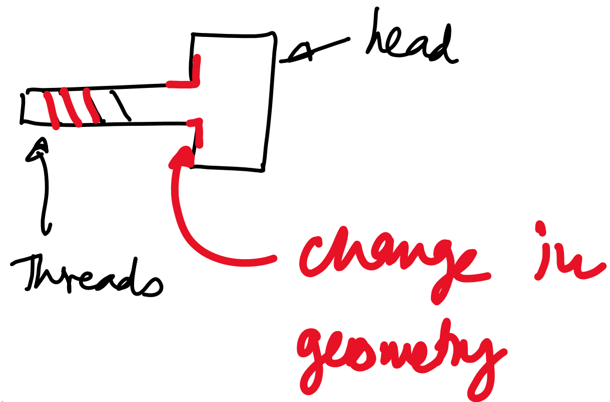
Stress Concentration

Example

1. Bolts



2. Transmission shafts with keys, keyways, key seat

3. Shoulders on shaft, grooves, holes, notches, etc. will cause stress concentration.

Stress concentration factor : K_t, K_{ts}

$$K_t = \frac{\sigma_{max}}{\sigma_0} \quad ; \quad K_{ts} = \frac{\tau_{max}}{\tau_0}$$

σ_0, τ_0 are the nominal stresses in the absence of discontinuity / change in geometry

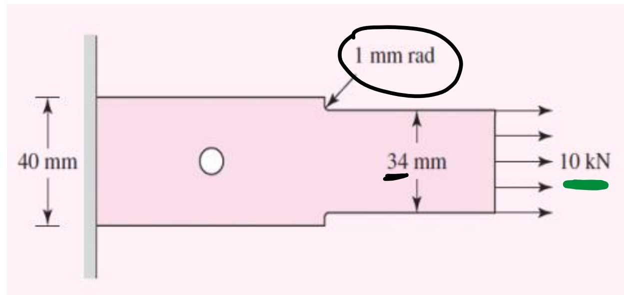
σ_{max}, τ_{max} are the maximum stresses due to discontinuity / change in geometry

K_t, K_{ts} – non-dimensional ; ≥ 1 depend only on geometry

K_t, K_{fs} – non-dimensional ; ≥ 1 depend only on geometry.

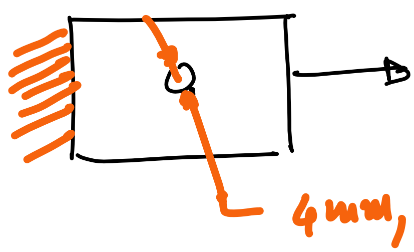
Q1

The 2-mm-thick bar shown in Fig. 3–30 is loaded axially with a constant force of 10 kN. The bar material has been heat treated and quenched to raise its strength, but as a consequence it has lost most of its ductility. It is desired to drill a hole through the center of the 40-mm face of the plate to allow a cable to pass through it. A 4-mm hole is sufficient for the cable to fit, but an 8-mm drill is readily available. Will a crack be more likely to initiate at the larger hole, the smaller hole, or at the fillet?



1. 4mm hole
2. 8 mm hole
3. 1mm filet

$$K_t = \frac{\sigma_{max}}{\sigma_0} \Rightarrow \sigma_{max} = K_t \, \sigma_0$$



