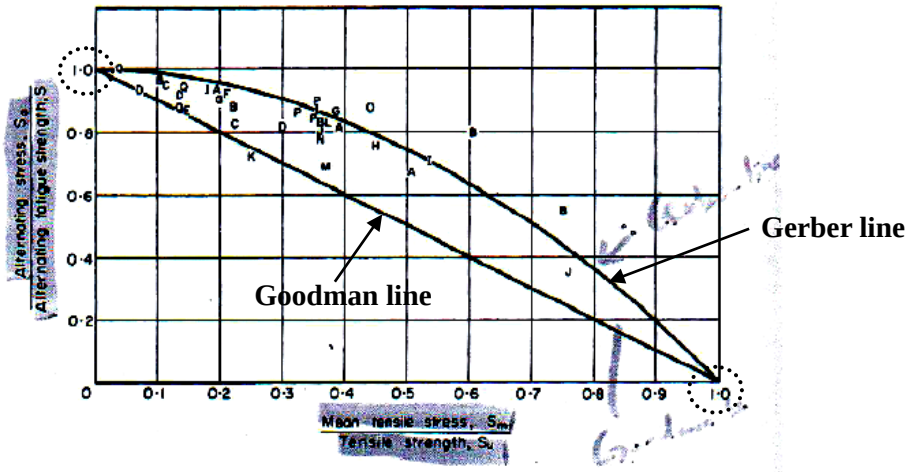
1. Significance of combined mean and alternating stress on failure.

1.1 Presence of a mean-stress component

When a tensile mean component of stress is added to the alternating component (i.e., repeated or fluctuating cyclic stresses), the material fails at lower alternating stress than it does under fully reversed loading.

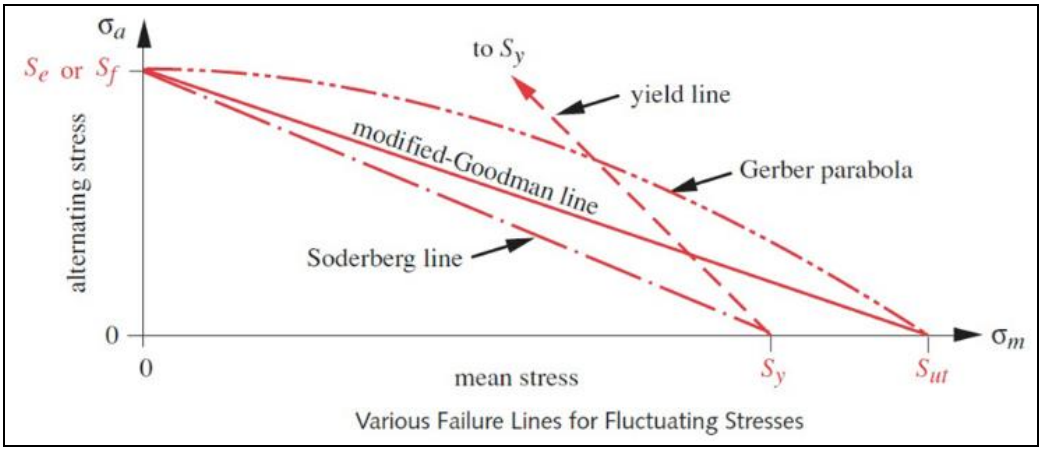
You need to introduce "Gerber line" and "Goodman line" for this problem.



Test results made on steels at N=10^7 to 10^8 cycles

Y: (alternating stress)/(**fatigue strength** under fully reversed stress at the same number of cycles)

X: (Mean tensile stress)/(**ultimate** tensile strength)



Various Failure Lines for Fluctuating Stresses

- Gerber line: Measure of the averaged behavior of these parameters for ductile material. Best fit for experimental failure data.
- (Modified-)Goodman line: Measure of their minimum behavior (often used as a design criterion since it is safer than the Gerber line)
- Soderberg line: rarely used and overly conservative

NOTE: 1) Intersect S_e or S_f on Y axis and S_{ut} on X-axis

2) If the part yields, it has failed regardless of its safety in fatigue)

1.2 Effect of mean stresses on failure when combined with alternating tensile stress (for both aluminum and steel)

Compressive mean stresses have a beneficial effect and tensile mean stresses are detrimental

(i.e., the fatigue strength or endurance limit of the material is effectively increased by the introduction of a compressive mean stress, whether applied or residual)

→ Opportunity to mitigate (lessen) the effects of alternating tensile stresses by the deliberate introduction of mean compressive stresses!

