محاضرات
تكنولوجيا مواد البناء

Building Materials Technology

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2016

يختص علم هندسة المواد وإختباراتها بدراسة المواد الهندسية المختلفة التى تستحدم في أقامة المنشات وفي صيانة الأعمال الهندسية المدنية. لذلك فمن الضروري الدراسة والتركيز على أهم الأمور ومنها:-

1. الخواص الميكانيكية والكيميائية والطبيعية للمواد.
2. الأجهادات والانفعالات لهذه المواد نتيجة تعرضها للأحمال الأستاتيكية والديناميكية والاخمال المتكررة والدورية.
3. الظروف الواجب مراعاتها عند استعمال المواد الهندسية للحصول على كفاءة اكبر للمنشات الهندسية.
4. الفحوصات والاختبارات الواجب اجراؤها على المواد الهندسية للتاكد من صلاحيتها للأعمال المختلفة ولتعيين خواصها المتنوعة ولبيان مدى تحملها مع الزمن.
5. معرفة وتحديد الماكنات والأجهزة المستخدمة في فحوصات المواد الهندسية في المختبر او موقع العمل.
6. الأجراءات الواجب اتخاذها لتحيين كفاءة المواد وخواصها لتتلائم مع مع الاستعمالات المطلوبة وبكفاءة اكبر.

Definitions

1. Stress

Is the intensity of internal forces = Force/Area

Stress units = Force unites / Area Units = $Kg./Cm^2$, $lb./in^2$, Ton/m^2.

1 Kg. = 2.205 lb. and 1 in. = 2.54 cm.

Then 1 $Kg./Cm^2$ = 14.223 lb / in^2 , and 1 $Kg./Cm^2$ = 10.0 T/m2

2. Strain

Is a dimensionless value, it is the ratio between the change of length to the original length:

Where:

$$\varepsilon = \frac{\Delta L}{L_o}$$

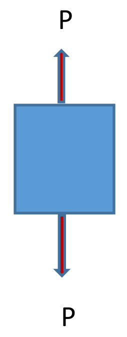
ε= Strain

ΔL = Change in length,

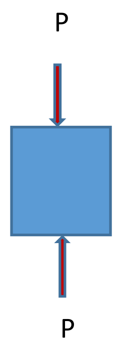
L_o= Original length.

3. Normal Stress (σ)

Is the stress normal to the section, and could be tension or compression stress:



Tension



Compression

$$\sigma = \frac{P}{A}$$

Where:
σ : Normal stress

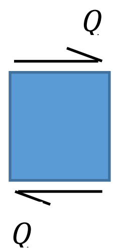
P: Applied load

A: Cross sectional area

4. Shear Stress (τ)

Is the tangential stress.

$$\tau = \frac{Q}{A}$$



Where:
τ: Shear stress

Q: Shearing (tangential) force

A: Cross-sectional area

5. **Poisson's Ratio** (μ)

Is the ratio between lateral strain to the longitudinal strain.

$$\mu = \frac{Lateral\ strain}{Longitudinal\ strain}$$

The value of μ for all materials varies over a range of $0.0 \leq \mu \leq 0.50$.

6. **Young's Modulus** (E)

The ratio between stress and strain in the elastic stage.

$$E = \frac{\sigma}{\varepsilon}$$

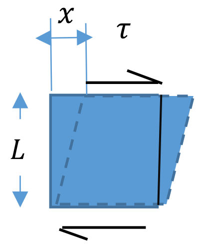
7. **Shear strain** (γ)

Is the ratio between the changes in length in lateral direction to the original length.

$$Shear\ strain = \frac{Deformation}{Original\ length}$$

$$\gamma = \frac{x}{L}$$

Where γ is the shear



8. **Shear Modulus (G)**

The shear modulus is the ratio between shear stress to shear strain

$$Shear\ Modulus = \frac{Shear\ stress}{Shear\ strain}$$

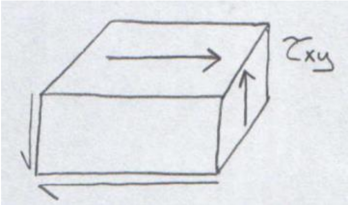
$$G = \frac{\tau}{\gamma}$$

Relation between E & G

$$G = \frac{E}{2(1+\mu)}$$

Each shear stress component produces only its corresponding shear strain component.

