Q: Shall we design the part based on σ_n or σ? Makes a big difference

Answer: σ_n (static loading, ductile behavior - metals)

Example

$A_c = 1\ in^2$ $\quad F = 10,000$ lbs

$K_t = 2$ (assume)

$S_y = 30\,000$ PSi — yield strength

$\sigma_n = \frac{F}{A_c} = 10\,000$ PSi

$\sigma = K_t \sigma_n = 2(10000) = 20\,000$ PSi

n = factor of safety

$$n = \frac{S_y}{\sigma_n} = \frac{30}{10} = 3$$

what happens as F increases?

Q: When material (metal) yields it becomes

a) weaker

a) weaker

(b) stronger

c) no difference

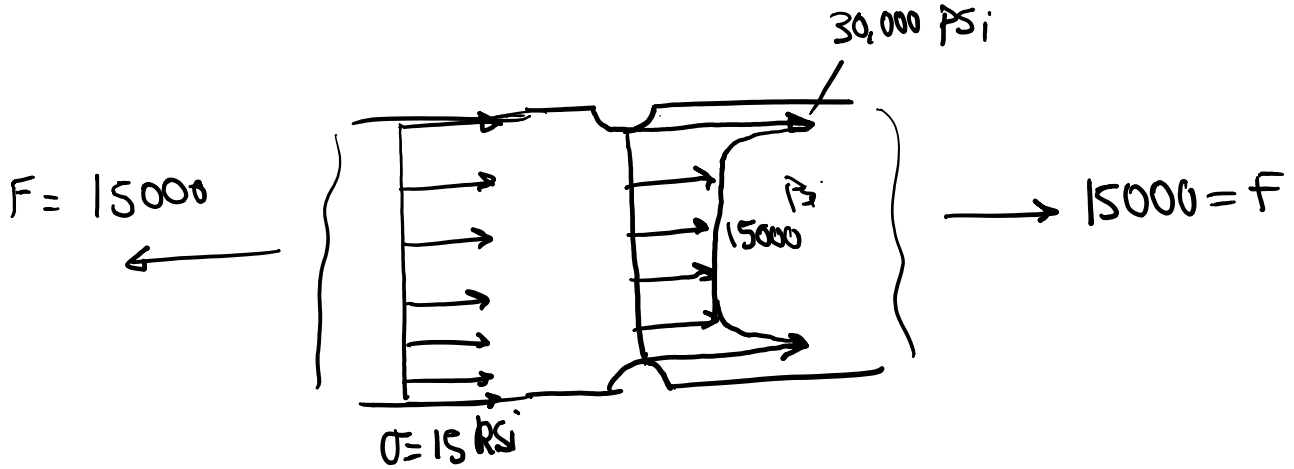
d) damaged

$\sigma = E\varepsilon$

Q) If material gets stronger after yielding, why is there so much fuss about it being not acceptable in machine design?

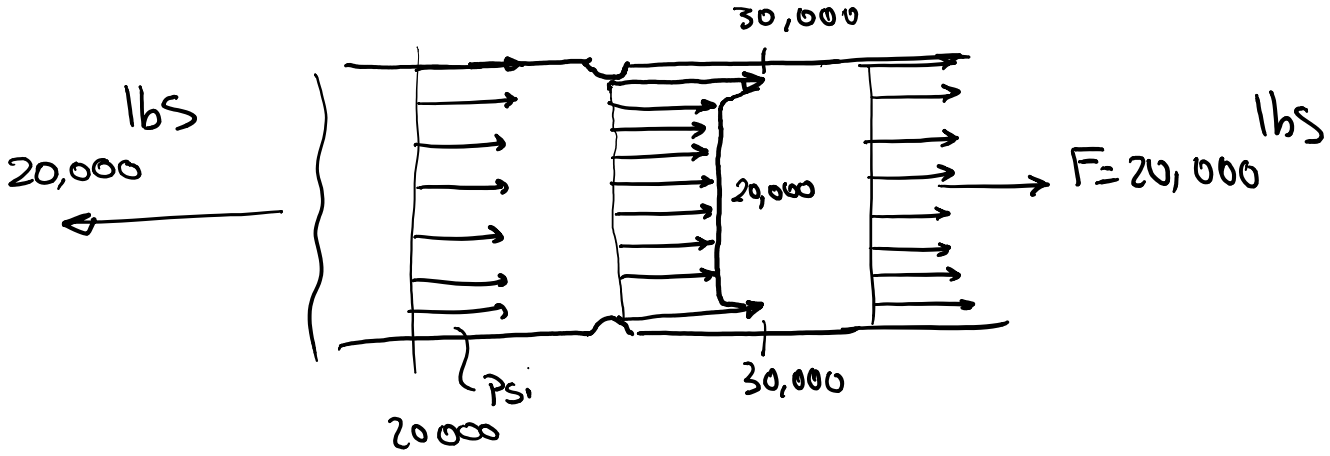
Answer: yielding is bad only when it leads to measurable geometry change in machine components