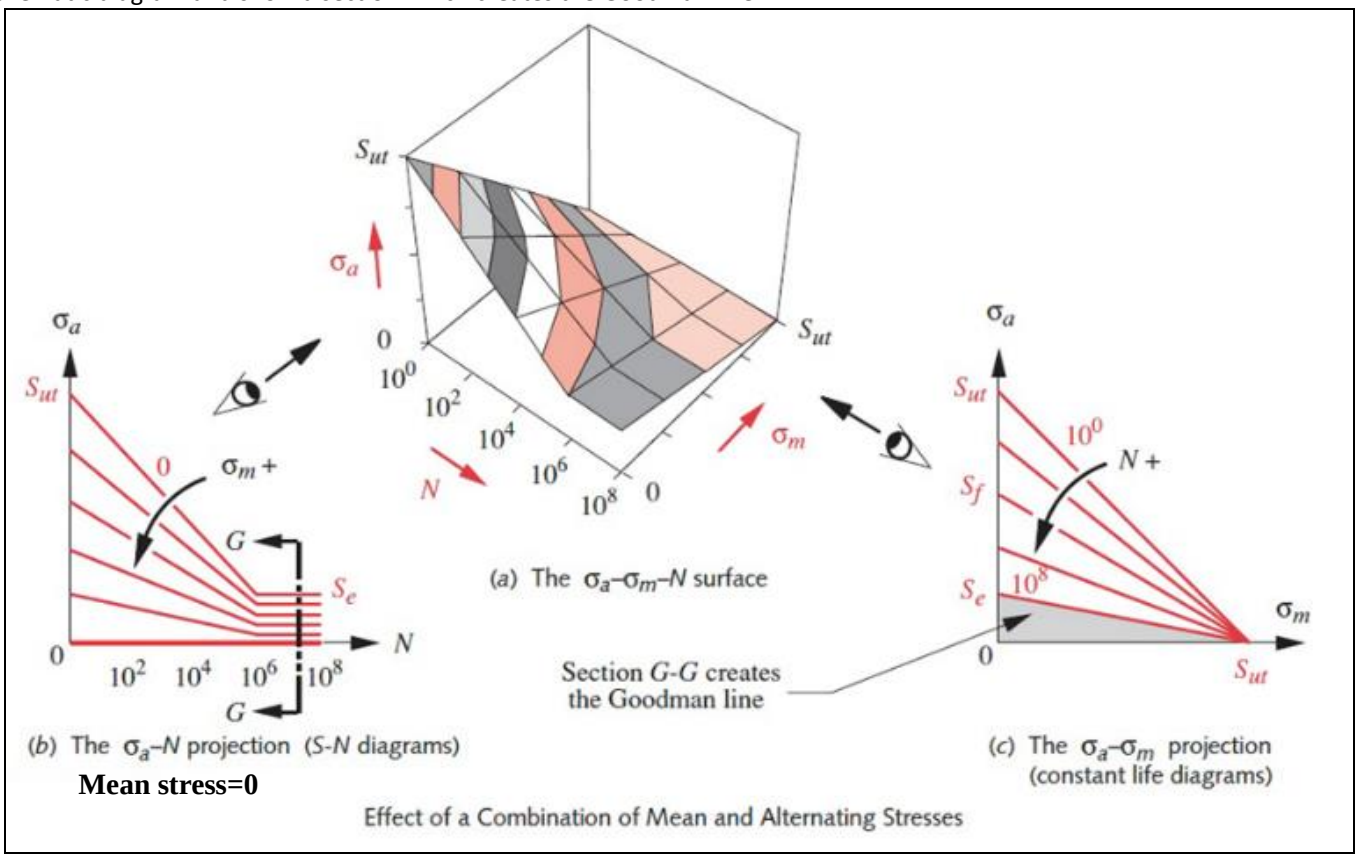
→Create residual compressive stress in the material in regions where large alternating components are expected.