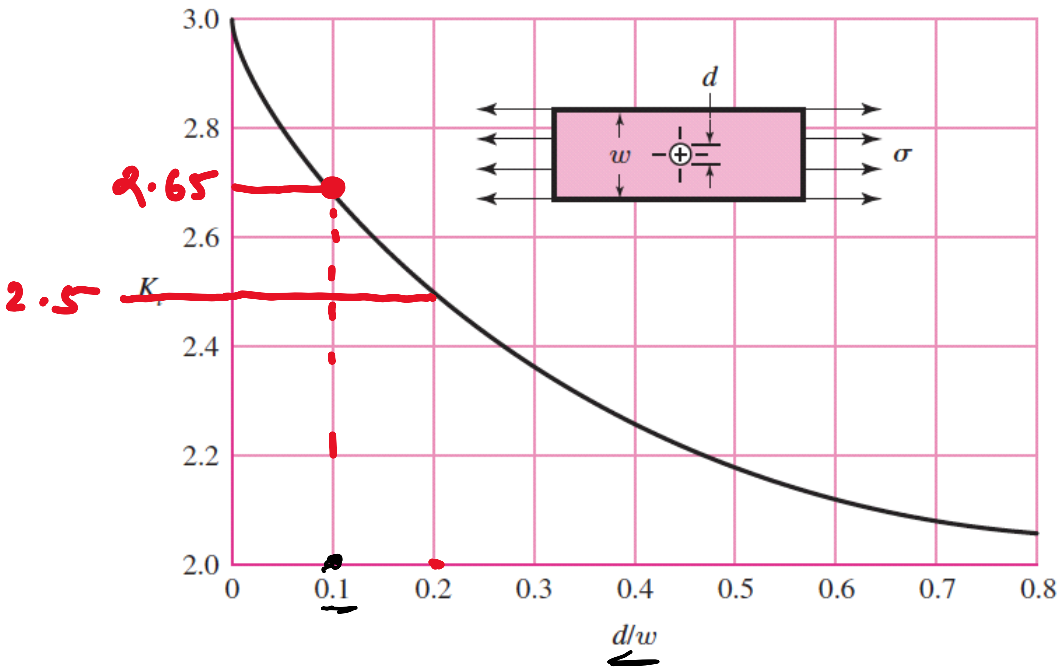
① 4mm hole

$d = 4mm$

$W = 40mm$

$\frac{d}{W} = \frac{4}{40} = 0.1$

$k_t = 2.65$



$$\sigma_o = \frac{F}{A} = \frac{F}{(w-d)t} = \frac{(10)(10^3)}{(40-4)(10^{-3})(2)(10^{-3})} = 139 \text{ MPa}$$

$(40-4) = (w-d)$

$$\sigma_{max} = k_t \sigma_o = (2.65)(139) \Rightarrow \sigma_{max} = 368.35 \text{ MPa}$$

② $d = 8mm$; $W = 40 mm$

$\frac{d}{W} = \frac{8}{40} = 0.2$; $k_t = 2.5$

$$\sigma_o = F/A = F/(w-d)t = \frac{(10)(10^3)}{(40-8)(10^{-3})(2)(10^{-3})} = 156 \text{ MPa}$$

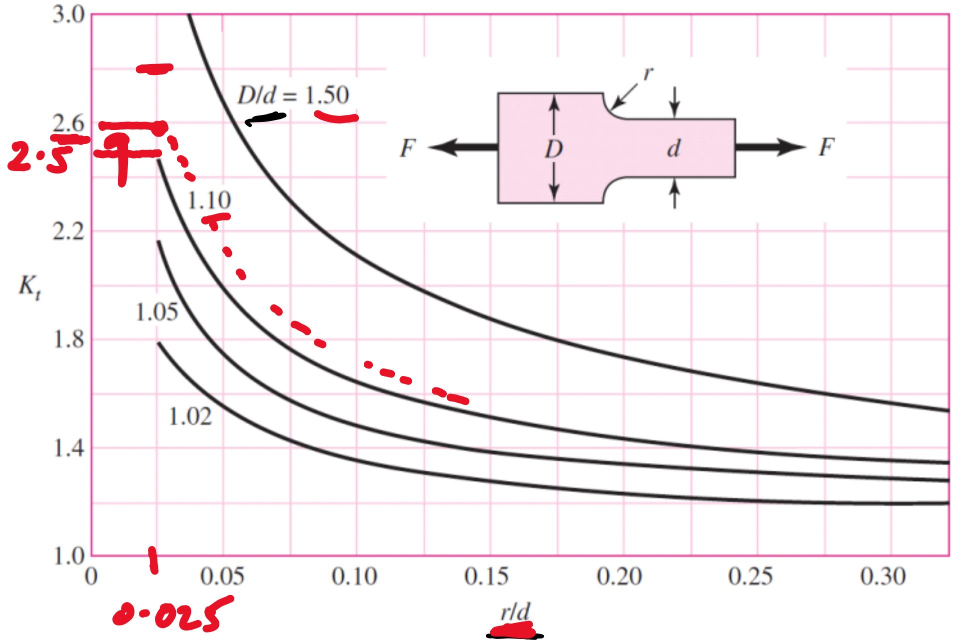
$$\sigma_{max} = k_t \sigma_o = (2.5)(156) \Rightarrow \sigma_{max} = 390 \text{ MPa}$$

③

$r = 1\,mm$

$d = 34$

$D = 40$



$$\frac{D}{d} = \frac{40}{34} = 1.18$$

$$\frac{r}{d} = \frac{1}{34} = 0.026$$

$K_t = 2.5$ (Better value would be 2.6 + to be more conservative)

$$\sigma_0 = \frac{F}{dt} = \frac{(10)(10^3)}{(34)(10^{-3})(2)(10^{-3})} = 147\,MPa$$

$$\sigma_{max} = K_t\,\sigma_0 = (2.5)(147) \Rightarrow \boxed{\sigma_{max} = 368\,MPa}$$

Summary

1. 4 mm hole : $\sigma_{max} = 368.35$ MPa
2. 8 mm hole : $\sigma_{max} = 390$ MPa

crack initiate at the 8mm hole.

3. 1mm fillet : $\sigma_{max} = 368$ MPa