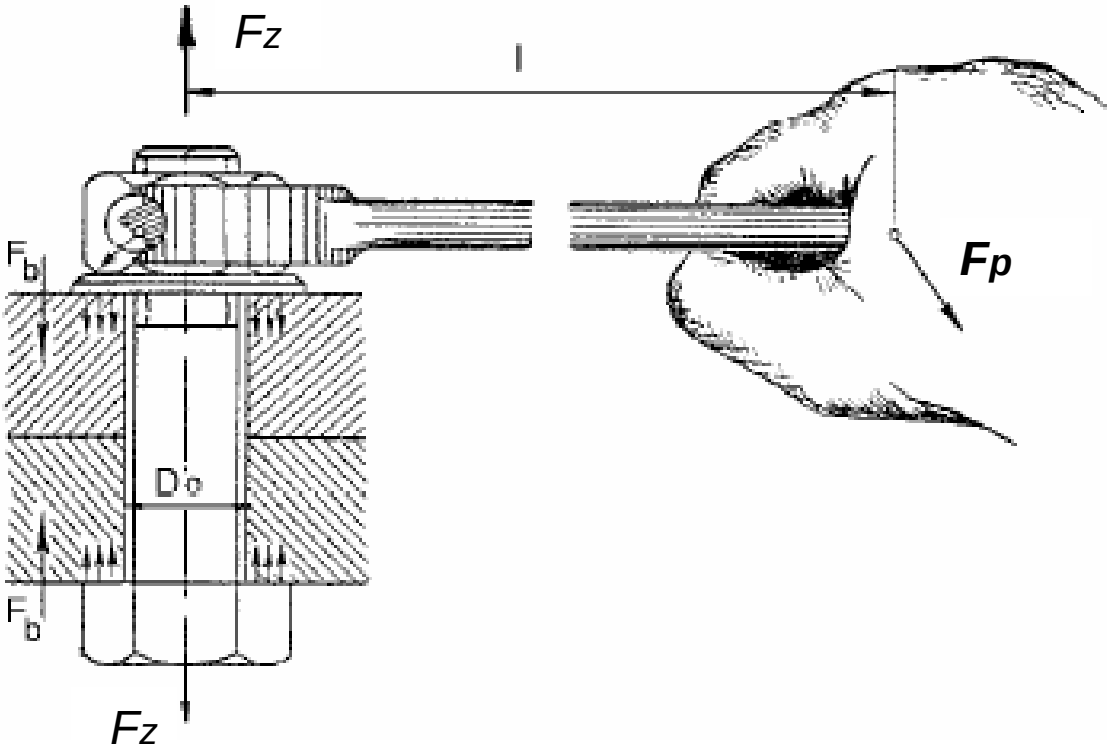
Pritezanje zavrtanjskih veza



U zavrtanjskoj vezi treba obezbediti uslove da ne dođe do razdvajanja niti do međusobnog relativnog kretanja spojenih delova.

To se postiže obezbeđivanjem dovoljne sile pritiska između spojenih delova koja se ostvaruje pritezanjem zavrtnja.

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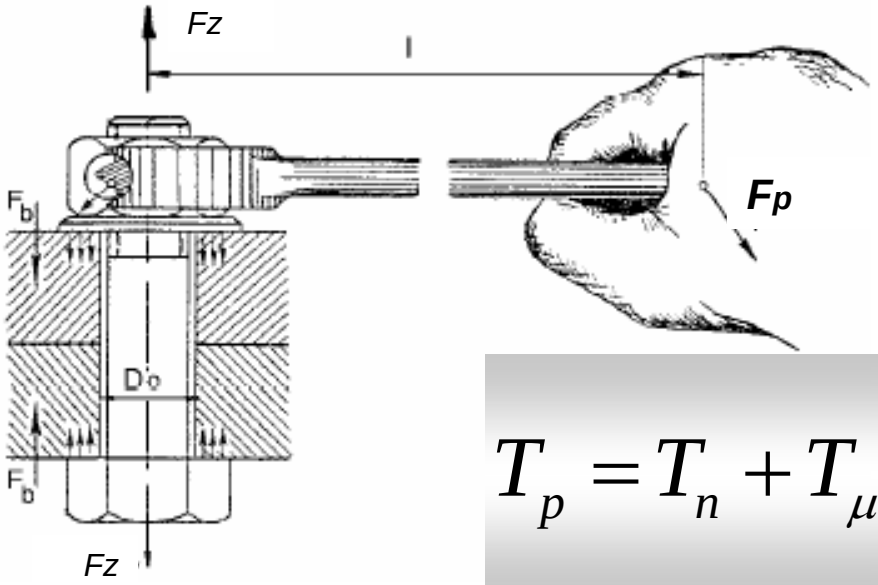
Moment pritezanja

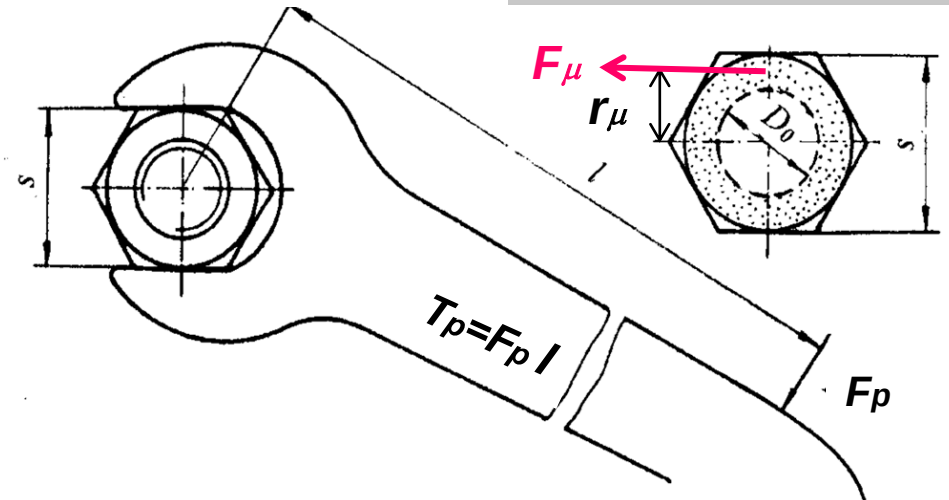


T_μ-moment otpora klizanju navrtke po podlozi

T_n-moment otpora u navojnom paru

Koeficijent trenja navrtka -podloga:
Za obrađene površine - μ=0,16...0,22
Korodirane površine - μ=0,20...0,35

$$T_p = T_n + T_\mu = F_p \left[\frac{d_2}{2} tg\left(\varphi + \rho_n\right) + r_\mu \mu \right]$$



$$r_\mu = \frac{s + D_0}{4}$$

Redukovani ugao trenja:

$$\rho_v = \operatorname{arctg} \frac{\mu_n}{\cos\frac{\alpha}{2}}$$

Koeficijent trenja u navojcima:
Za finu obradu- μ_n=0,18...0,20
Za grubu obradu- μ_n=0,25...0,30

φ -Ugao uspona zavojnice na srednjem prečniku.

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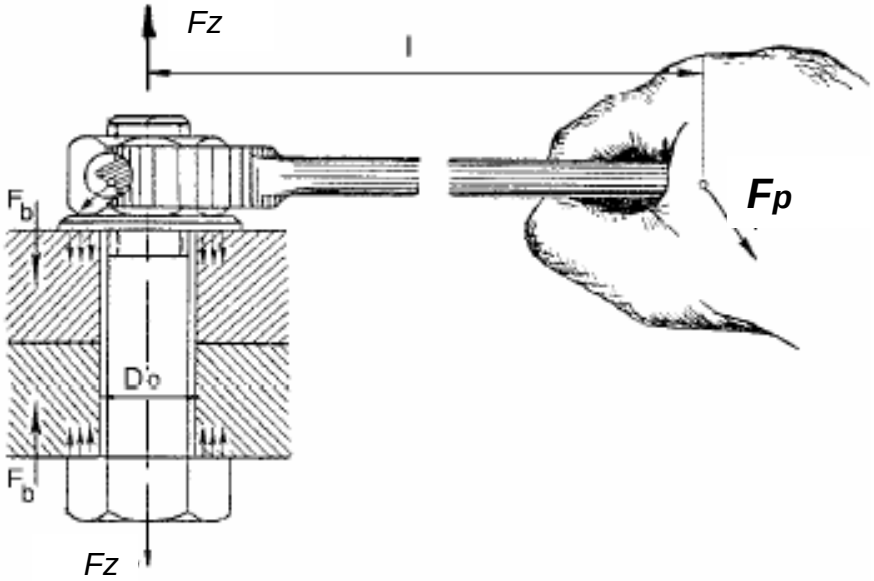
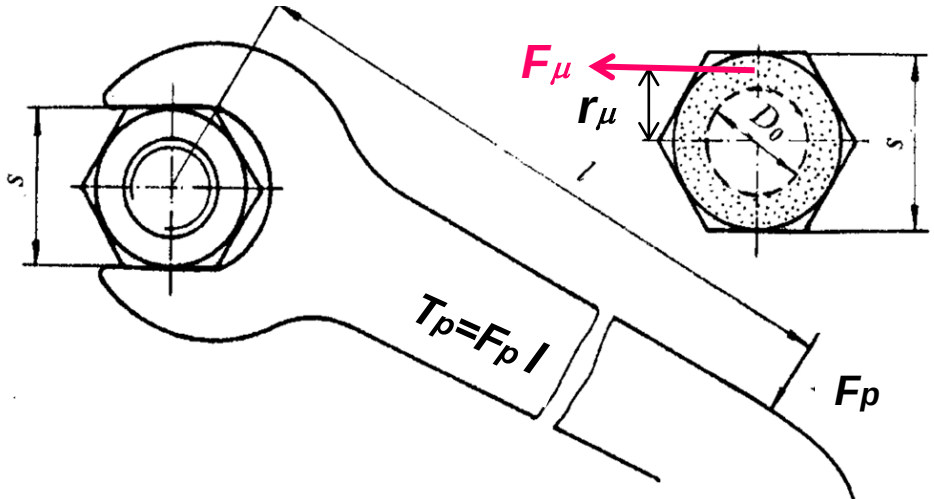
- **Pritezanje zavrtanjskih veza**

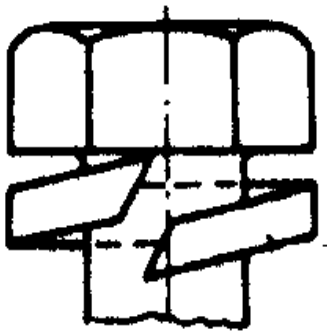


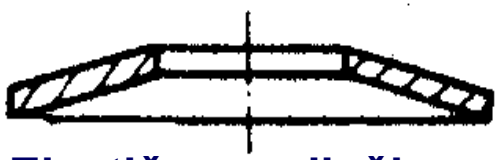


Napon usled dejstva sile pritezanja

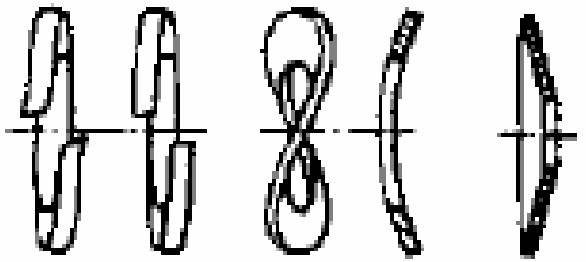
$$\sigma = \frac{F_p}{A_s} = (0,6...0,8)\sigma_{TM}$$