increase load to F=15000

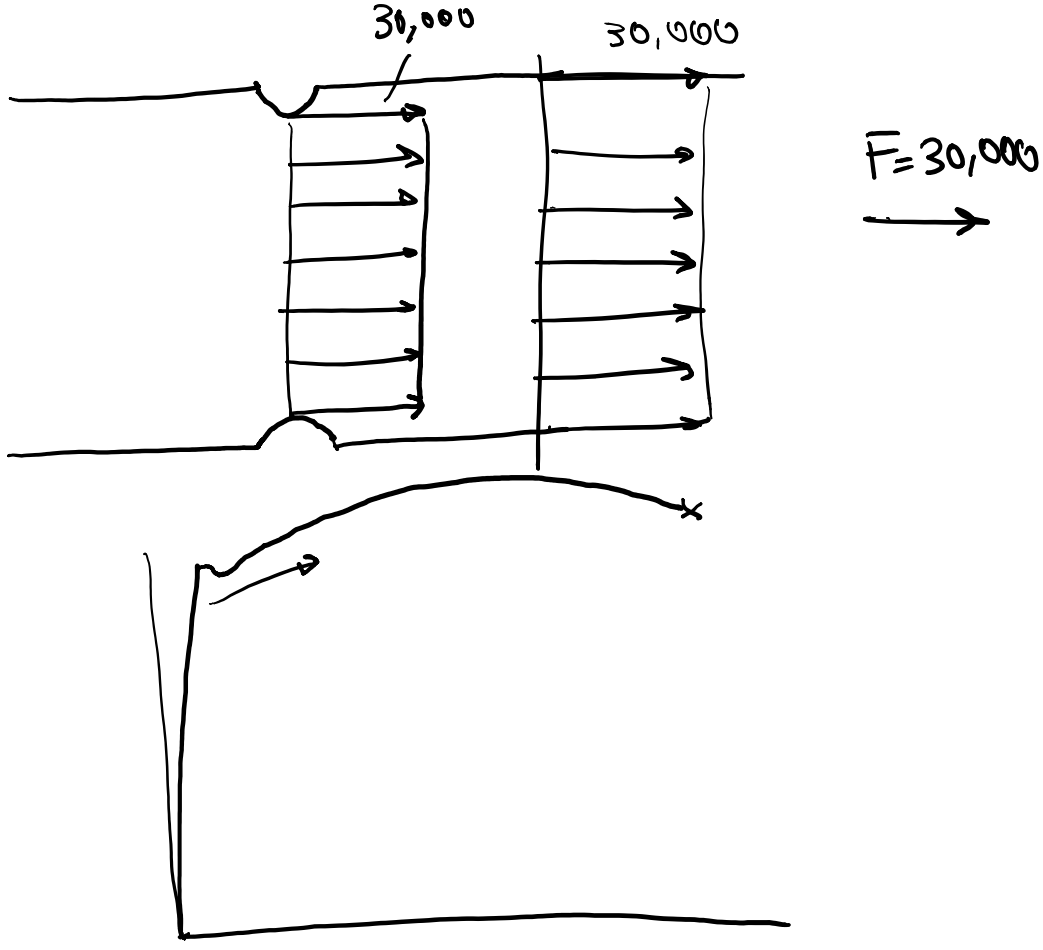


no measurable change in length

increase load to F = 20,000 lbs



increase force to F = 30,000



after the whole section yields, the bar

will have measurable deformation (unacceptable)

