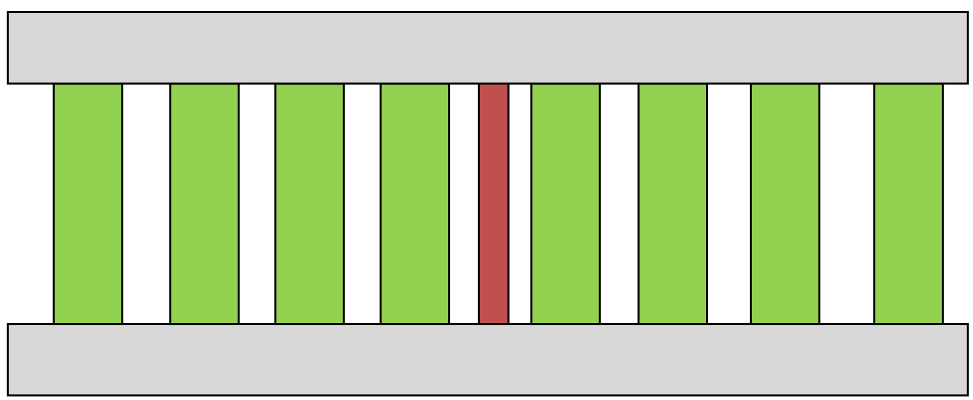
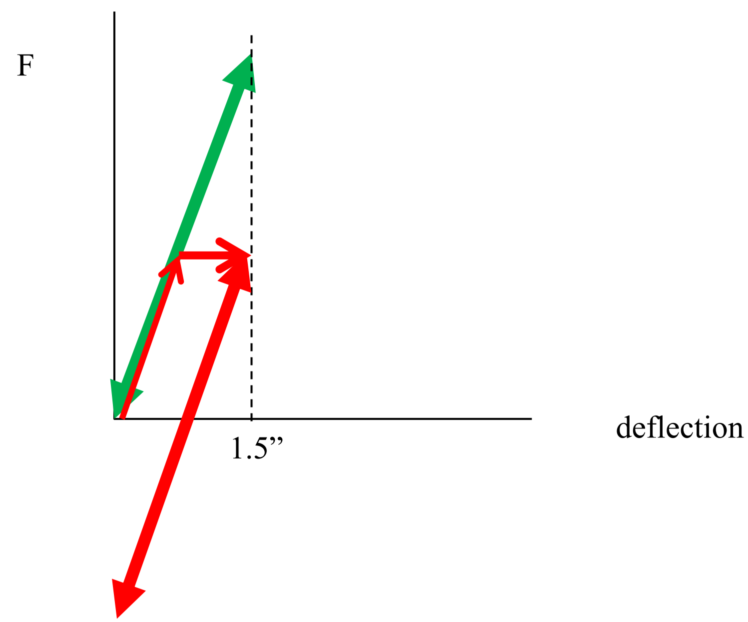
Imagine two types of springs – Spring A (green) which is strong and Spring B (red) which is less strong. Both are 4 inches long, originally. Spring A can stretch 2 inches elastically, Spring B can only be stretched 1 inch elastically. If these springs are each stretched 1.5 inches, Spring A will return to its original length (4 inches), but Spring B will be 0.5 inches longer than original. Since it was stretched 0.5 inches beyond its elastic limit, when the force is removed it will now be about 0.5 inches longer (4.5 inches long, now).

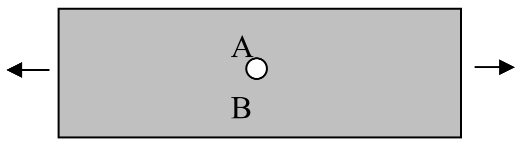
Now imagine a series of these springs connected to the bar shown below. Most of the springs are strong (green) but one is less strong (red). Initially, all of the springs are 4 inches long. The plates are then pulled apart 1.5 inches longer than initial separation. Since most of the springs are still elastic, the plate will return to its original separation of 4 inches. The majority dominates. Spring B after being stretched, wants to be 4.5 inches, but is compressed to be only 4 inches. Therefore, it is now in a state of compression. If the bars are repeatedly pulled 1.5" and then released, during each load cycle red spring will experience compression and tension as indicated in the Force-deflection diagram.





This is somewhat analogous to what may happen near a stress concentration. The material near stress concentrations is the same as everywhere else, so it is not less strong. However, the strain is greater there (K_t times greater), so the material is "stretched" further than elsewhere. It the stress near the stress concentration exceeds the yield strength, the material will yield locally. However, away from the stress concentration, there will be only elastic loading (assuming no "bulk" or "gross" yielding). Therefore, upon unloading, there will be compressive residual stress at the stress concentration. This ***improves*** the fatigue life of the part. *…see next page for more….*

What happens to the stress at the stress concentration if there is local yielding (yielding at the stress concentration)? Assume A is very near the hole, B is far away (but in-line with the hole). Therefore, $\sigma_A = K_t\,\sigma_B$, and let $K_t = 2$. Assume the force goes from zero to some positive (tensile) value such that the stress at A exceeds the yield strength ($K_t\,\{\sigma_{amp} + \sigma_{mean}\} > S_{ys}$), but there is no "gross" (aka "bulk") yielding; in other words, material does not yield at B ($\{\sigma_{amp} + \sigma_{mean}\}_{at\,B} < S_{ys}$). Note from the sketch below that the actual stress at A differs from the "theoretical" stress but the stress amplitude is the same ($K_t\,\sigma_{amp}$). The mean stress at the stress concentration is approximately σ_{mean}, **not** $K_t\,\sigma_{mean}$. The stress at A is best described as: amplitude at A, $\sigma_{amp\text{-}A} = K_f\,\sigma_{amp\text{-}B}$ but the mean stress at A, $\sigma_{mean\text{-}A} = \sigma_{mean\text{-}B}$ BUT ONLY IF THERE is LOCAL YIELDING. **Local yielding occurs if: $K_t\,(\sigma_{amp} + \sigma_{mean}) > S_{ys}$**



Goodman Equation, **if no local yielding**:
$K_f\,\sigma_{amp} / S_{fail} + K_f\,\sigma_{mean} / S_{UT} = 1/n$

Goodman Equation, **if $\sigma_m < 0$**
$K_f\,\sigma_{amp} / S_{fail} = 1/n$

Goodman Equation, if **local yielding**:
$K_f\,\sigma_{amp} / S_{fail} + \sigma_{mean} / S_{UT} = 1/n$

STRESS STRAIN diagram:
(elastic-perfectly plastic)