- **Osiguranja od labavljenja i samoodvrtanja**

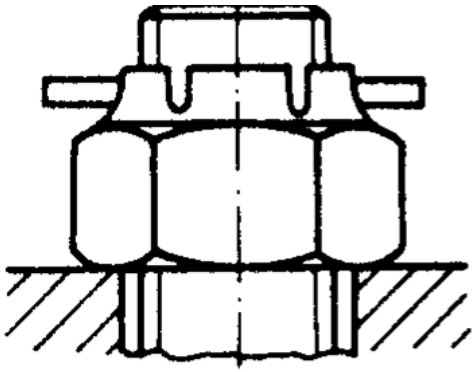


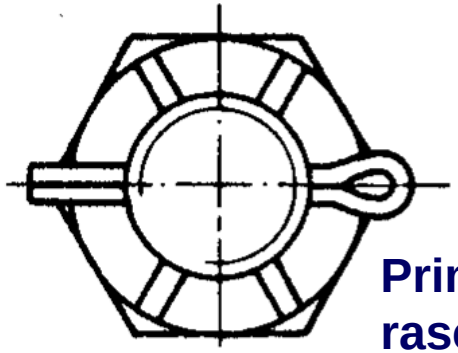


Elastične podloške



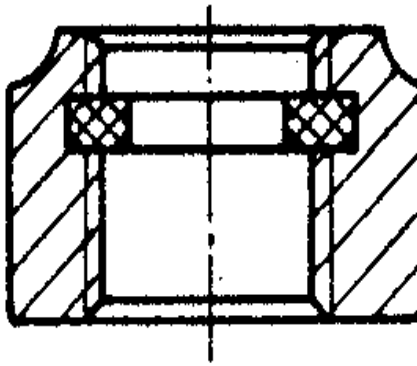
Krunasta navrtka





Primenom rascepke

Dvostruka navrtka



Samoosiguravajuća navrtka

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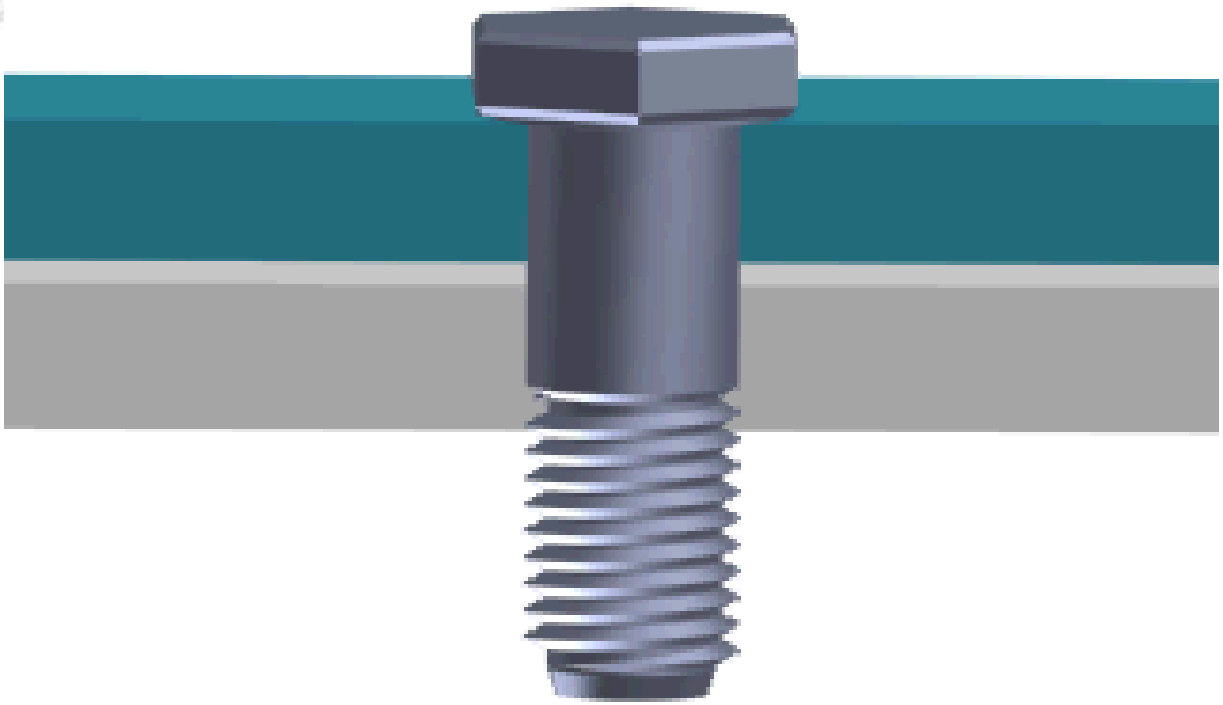
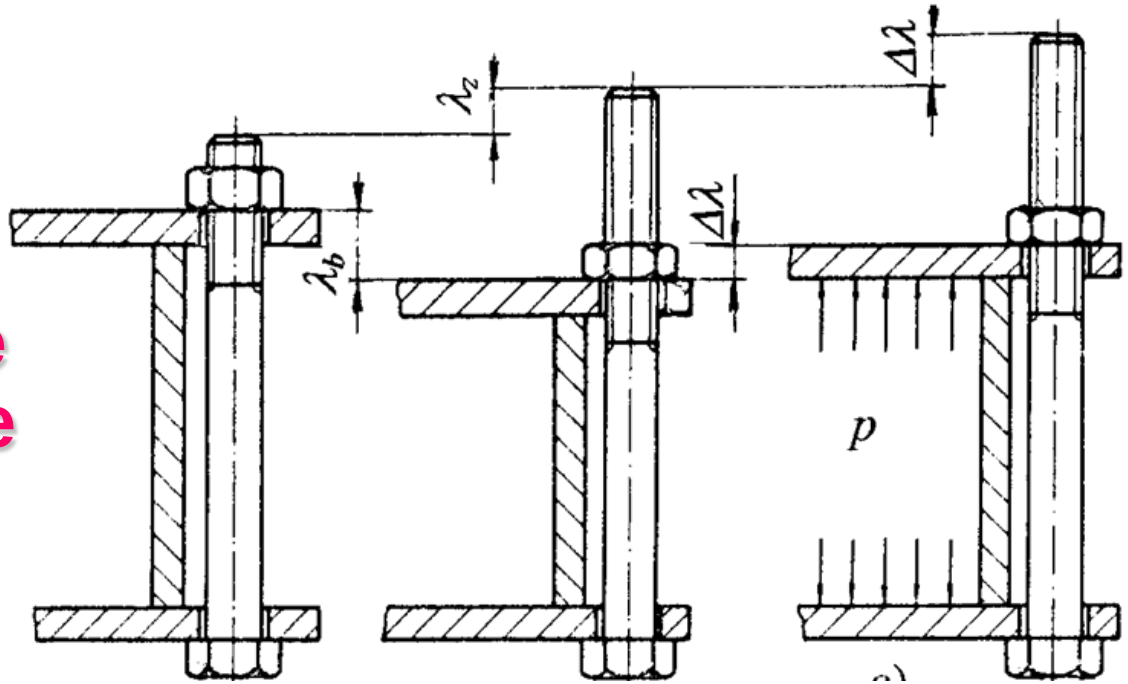
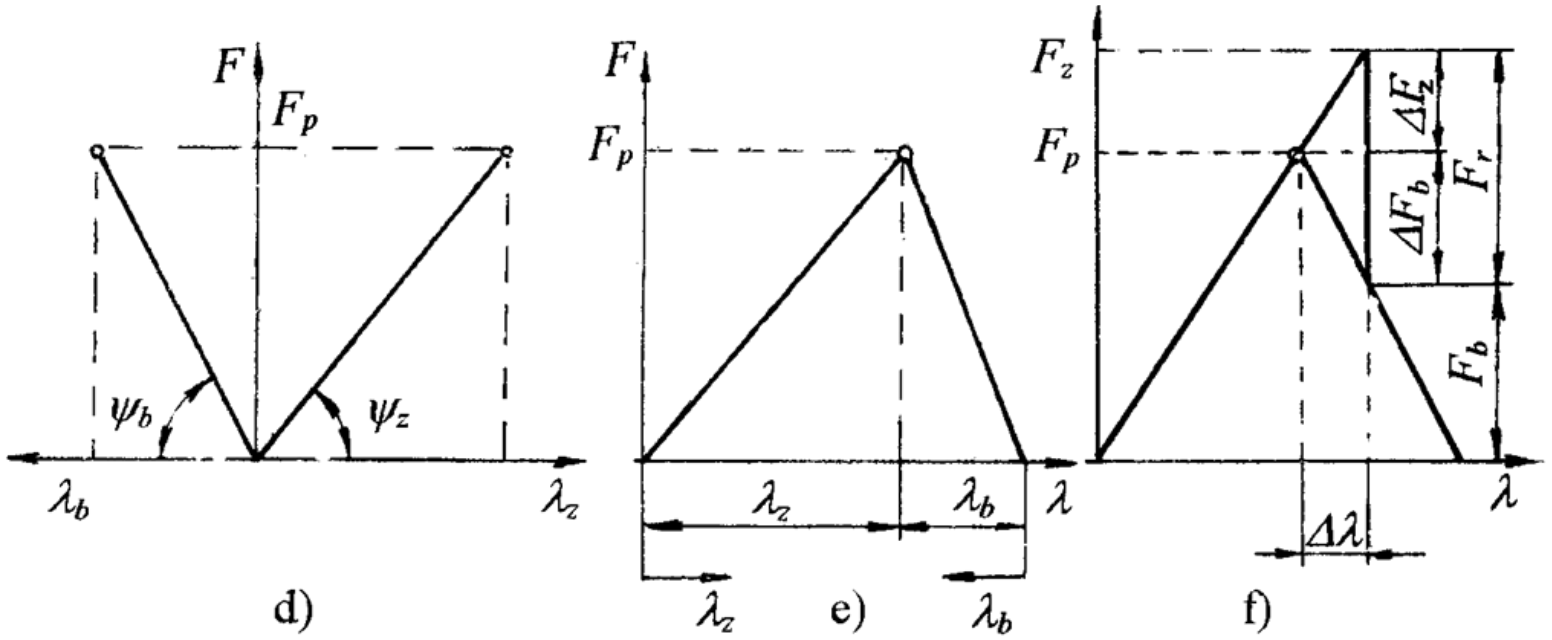


- **Uzdužno opterećene zavrtanjske veze**



Sile i deformacije



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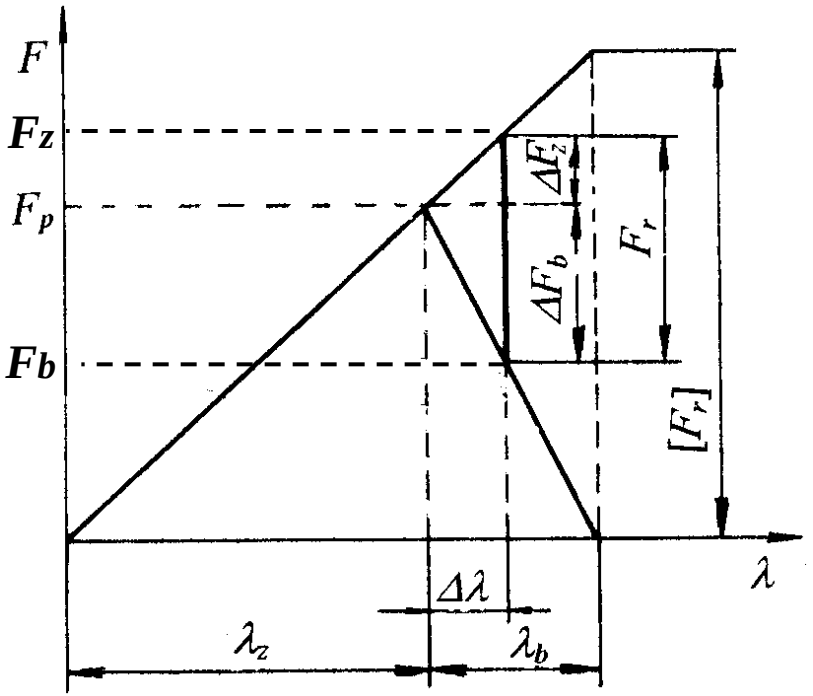
- **Uzdužno opterećene zavrtanjske veze**