→ HOW: Thermal treatments. Hardening. Surface treatments. Shot peening. Cold forming, etc.

NOTE: Residual stresses: "built-in" stresses of an unloaded part.

2. Constant-life diagram (i.e., $\sigma_a - \sigma_m$ plane for various values of N)

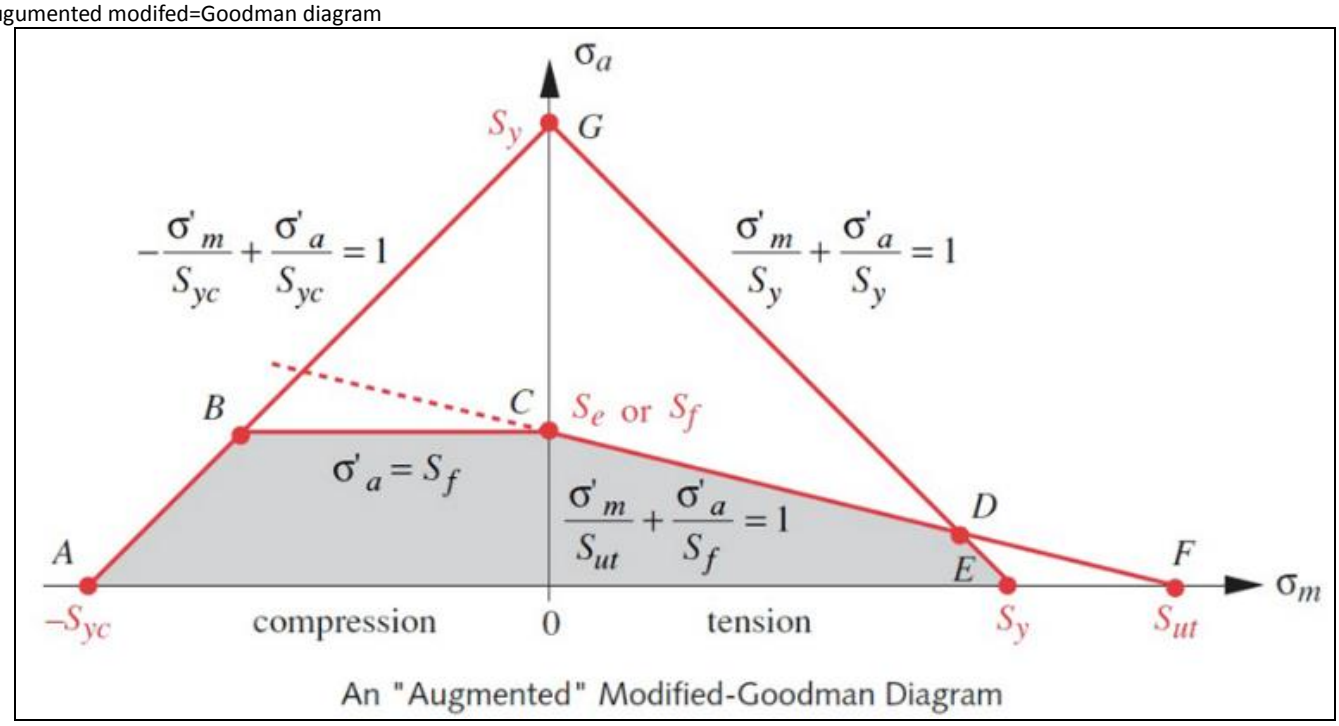
Schematic diagram and show a section which creates the Goodman line



Mean stress=0

Effect of a Combination of Mean and Alternating Stresses

Augumented modifed=Goodman diagram



An "Augmented" Modified-Goodman Diagram

It is convential to draw the more conservative line CB to represent a failure line in the compressive region.
→ This in effect ignores the beneficial effects of compressive mean stress and considers that situation to be identical to the fully reversed case.

- Line GE: Static yielding
- Line CD and Line DE: possibility of either fatigue or yield failure
- Region DEF: safe within the Goodman line but would yield on the first cycle
- Region ABCDEA: SAFE!!