Conclusion

Design against yielding that causes measurable deformation

i.e. ignore stress concentration is static loading for metals (ductile behavior)

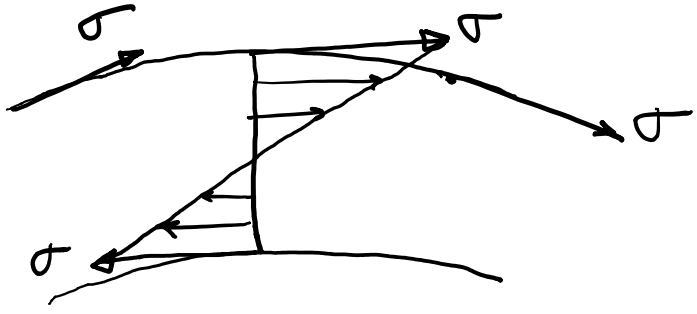
Direct tension Compression

$$\sigma = \frac{F}{A} \leq S_y$$

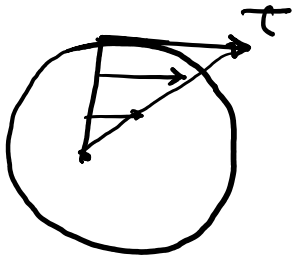
$A \equiv$ section area

Bending

$$\sigma = \frac{Mc}{I} \leq S_y$$



Torsion $\tau = \frac{Tr}{J} \leq 0.58\, S_y$



For repeated loading $n \geq 1000$

Things would be different

* For situations to ignore stress raisers the material and conditions must allow at least a little stretching before fracture
    1) material must have sufficient ductility (at least 2-3%)
    2) Processing (heat treatment / cold working) must not reduce ductility to below 2-3%.
    3) Temp must not be extremely cold
    4) Loading must not be severe impact
    5) Loading must not repeat many times < 1000 cycles

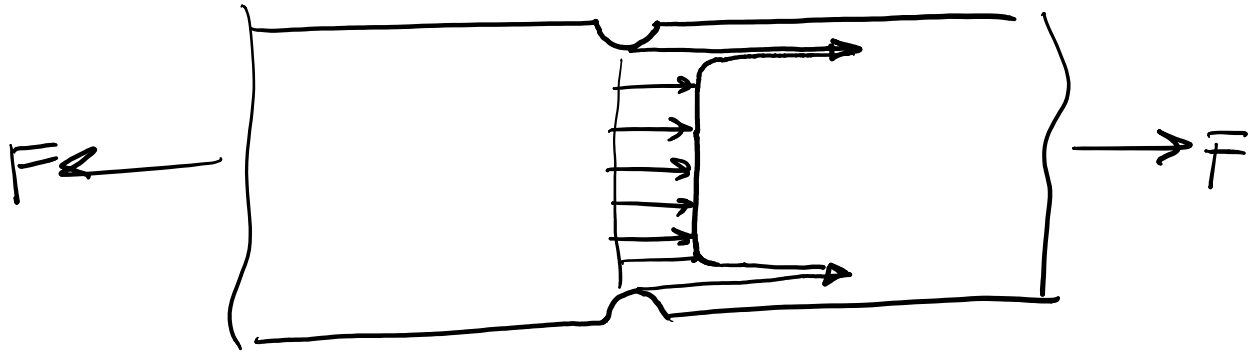
* ignore stress concentration for materials with flawed micro-structure (gray cast

iron) in all situation (static or repeated)

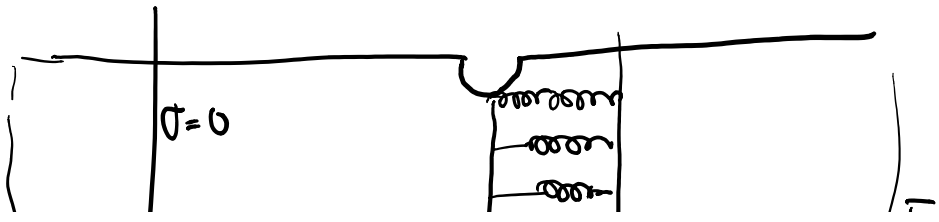
* Brittle materials (ceramics) with uniform micro-structure : Apply stress raisers