Sila u zavrtnju

$$F_z = F_p + \Delta F_z = F_p + \frac{c_z}{c_z + c_b} F_r$$

Sila u spojenim delovima

$$F_b = F_p - \Delta F_b = F_p - \frac{c_b}{c_z + c_b} F_r$$



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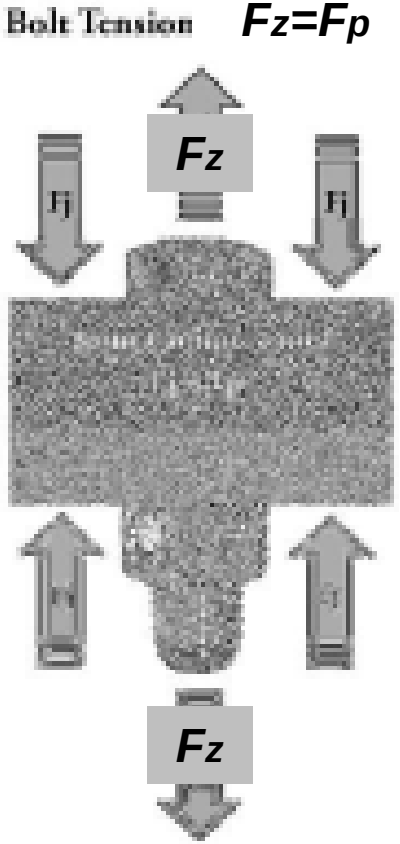
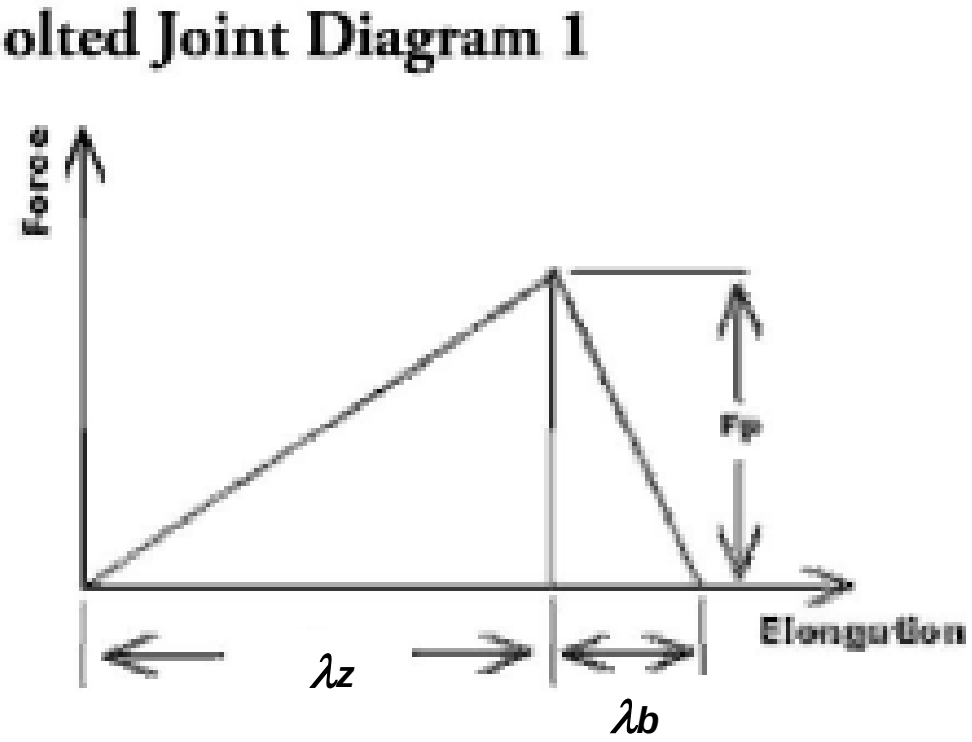
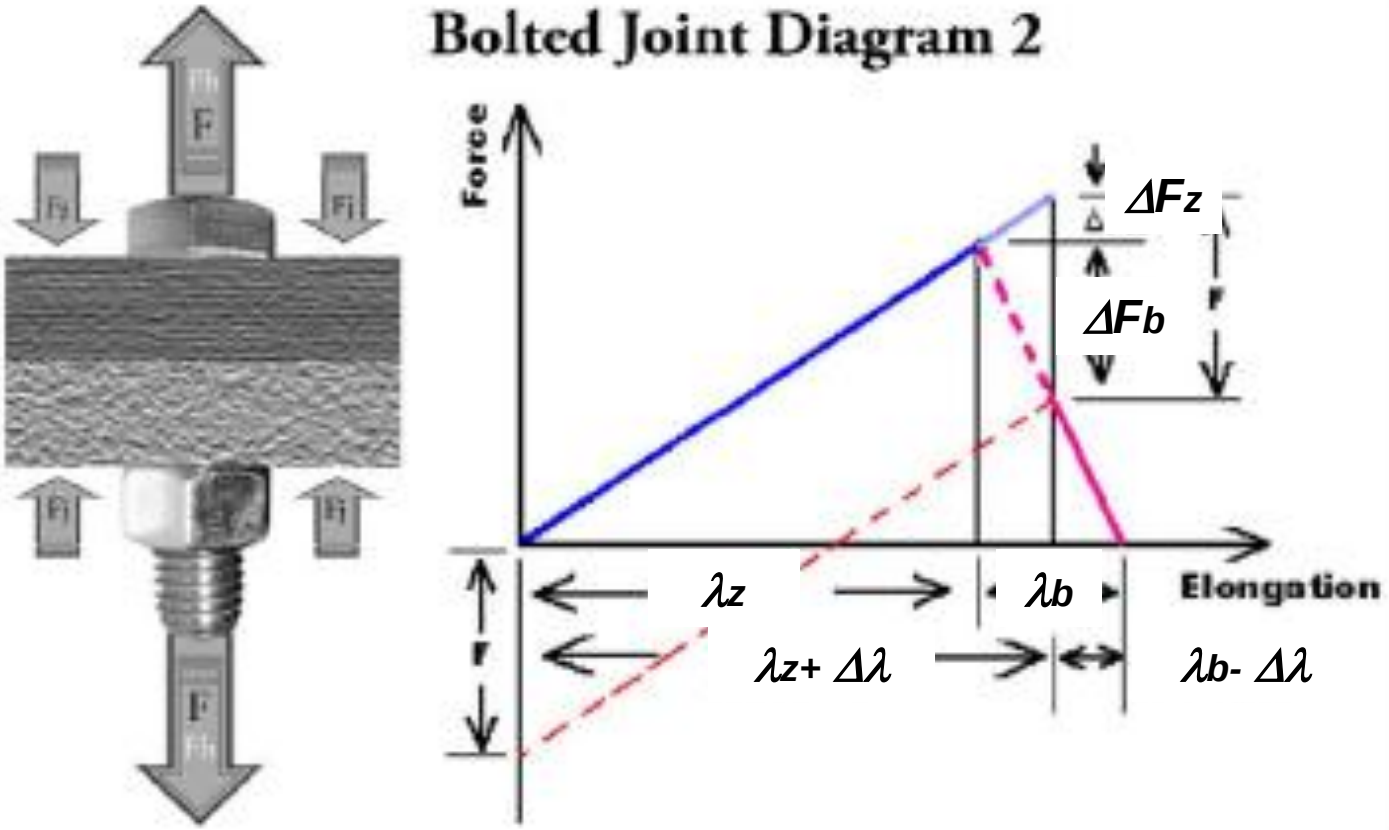




MAŠINSKI ELEMENTI 1



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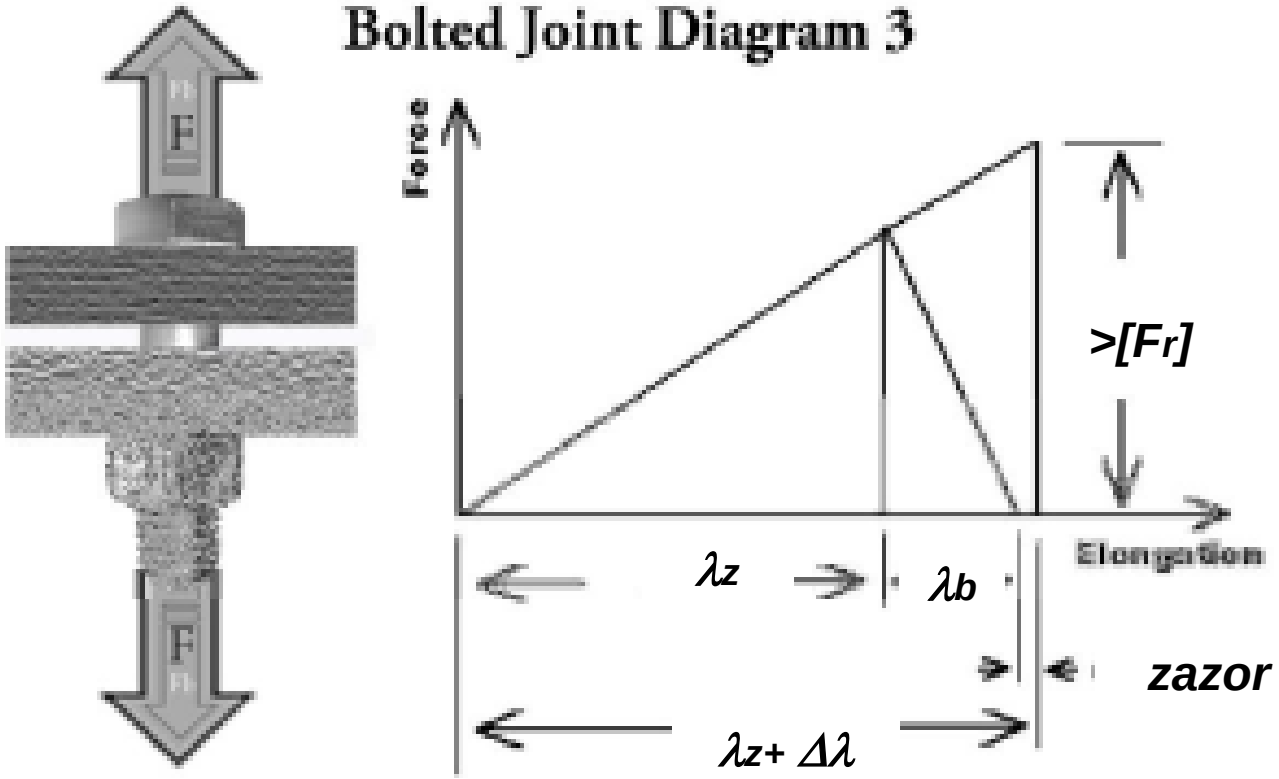

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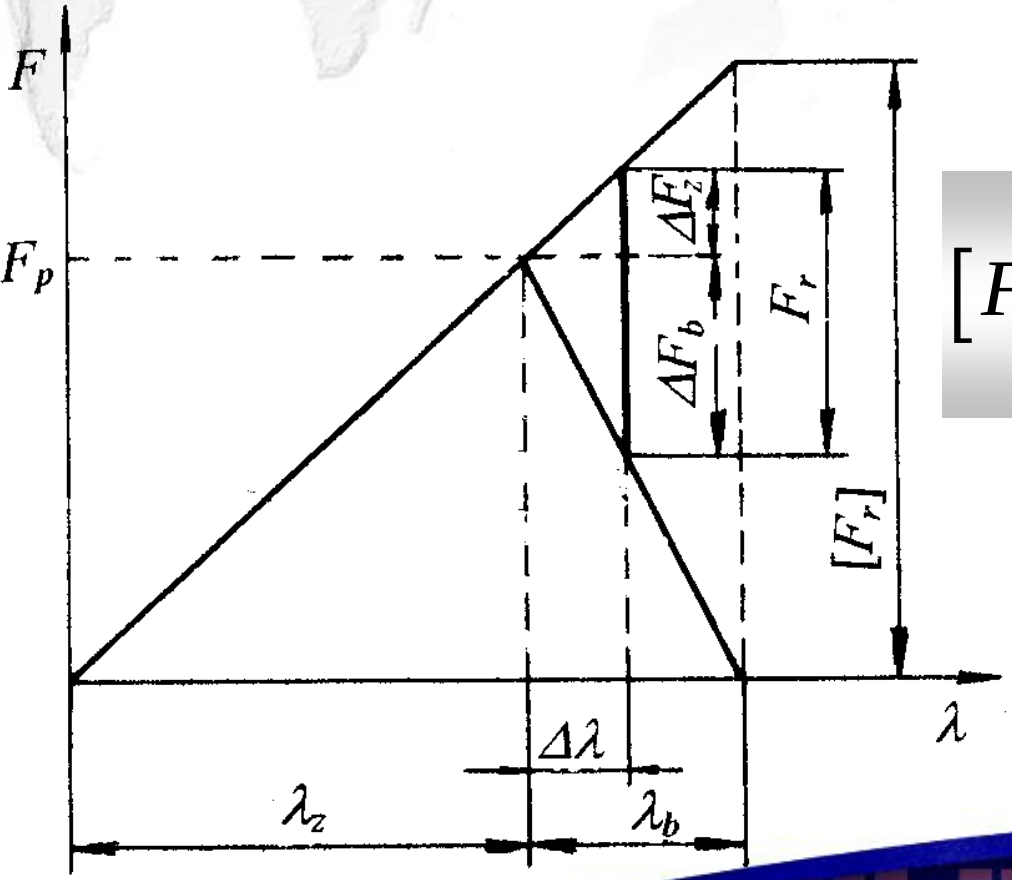
Dijagram sila i deformacija-kritična sila



$$F_b = F_p - \frac{c_b}{c_z + c_b} F_r = 0$$

$$[F_r] = F_p \frac{c_z + c_b}{c_b} = F_p \left(1 + \frac{c_z}{c_b}\right)$$

Stepen sigurnosti protiv razdvajanja veze

$$S_r = \frac{[F_r]}{F_r}$$

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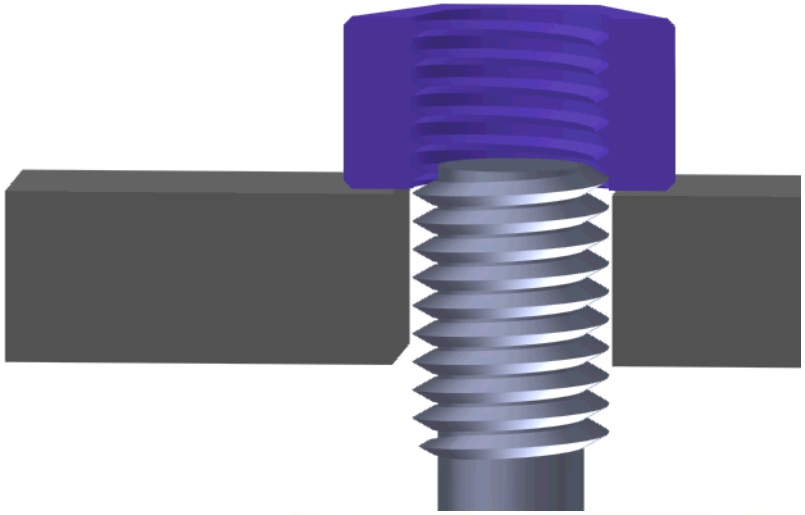
- **Stepen sigurnosti protiv plastičnih deformacija na kraju pritezanja**

Zavrtanj uzdužno opterećene zavrtanjske veze može biti plastično deformisan pri pritezanju dejstvom sile *Fp* i momenta *Tn.*
Proverom stepena sigurnosti protiv plastičnih deformacija ocenjuje se mogućnost pojave ovog kritičnog stanja.

