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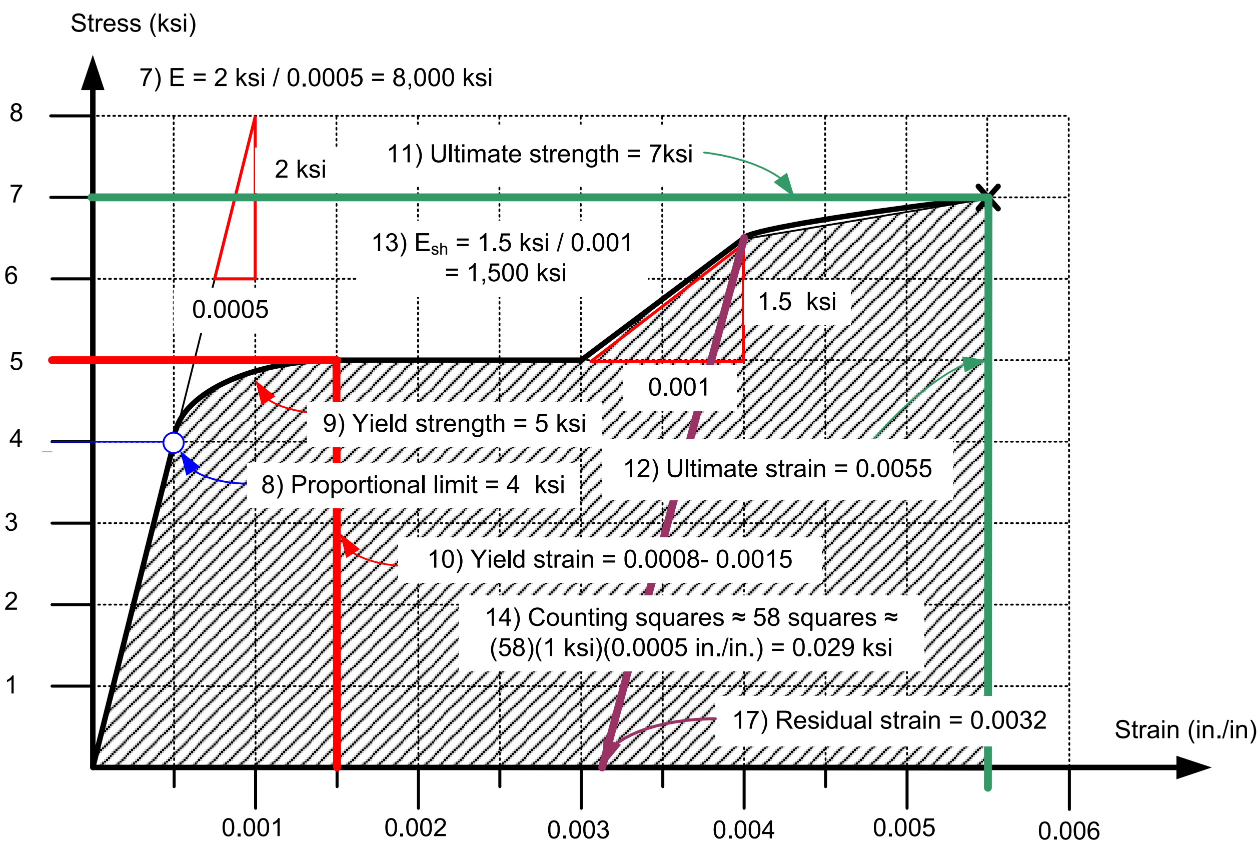
CE 3020 - Construction Materials
Spring 2010 - EXAM #1

1. In characterizing materials for short-term behavior, the two most important mechanical properties for a material are **_strength_** and _stiffness_
2. The **_ International Organization for Standardization (ISO)_** is the main ***international*** organization developing consensus-based standards for materials.
3. For phase diagrams, Gibb's rule says that P + F = C +2, where C is the number of components and P is the number of phases. F is the **_number of degrees of freedom** (variables affecting the problem) .
4. Deformations in ductile metallic materials occur primarily due to _shear_ forces.
5. What is the free surface energy and how does it arise? **Energy that arises at surface as the result of asymmetry of atomic arrangement at boundary - See section 4.1 (p. 66 of your text – we talked about it wrt fracture energy.**
6. Explain why carbon (C) has a low diffusivity (solubility) in iron (Fe):

   The interstitial spaces in iron are about 20% smaller than the diameter of a carbon atom; thus distorsions of the atomic structure are needed in order to fit the carbon atoms into the iron atom; this "difficulty" leads to a low difussivity.

