Imagine two types of springs – Spring A which is “strong stretchy” and Spring B which is “wimpy and not as stretchy.” 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 longer than original. Since it was stretched 0.5 inches beyond its elastic limit it will now be about 0.5 inches longer (4.5 inches long, now).

Now imagine a series of these springs. Most of the springs are like Spring A (stretchy) but one of them is like Spring B (not so stretchy). Initially, all of the springs are 4 inches long. They are attached to two plates as shown below. The green “springs” below are “stretchy” springs, the red one is “not so stretchy.” 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.

This is somewhat analogous to what may happen near a stress concentration. The material near the stress concentration is the same as everywhere else, so it is not “wimpy”. However, the strain is greater there, so the material is “stretched” further than elsewhere. If 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….
Assume A is very near the hole, B is far away. \( \sigma_A = K_f \sigma_B \), and let \( K_f = 2 \). Assume the force goes from zero to some positive (tensile) value such that the theoretical stress at A exceeds the yield strength, but there is no “gross” yielding (B does not yield). Note that the mean “actual” stress at A differs from the “theoretical” stress but the stress amplitude is the same. This is why the Goodman equation should include \( K_f \) with \( \sigma_{amp} \) but NOT with \( \sigma_{mean} \) IF THERE is LOCAL YIELDING.

If local yielding:
\[
K_f \sigma_{amp} / S_{fail} + \sigma_{mean} / S_{UT} = 1/n
\]

If no local yielding:
\[
K_f \sigma_{amp} / S_{fail} + K_f \sigma_{mean} / S_{UT} = 1/n
\]

**STRESS STRAIN diagram:** (elastic-perfectly plastic)

- Theoretical max stress at A (\( \sigma_A = K_f \sigma_B \))
- Theoretical cyclic stress at A
- Actual max stress at A
- Stress at A with no load on structure (compressive residual)
- Stress amplitude at A
- Actual stress at A

\[ \sigma_{B-max} \]
\[ \epsilon_A \]
\[ \epsilon_B \]