$$\gamma_{xy} = \frac{\tau_{xy}}{G}$$



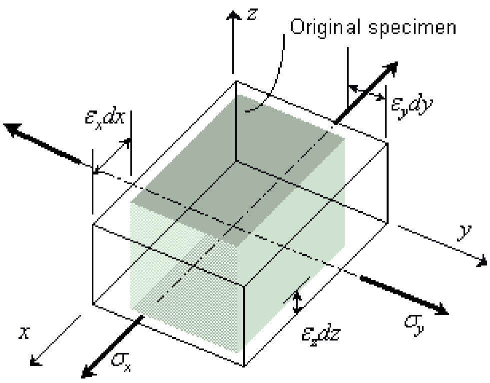
Generalized Hook's Law

The generalized Hooke's Law can be used to predict the deformations caused in a given material by an arbitrary combination of stresses.

$$\varepsilon_x = \frac{\sigma_x}{E} - \mu\frac{\sigma_y}{E} - \mu\frac{\sigma_z}{E}$$

$$\varepsilon_y = \frac{\sigma_y}{E} - \mu\frac{\sigma_x}{E} - \mu\frac{\sigma_z}{E}$$

$$\varepsilon_z = \frac{\sigma_z}{E} - \mu\frac{\sigma_x}{E} - \mu\frac{\sigma_y}{E}$$

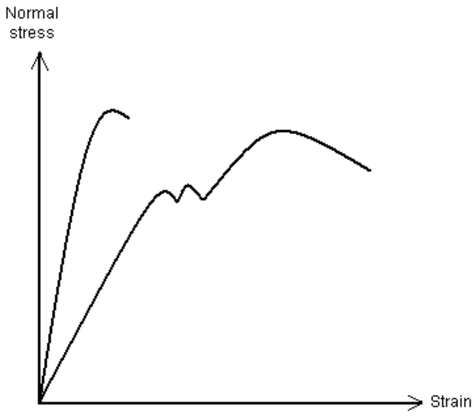


Where

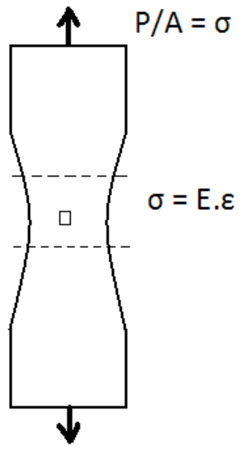
E: Young's Modulus

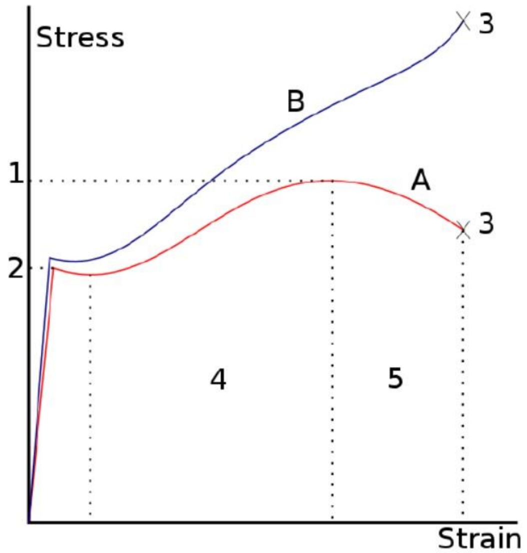
μ: Poisson Ratio

The generalized Hooke's Law also reveals that strain can exist without stress. For example, if the member is experiencing a load in the y-direction (which in turn causes a stress in the y-direction), the Hooke's Law shows that strain in the x-direction does not equal to zero. This is because as material is being pulled outward by the y-plane, the material in the x-plane moves inward to fill in the space once occupied, just like an elastic band becomes thinner as you try to pull it apart. In this situation, the x-plane does not have any external force acting on them but they experience a change in length. Therefore, it is valid to say that strain exist without stress in the x-plane.