A typical tension test has been run on a coupon of a polymeric material, giving the following results in terms of engineering stress-strain. Determine:



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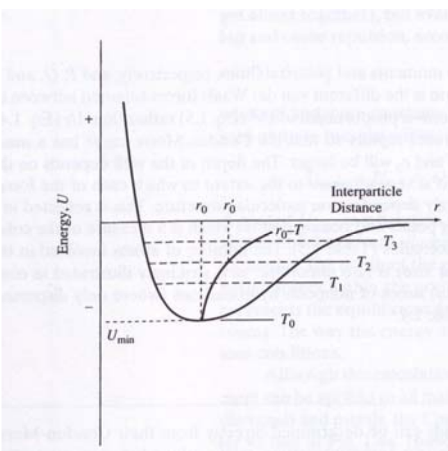
7. Modulus of elasticity: __**8000 ksi**__
8. Proportional limit: __**4 ksi** --
9. Yield strength**: __5 ksi**
10. Yield strain ≈ **_0.0015 (somewhere b/t 0.0008 and 0.0015) _ in./in.**
11. Ultimate strength: __**7 ksi**
12. Ultimate strain: **_0.0055_ in./in.**
13. Strain-hardening modulus**: _1500 ksi**
14. Toughness ≈ __**0.029_ ksi**
15. True ultimate strain ≈____ $\varepsilon_{true} = \ln(1+\varepsilon_{eng}) = 0.0054$ _______________ in./in.
16. True ultimate strength ≈ __unknown form this dat > 7 ksi ______ ksi
17. Residual strain if specimen is downloaded from 6.5 ksi **≈ __0.0032__ in./in.**
18. What important elastic constant can be obtained directly from the energy-distance curves shown below?:

Coefficient of thermal expansion (see pp. 9-12 of text)

19. What are its units: **_(in./in. per degree) _**
20. What ranges of values would be typical for a metal? __**12-24 x 10-6**_______



Given:

$T_0 = 0°$ K

$T_2 = 293°$ K

$r_0 = 140$ pm (140×10^{-12} meter)

$r'_0 = 158$ pm

The removal of an existing bridge requires that current traffic be rerouted through an older steel bridge for which the S-N curve for the critical element is given by Curve D in the figure below. It is estimated that the rerouting will result in 500,000 cycles at 50MPa. If the previous load history for this bridge consisted of:

- 2,000,000 cycles at 40MP
- 300,000 cycles at 80Mpa , and
- 500,000 cycles at 100Mpa

There were several possible solutions, depending on whether you assumed that there was a infinite life plateau (dashed line in graph). The second solution on the next page is what I was looking for:

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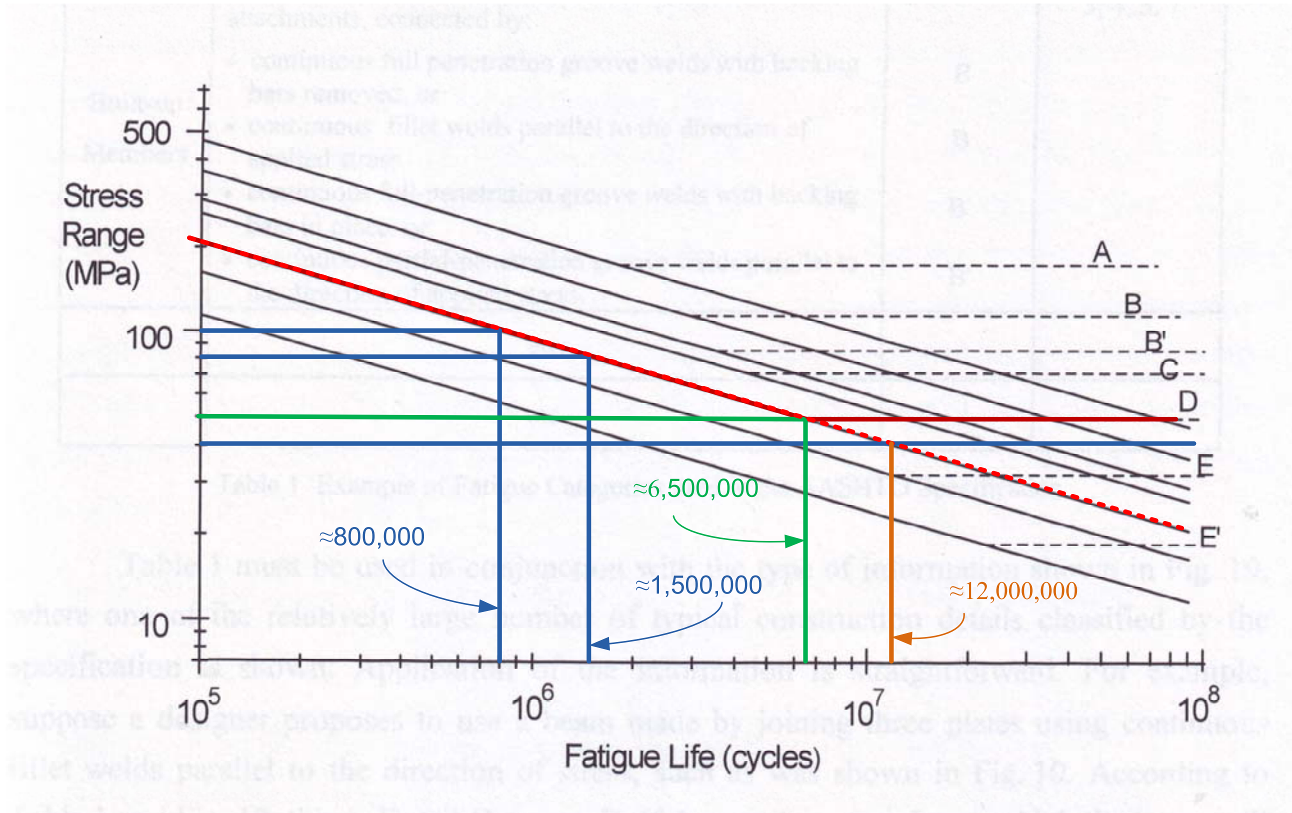

Original Problem:

$$\frac{n_1}{N_1}+\frac{n_2}{N_2}+\frac{n_3}{N_3}+\frac{n_4}{N_4}=\frac{2,000,000}{\infty}+\frac{300,000}{1,500,000}+\frac{500,000}{800,000}+\frac{500,000}{6,500,000}$$

$$\frac{n_1}{N_1}+\frac{n_2}{N_2}+\frac{n_3}{N_3}=0.000+0.200+0.625+0.077=0.902$$

So O.K.,but not much capacity left; only about another 500,000 cycles at 50MPa.

As stated (with infinite life plateau included):

$$\frac{n_1}{N_1}+\frac{n_2}{N_2}+\frac{n_3}{N_3}=\frac{2,000,000}{\infty}+\frac{500,000}{800,000}+\frac{500,000}{6,500,000}$$

$$\frac{n_1}{N_1}+\frac{n_2}{N_2}+\frac{n_3}{N_3}=0.000+0.625+0.077=0.702$$

So O.K., with lots of capacity left.

As stated (without infinite life plateau included):

$$\frac{n_1}{N_1}+\frac{n_2}{N_2}+\frac{n_3}{N_3}=\frac{2,000,000}{12,000,000}+\frac{500,000}{800,000}+\frac{500,000}{6,500,000}$$

$$\frac{n_1}{N_1}+\frac{n_2}{N_2}+\frac{n_3}{N_3}=0.167+0.625+0.077=0.868$$

So O.K., some capacity left; about another 850,000 cycles at 50MPa

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24-26 The figure below shows a highly magnified initial portion of the stress-strain curve for a mild steel tension test. The solid line is the data and the dashed line corresponds roughly to a slope of 175 GPa. Will you consider this a good test or not? Why?

No: (a) the actual slope is about 20% low – that is too much; (b) the raggedness of the curve probably indicates that the extensometer is slipping; (c) for some measurements there are two strains for the same stress; (d) the data falls all on one side of the proposed best fit..

27. What is the bulk modulus for steel? **__23,000 ksi (160 GPa)____**

28. Which is more weldable, a steel with an equivalent carbon content of 0.15% or one with 0.5%? **_0.15%**

Bonus questions (2 points each):

a) The Secretary General of the United Nations is: ____ **Ban Ki-moon** _____________ (2 points)

b) When was Herbert Hoover president of the USA? ___1929-933 **(Great Depression era)**_____

c) Each year we use an average of ___**_≈ 1 – 2** __ cubic yards of concrete per person in the world (2 points).