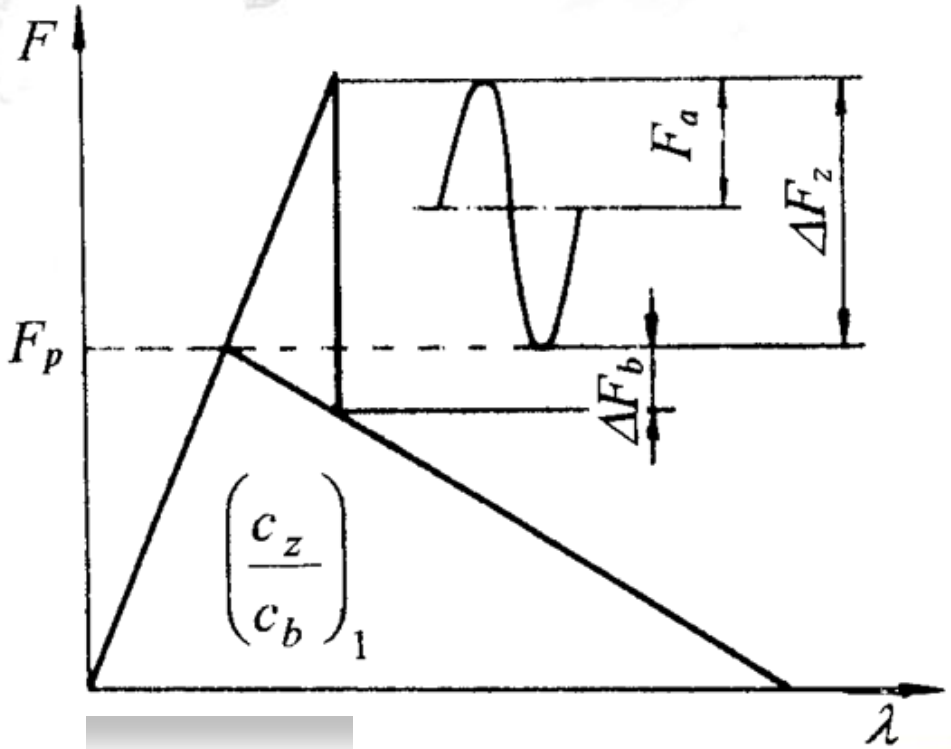
$$S = \frac{\sigma_{TM}}{\sigma}$$

$$\sigma = \frac{F_z}{A_{\min}} = \frac{F_z}{A_S}$$

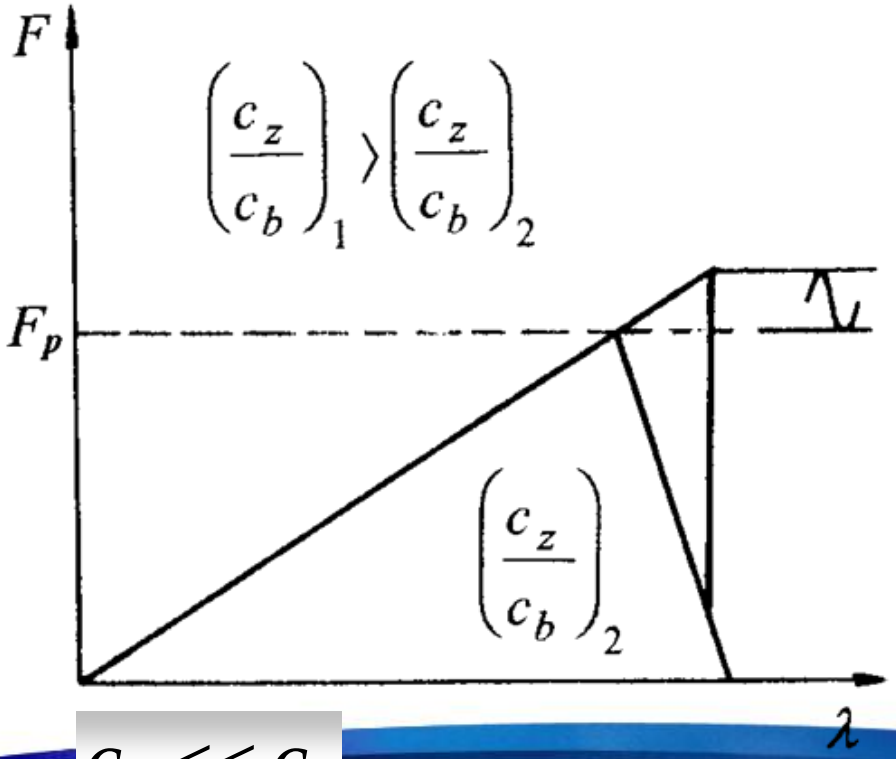


MAŠINSKI ELEMENTI 1

- **Uticaj odnosa krutosti zavrtnja i spojenih delova na raspodelu sila u zavrtanjskoj vezi**



$c_z >> c_b$



$c_z << c_b$

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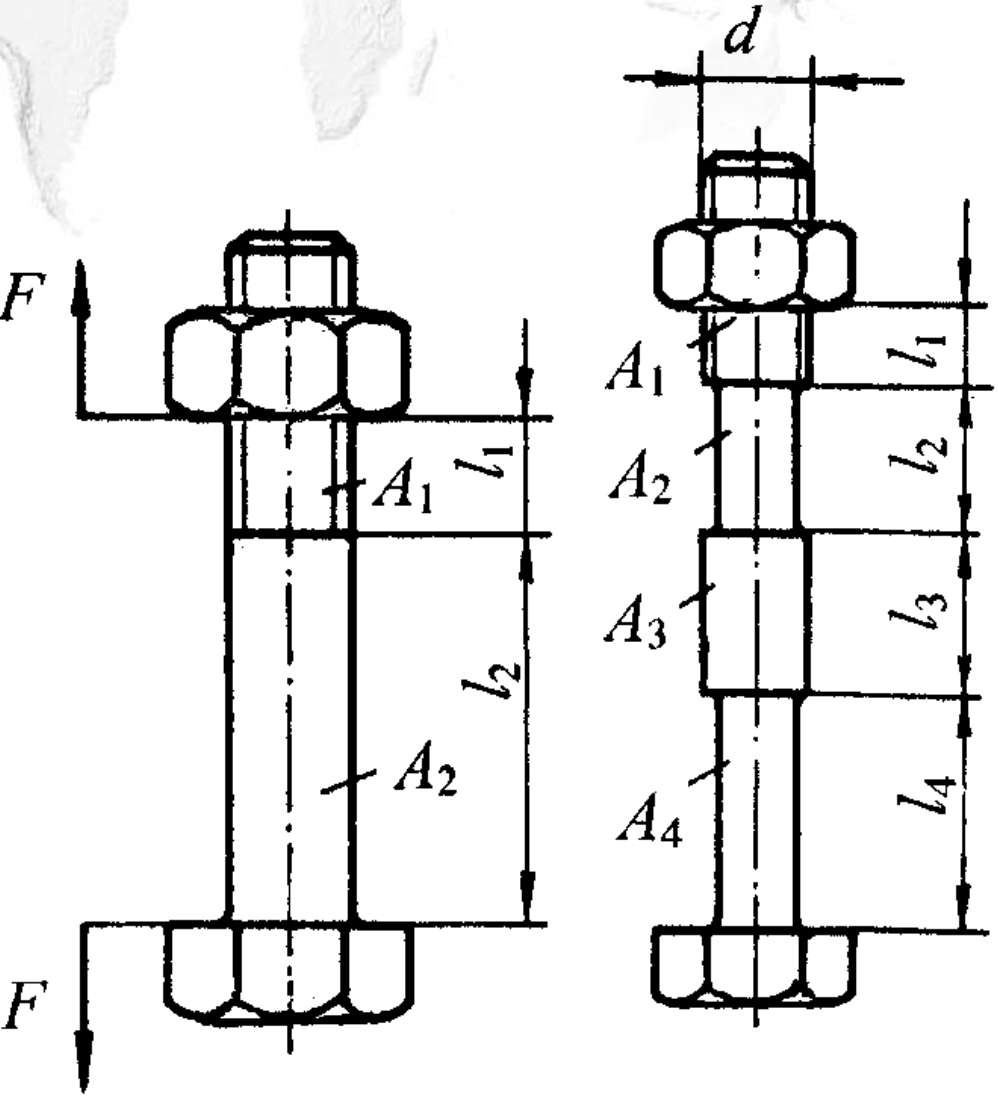
- **Određivanje krutosti zavrtnja-tabl.5.9**



$$\frac{1}{c_z} = \frac{1}{c_s} + \frac{1}{c_g} + \frac{1}{c_n}$$

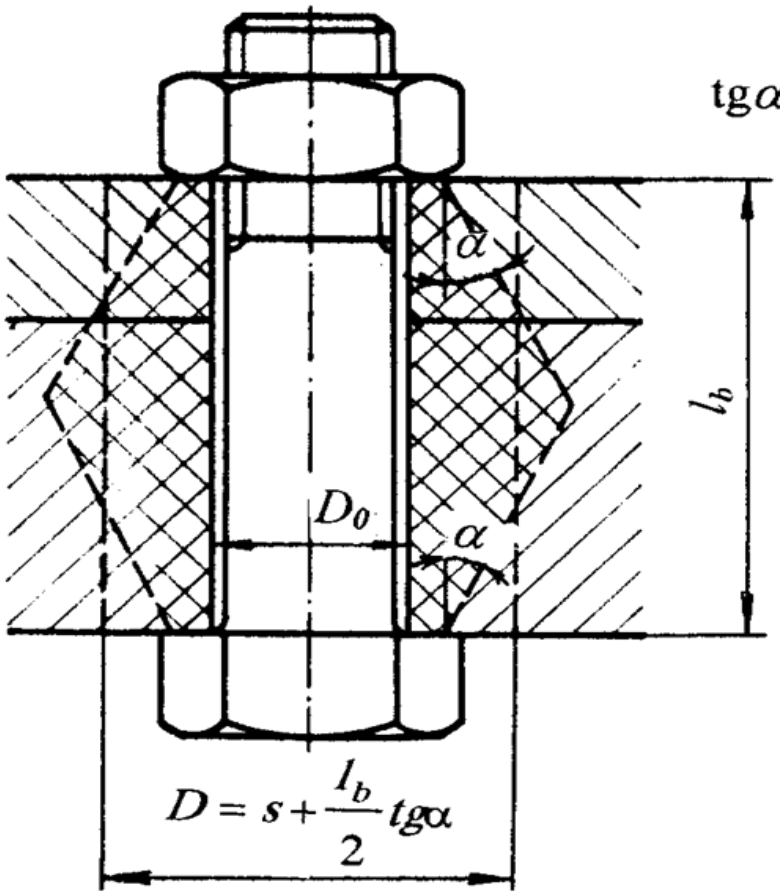
$$\frac{1}{c_s} = \frac{1}{E_z} \sum_{i=1}^{n} \frac{l_i}{A_i}$$

$$\frac{1}{c_g} = \frac{o,15}{E_z h}$$

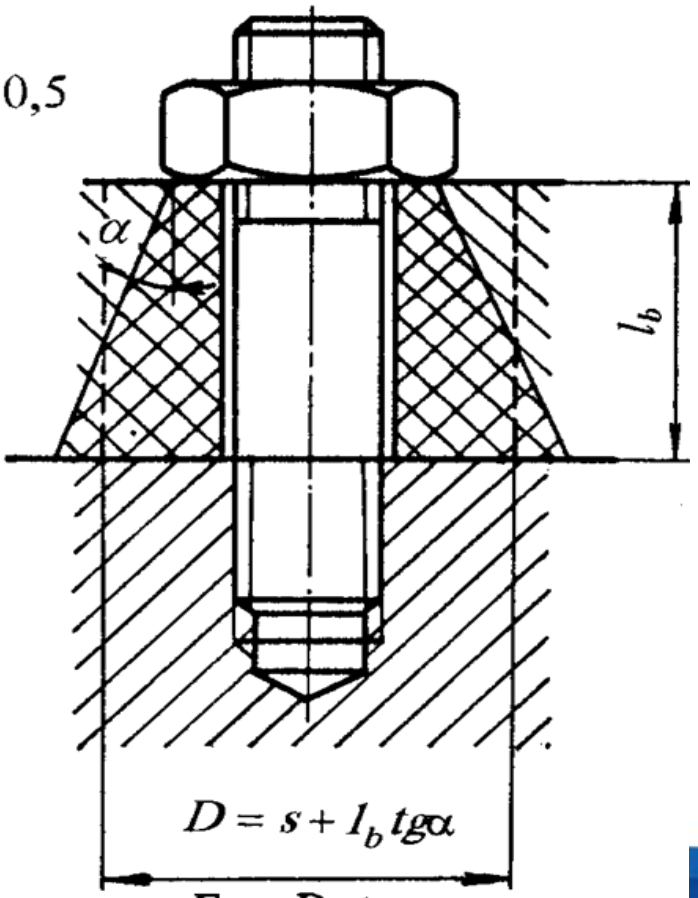
$d/P = 6...10$	$d/P = 10...20$
$\frac{1}{c_n} = (0,95...0,8)\frac{1}{Ed}$	$\frac{1}{c_n} = (0,8...0,7)\frac{1}{Ed}$