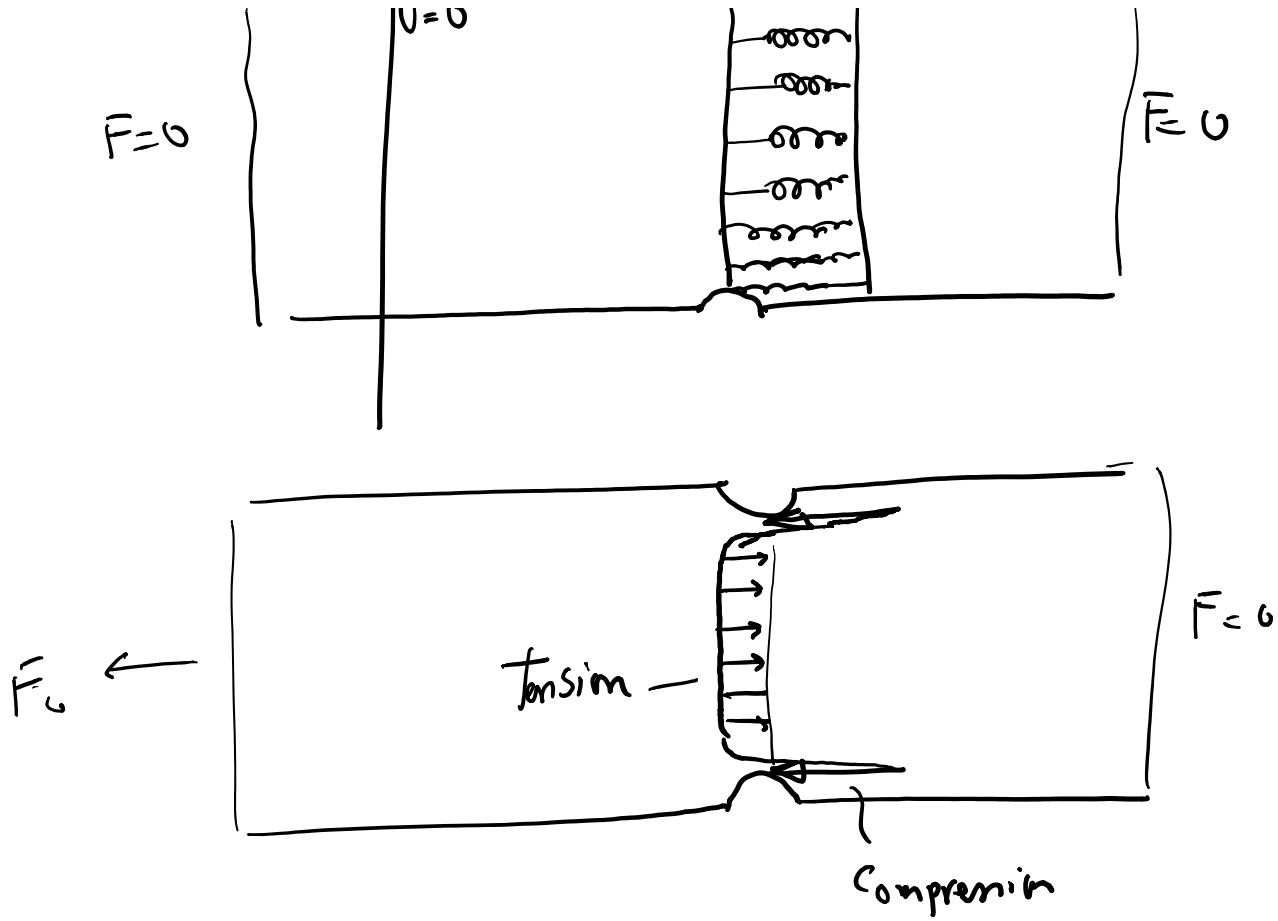
Why not ignore stress raisers for ductile materials when loading is repeated?

What happens when the load is removed after localized yielding (static loading)



After load is removed





Surface builds compressive stress & that is a very good thing for fatigue resistance -

methods:

- rolling, extruding
- shot peening
- impact hammers