STRESS CONCENTRATION & NOTCH SENSITIVITY

MET 4501 — LECTURE NOTES — PROF. LEAH GINSBERG

STRESS CONCENTRATION REFERS TO THE OCCURRENCE OF LOCALIZED STRESS INCREASES IN A MATERIAL, TYPICALLY AROUND GEOMETRIC DISCONTINUITIES, SUCH AS HOLES, NOTCHES, SHARP CORNERS, KEYWAYS, OR GROOVES. THESE DISCONTINUITIES CAUSE THE MATERIAL TO BEHAVE IN A NONUNIFORM WAY UNDER LOAD.

A STRESS CONCENTRATION FACTOR IS USED TO RELATE THE ACTUAL MAXIMUM STRESS AT THE DISCONTINUITY TO THE NOMINAL STRESS.

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

WHERE K_t IS USED FOR NORMAL STRESS AND K_{ts} IS USED FOR SHEAR STRESS, AND σ_0 AND τ_0 ARE THE NOMINAL NORMAL AND SHEAR STRESS, RESPECTIVELY.

SEE TABLES A-15 & A-16 IN SHIGLEY FOR STRESS CONCENTRATION FACTORS FOR A VARIETY OF GEOMETRIES.

NOTE: IN DUCTILE MATERIALS UNDER STATIC LOADING, THE STRESS-CONCENTRATION FACTOR IS NOT USUALLY APPLIED BECAUSE PLASTIC STRAIN IN THE REGION OF THE STRESS CONCENTRATION IS LOCALIZED AND HAS A STRENGTHENING EFFECT.

NOTCH SENSITIVITY

THE THEORETICAL STRESS CONCENTRATION FACTOR K_t IS DEFINED FOR STATIC LOADING CONDITIONS. UNDER VARIABLE LOADING, NOT ALL MATERIALS EXPERIENCE THE FULL THEORETICAL STRESS CONCENTRATION FACTOR, ESPECIALLY DUCTILE MATERIALS, BECAUSE THEY CAN REDISTRIBUTE STRESS THROUGH PLASTIC DEFORMATION BEFORE FAILURE.

NOTCH SENSITIVITY (q) IS A MATERIAL'S SENSITIVITY TO STRESS CONCENTRATION EFFECTS, DEFINED AS:

$$q = \frac{K_f - 1}{K_t - 1} \qquad q_s = \frac{K_{fs} - 1}{K_{ts} - 1}$$

IF $q=0$, THEN $K_f = 1$ AND THE MATERIAL HAS NO SENSITIVITY TO NOTCHES.
IF $q=1$, THEN $K_f = K_t$ AND THE MATERIAL HAS FULL NOTCH SENSITIVITY.

K_f IS A REDUCED VERSION OF K_t, CALLED THE FATIGUE STRESS CONCENTRATION FACTOR. IT IS DEFINED AS

$$K_f = \frac{\text{FATIGUE STRENGTH OF NOTCH-FREE SPECIMEN}}{\text{FATIGUE STRENGTH OF NOTCHED SPECIMEN}}$$

AND, SIMILAR TO K_t,

$$K_f = \frac{\sigma_{max}}{\sigma_0} \qquad K_{fs} = \frac{\tau_{max}}{\tau_0}$$

IN ANALYSIS OR DESIGN WORK, THE PROCESS IS TYPICALLY:

1. FIND K_t, FROM THE GEOMETRY OF THE PART
2. SPECIFY THE MATERIAL
3. FIND q (FROM FIG. 6-26, FOR EXAMPLE)
4. SOLVE FOR K_f

$$K_f = 1 + q(K_t - 1) \qquad K_{fs} = 1 + q_s(K_{ts} - 1)$$