MAŠINSKI ELEMENTI 1

- Krutost spojenih delova



$tg\alpha = 0{,}4 \ldots 0{,}5$



$$c_b = \frac{E_b \pi D_o \, tg\alpha}{4{,}6 \log \frac{(s+D_o)(s+l_b tg\alpha - D_o)}{(s-D_o)(s+l_b tg\alpha + D_o)}} \; ; \qquad c_b = \frac{E_b \pi D_o \, tg\alpha}{2{,}3 \log \frac{(s+D_o)(s+2l_b tg\alpha - D_o)}{(s-D_o)(s+2l_b tg\alpha + D_o)}}$$

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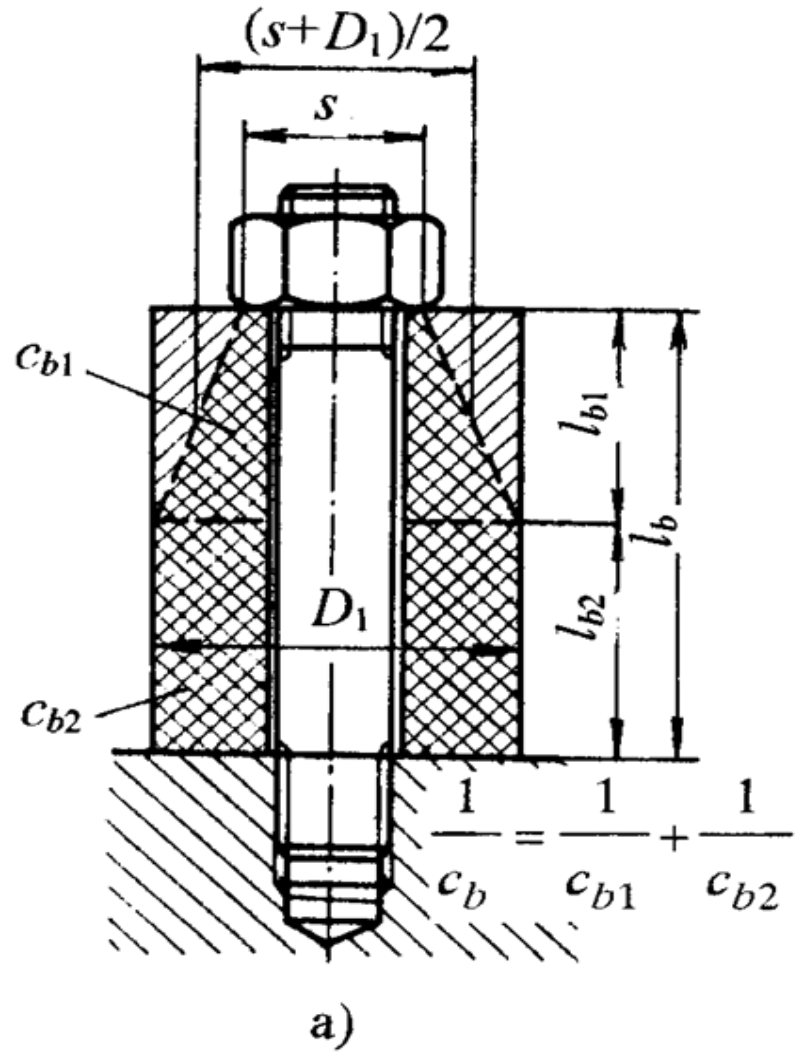
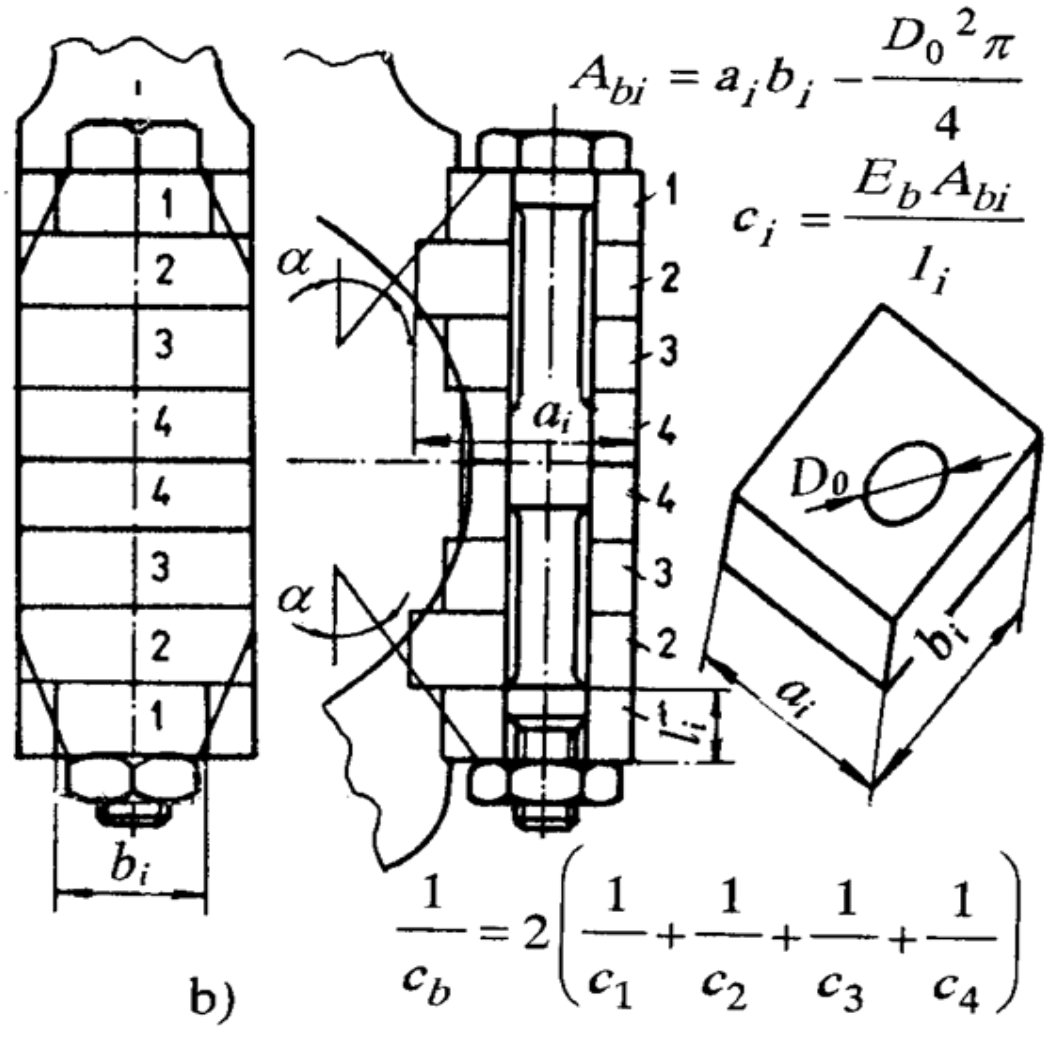
- Krutost spojenih delova





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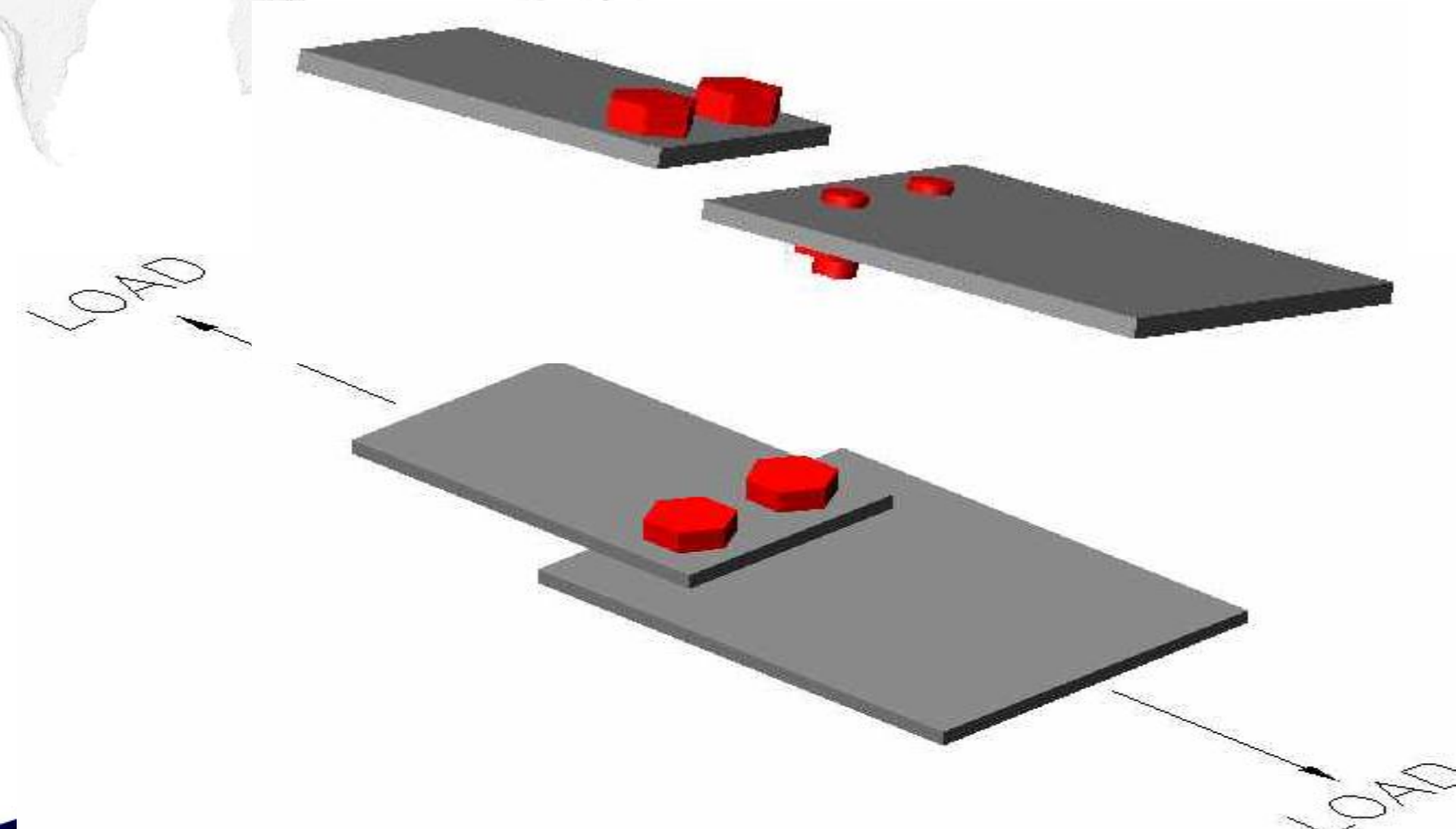
- **Poprečno opterećene zavrtanjske veze**



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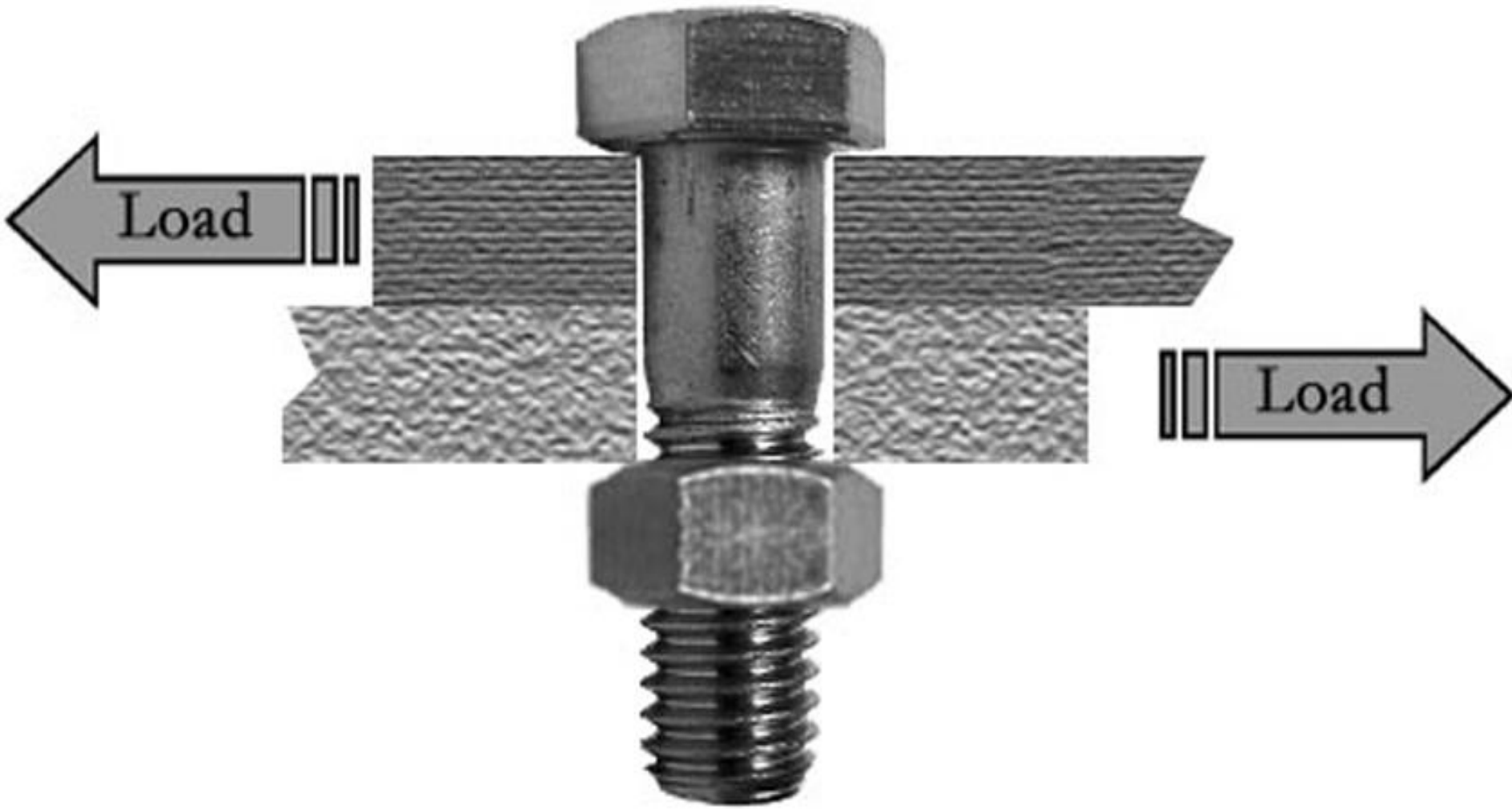
- **Poprečno opterećene zavrtanjske veze**



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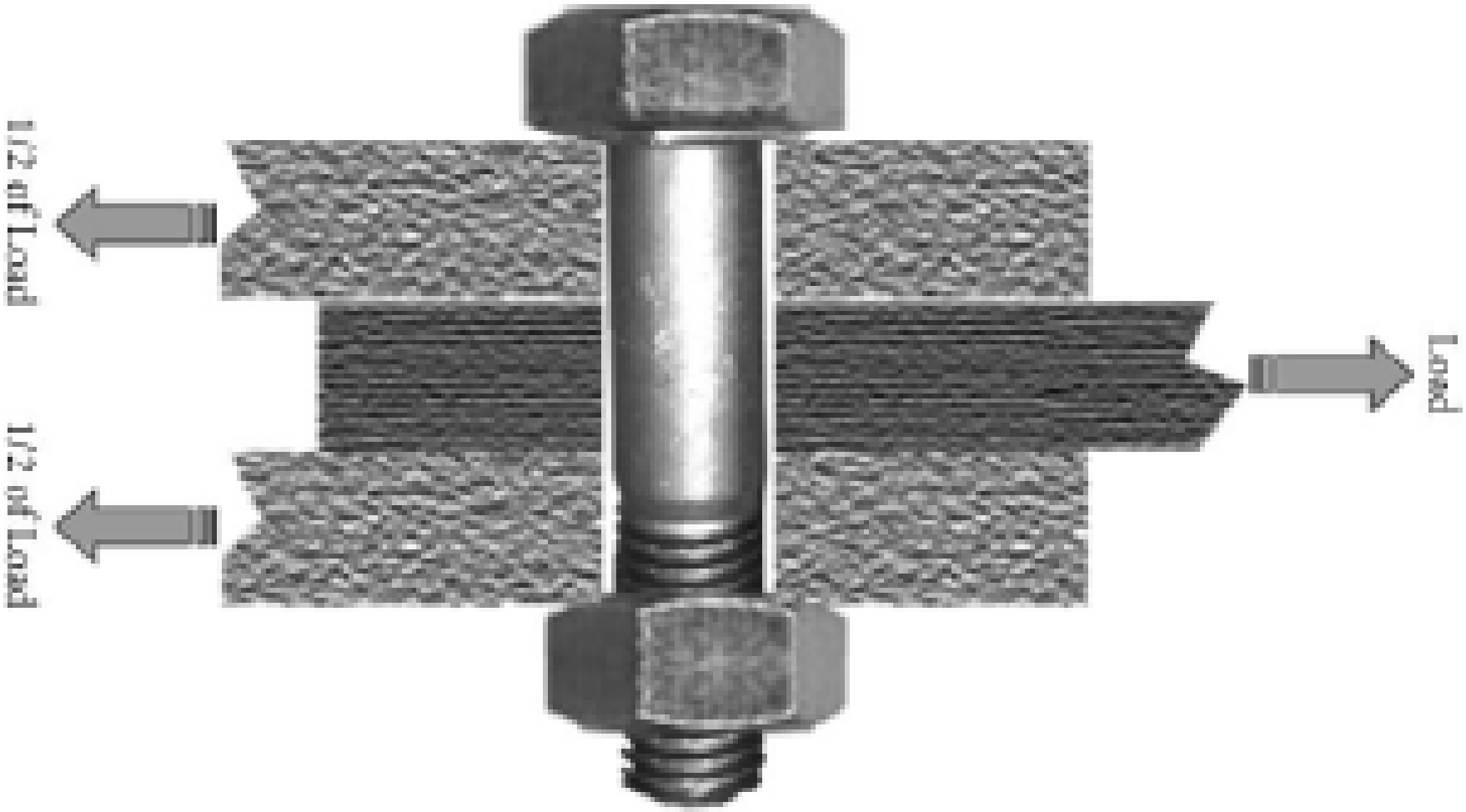
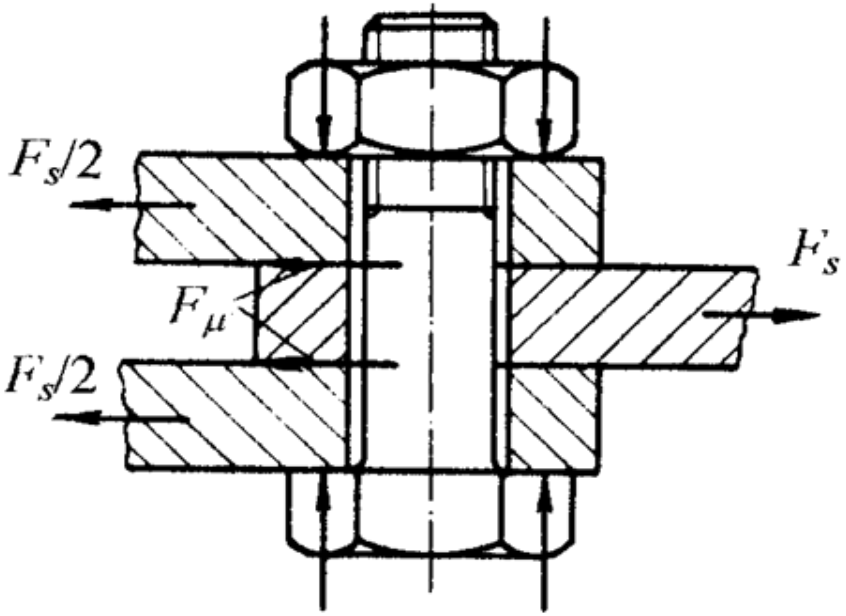
- **Poprečno opterećene zavrtanjske veze**



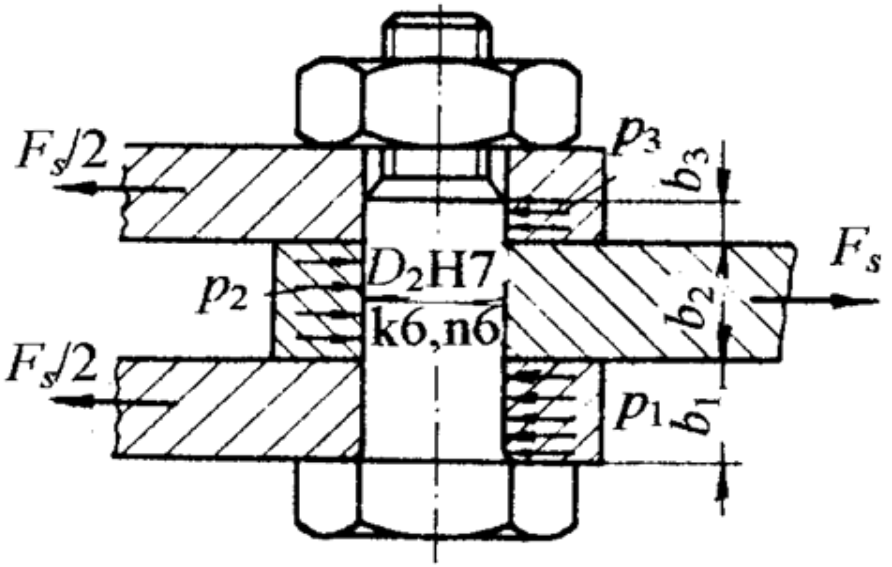
MAŠINSKI ELEMENTI 1

- **Poprečno opterećene zavrtanjske veze**

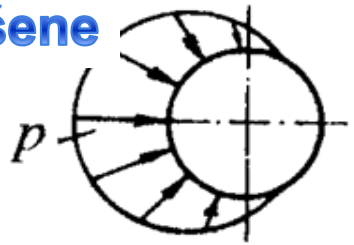
Radno opterećenje (*Fs*) - deluje poprečno na osu zavrtnja



Nepodešene



Podešene



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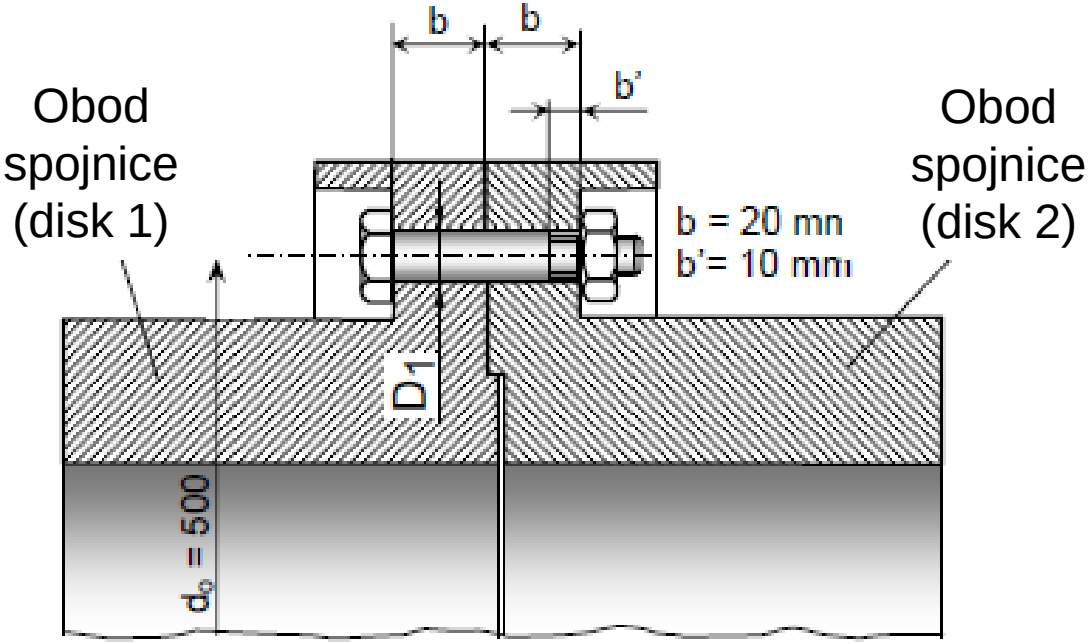
Podešene zavrtanjske veze

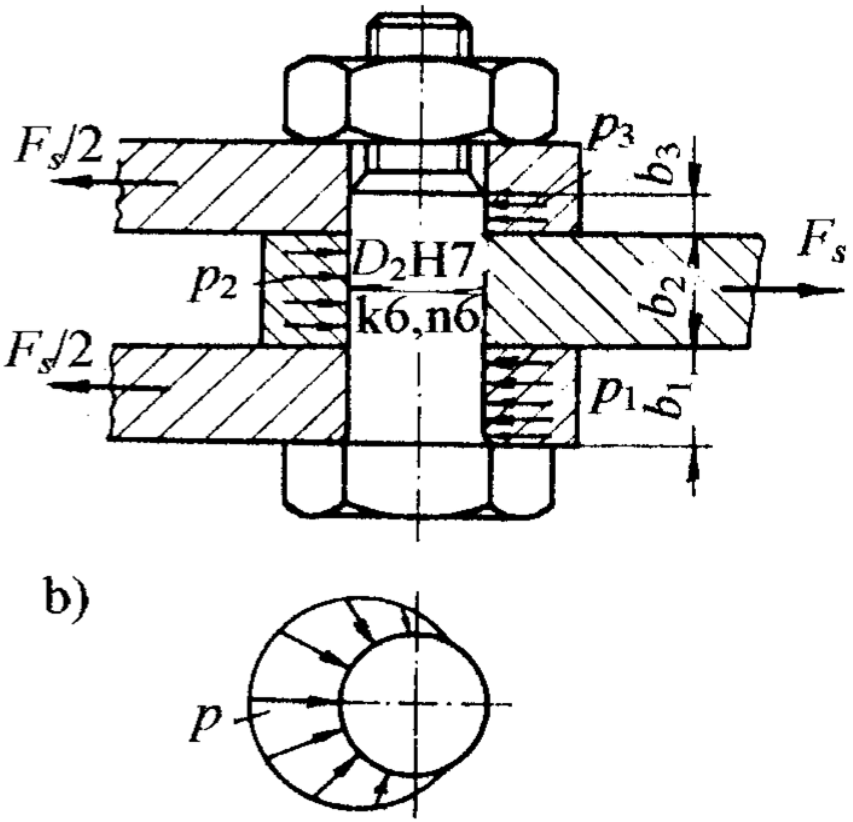


- Postavljanje podešenih zavrtnjeva u otvore spojenih delova
- Neizvesno naleganje H7/n6 ili H7/k6, **prečnik nenavojnog dela zavrtnja** se obrađuje na odgovarajuću meru
- **Navojni deo** zavrtnja ima sekundarnu ulogu (**ne učestvuje u prenošenju radnog opterećenja**- ograničava pomeranje spojenih delova u pravcu ose zavrtnja).

MAŠINSKI ELEMENTI 1

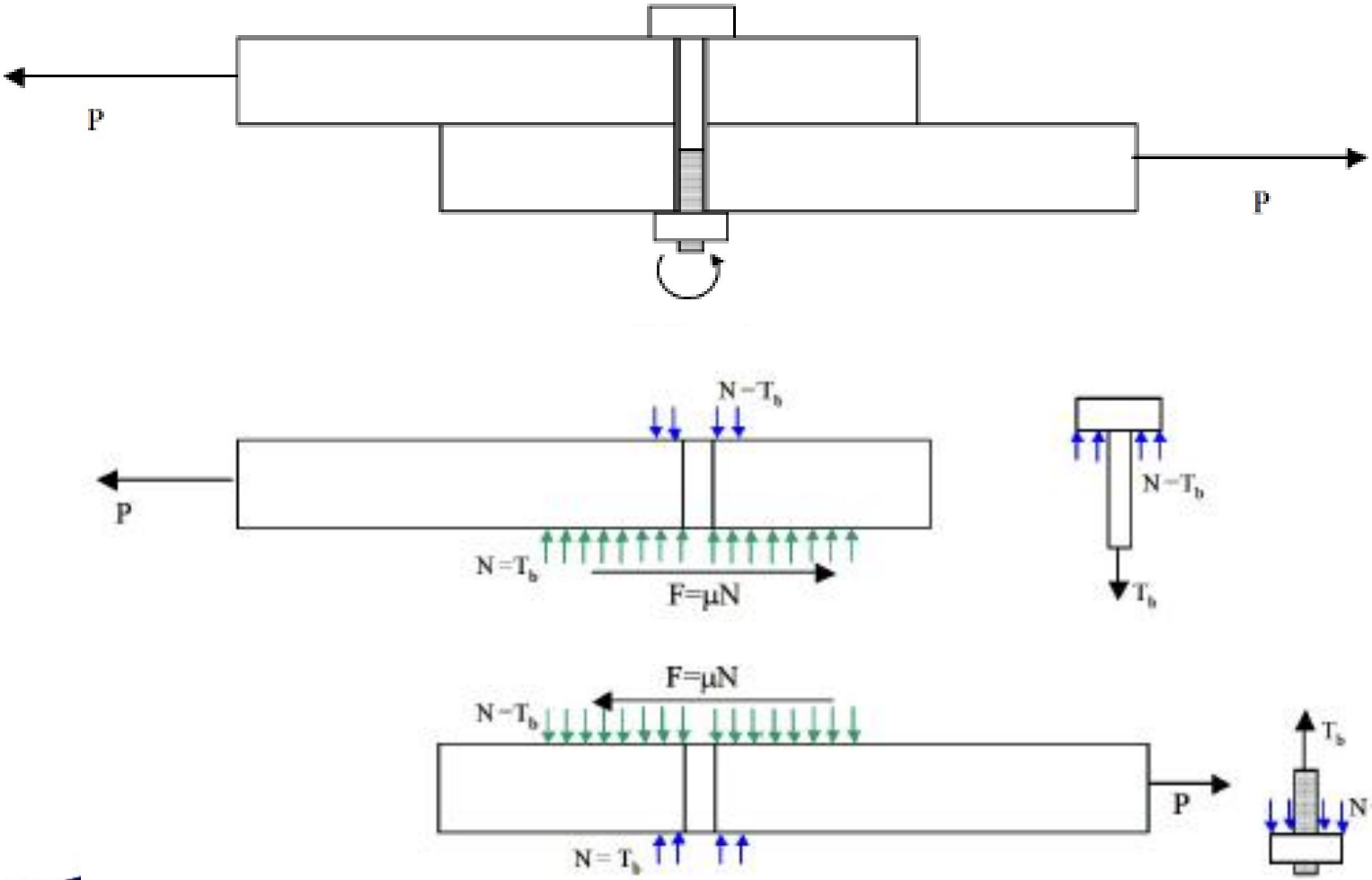
Podešene veze

- **Prenošenje radnog opterećenja** sa jednog dela spoja na drugi deo ostvaruje se **direktno preko stabla zavtnja**.
- **Napadna linija radnog opterećenja** je upravna na osu vijka.
- Da bi se što potpunije iskoristila zapreminska čvrstoća vijka, smanjila masa i povećao ekonomski efekt, **podešeni zavrtnji se mogu pritezati**.



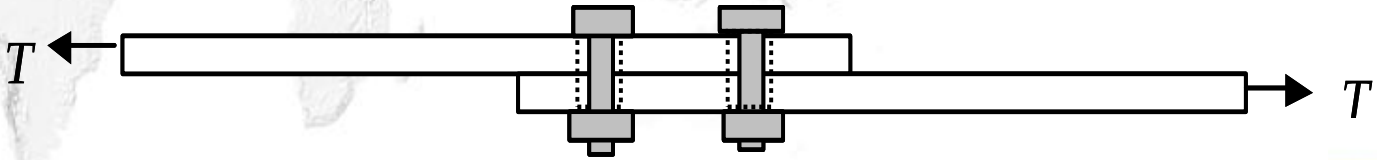
MAŠINSKI ELEMENTI 1

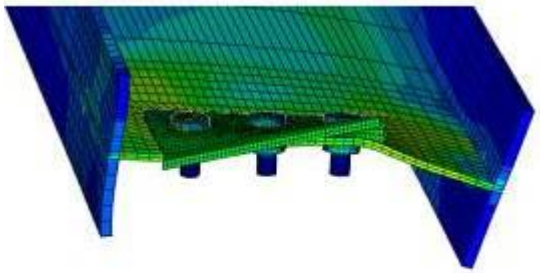
- **Nepodešene zavrtanjske veze**



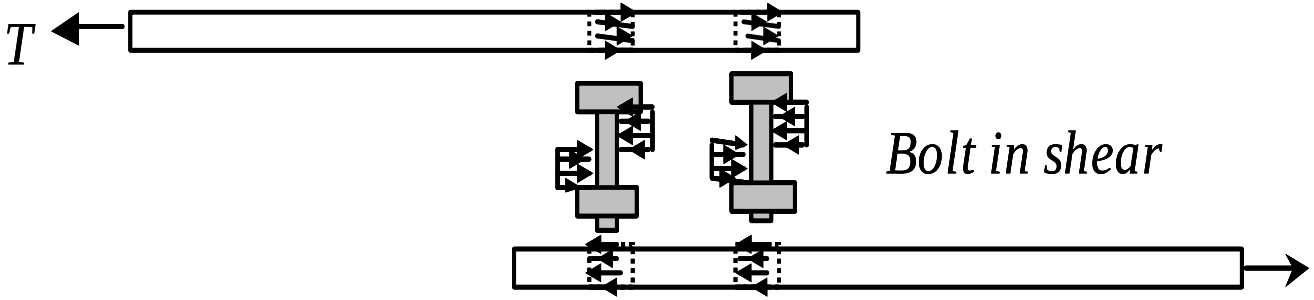
MAŠINSKI ELEMENTI 1

Podešene



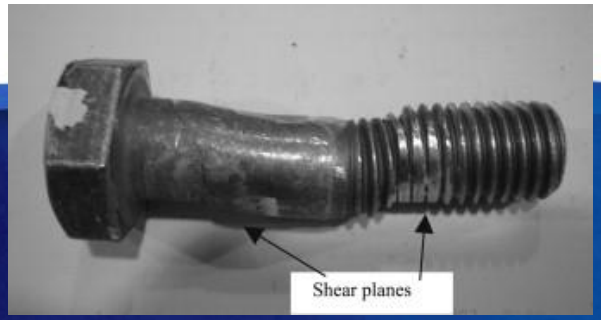


Bearing stresses in plate



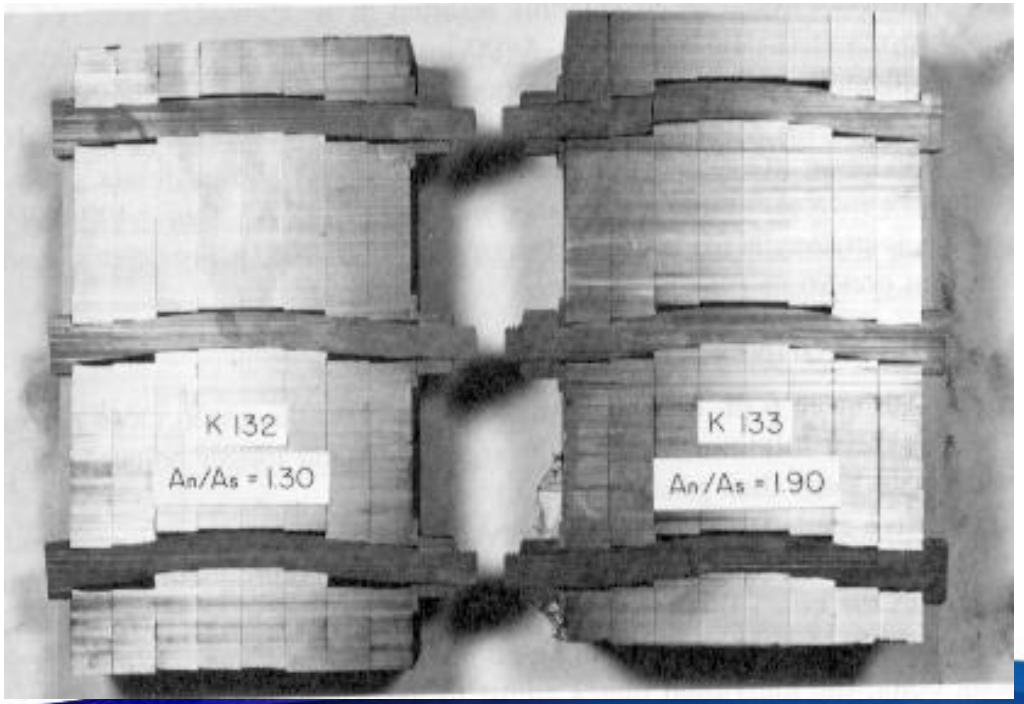
Bolt in shear

Bearing stresses in plate

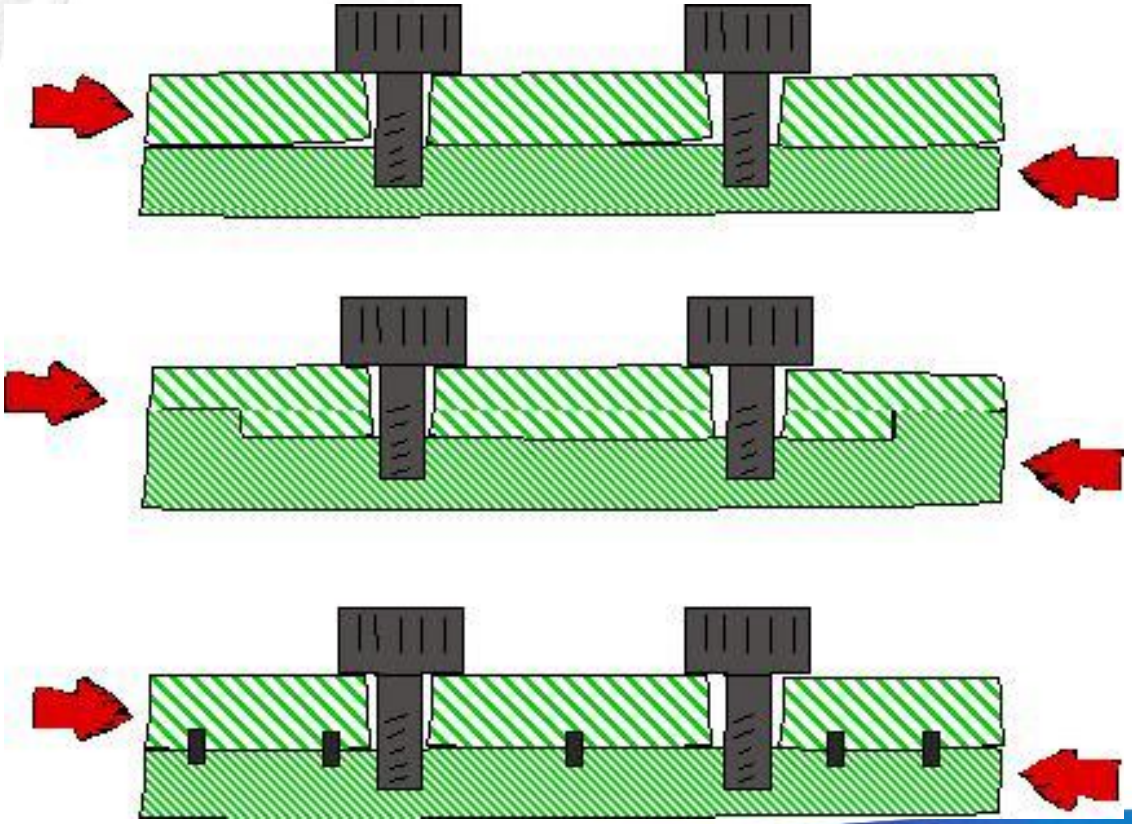


MAŠINSKI ELEMENTI 1

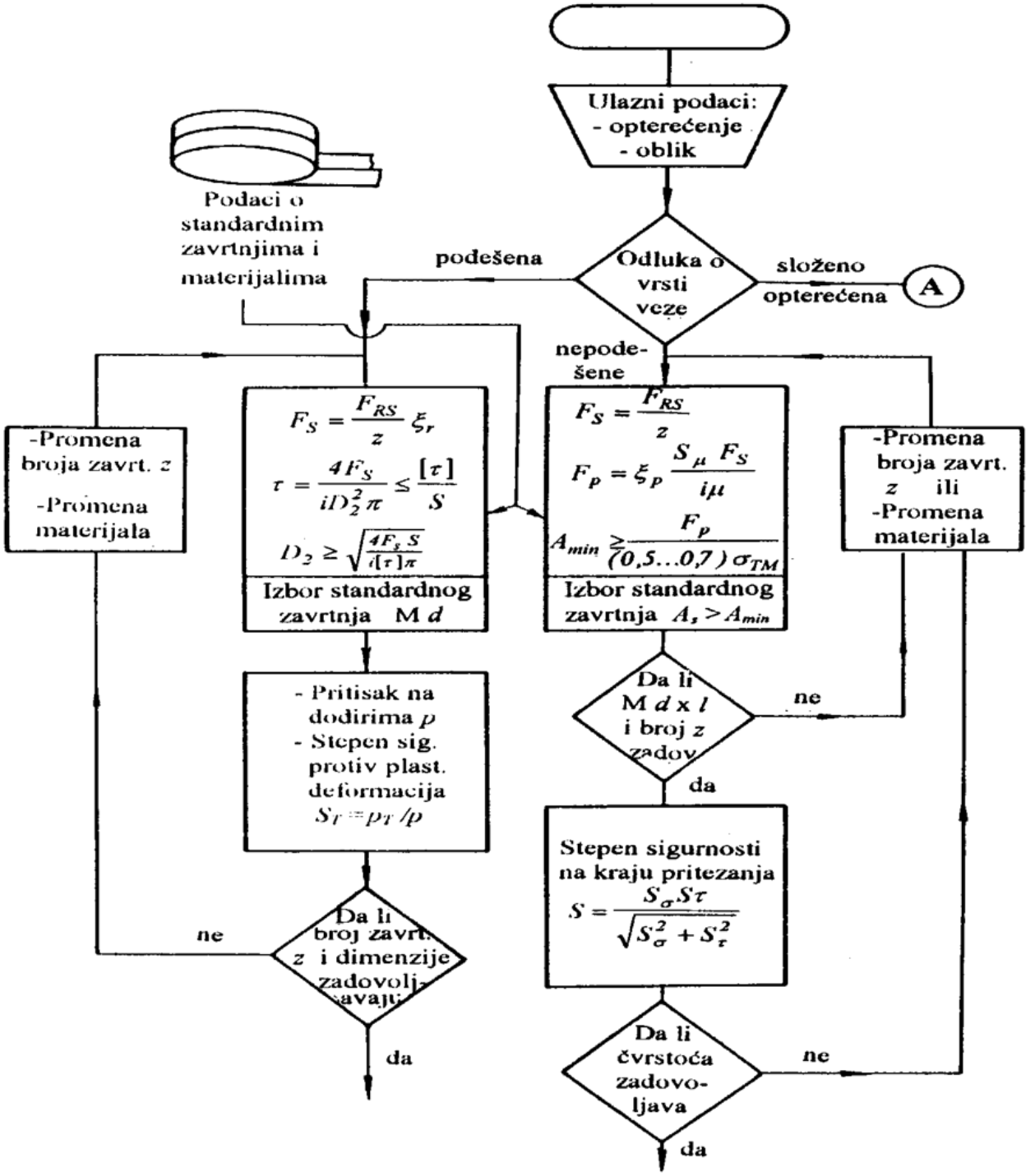
- **Poprečno opterećene zavrtanjske veze**
- **Pokretni navojni spojevi**

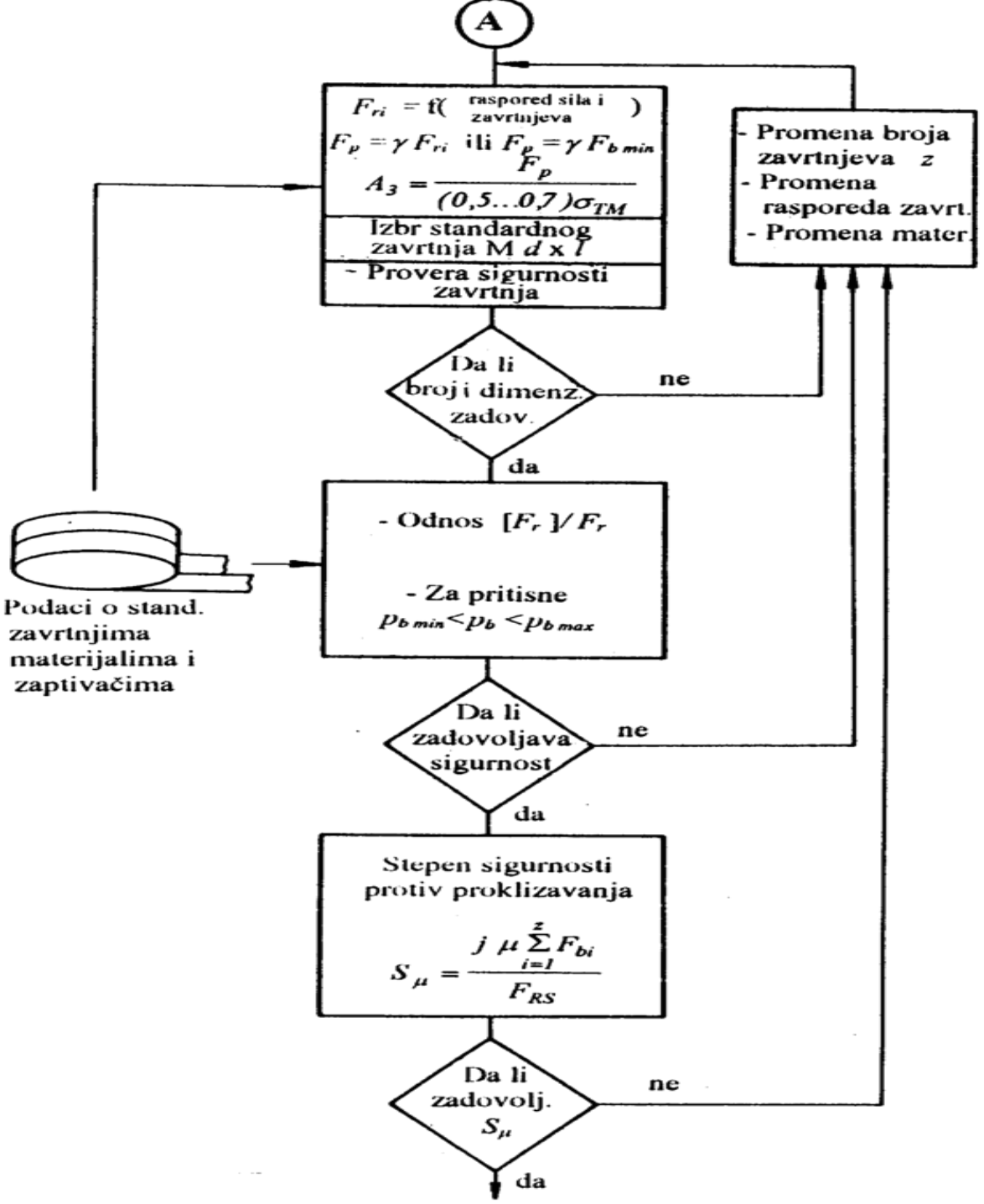


MAŠINSKI ELEMENTI 1



čivije


Ulazni podaci:
- opterećenje
- oblik
Podaci o standardnim zavrtnjima i materijalima
Odluka o vrsti veze
podešena
složeno opterećena
A
nepode-šene
$F_S = \frac{F_{RS}}{z} \xi_r$
$\tau = \frac{4F_S}{iD_2^2\pi} \le \frac{[\tau]}{S}$
$D_2 \ge \sqrt{\frac{4F_S S}{i[\tau]\pi}}$
Izbor standardnog zavrtnja M d
$F_S = \frac{F_{RS}}{z}$
$F_p = \xi_p \frac{S_\mu F_S}{i\mu}$
$A_{min} \ge \frac{F_p}{(0,5...0,7)\sigma_{TM}}$
Izbor standardnog zavrtnja $A_s > A_{min}$
-Promena broja zavrt. z
-Promena materijala
-Promena broja zavrt. z ili
-Promena materijala
- Pritisak na dodirima p
- Stepen sig. protiv plast. deformacija $S_T = p_T / p$
Da li M d x l i broj z zadov
ne
da
Da li broj zavrt. z i dimenzije zadovolj-avaju
ne
da
Stepen sigurnosti na kraju pritezanja
$S = \frac{S_\sigma S_\tau}{\sqrt{S_\sigma^2 + S_\tau^2}}$
Da li čvrstoća zadovo-ljava
ne
da


A
$F_{ri} = f($ raspored sila i zavrtnjeva $)$
$F_p = \gamma F_{ri}$ ili $F_p = \gamma F_{b\,min}$
$A_3 = \frac{F_p}{(0{,}5\ldots0{,}7)\sigma_{TM}}$
Izbr standardnog zavrtnja M d x l
- Provera sigurnosti zavrtnja
Da li broj i dimenz. zadov.
ne
da
- Promena broja zavrtnjeva z
- Promena rasporeda zavrt.
- Promena mater.
- Odnos $[F_r]/F_r$
- Za pritisne
$p_{b\,min} < p_b < p_{b\,max}$
Podaci o stand. zavrtnjima materijalima i zaptivačima
Da li zadovoljava sigurnost
ne
da
Stepen sigurnosti protiv proklizavanja
$S_\mu = \frac{j\,\mu \sum_{i=1}^{z} F_{bi}}{F_{RS}}$
Da li zadovolj. S_μ
ne
da