Stress-strain diagram



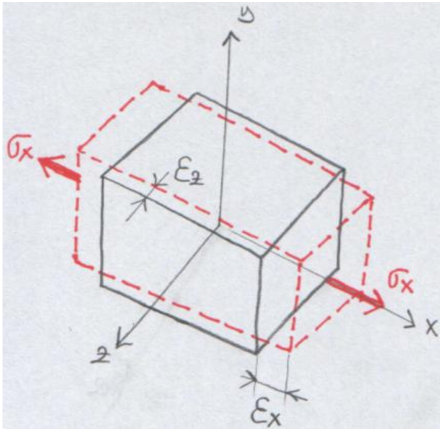


Stress–strain curve for low-carbon steel. Hooke's law is only valid for the portion of the curve between the origin and the yield point(2).

1. Ultimate strength
2. Yield strength-corresponds to yield point.
3. Rupture
4. Strain hardening region
5. Necking region.

A: Apparent stress (F/A0)
B: True stress (F/A)

Consider an element on which there is only one component of normal stress acting.



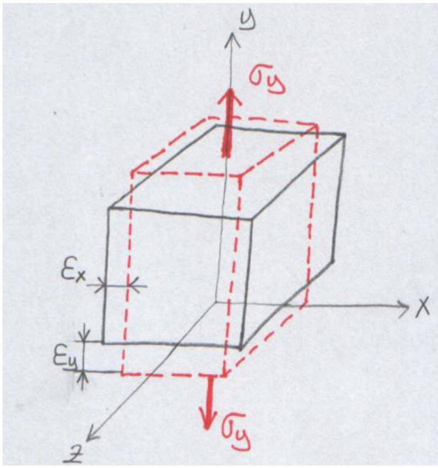
$$\sigma_y = \sigma_z = 0$$

$$\varepsilon_x = \frac{\sigma_x}{E}$$

$$\varepsilon_y = \varepsilon_z = -\mu \frac{\sigma_x}{E}$$

$$\sigma_y = \sigma_z = 0$$

If the stress applied in y-direction



$$\varepsilon_y = \frac{\sigma_y}{E}$$

$$\sigma_x = \sigma_z = 0$$

$$\varepsilon_x = \varepsilon_z = -\mu \frac{\sigma_y}{E}$$

Similar result for loading in the z direction

$$\varepsilon_z = \frac{\sigma_z}{E}$$

$$\sigma_x = \sigma_y = 0$$

$$\varepsilon_x = \varepsilon_y = -\mu \frac{\sigma_y}{E}$$

Initial Tangent Modulus, Tangent Modulus and Secant Modulus

The initial tangent modulus is usually used when no straight portion exists on the stress versus strain diagram. Figure 1 shows that the initial tangent modulus is taken by the slope of a tangent to the stress-strain curve through the origin. However, there is little practical importance to using the initial tangent modulus since it is only valid for very low stresses.

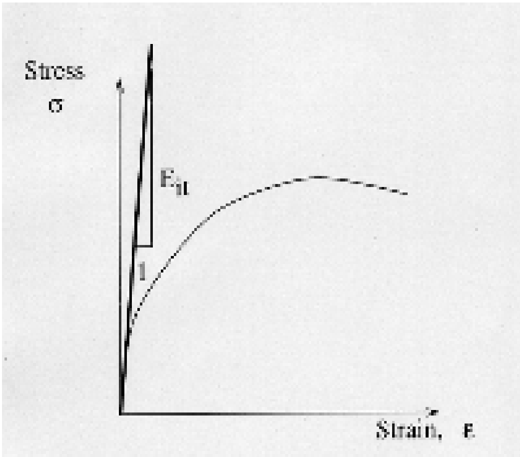


Figure 1

The tangent modulus can be taken at any point on the stress-strain curve. Figure 2 shows that the tangent modulus is represented by the slope of the tangent to any point on the curve. The accuracy in calculating the tangent modulus is somewhat limited because the tangent is usually drawn by hand.

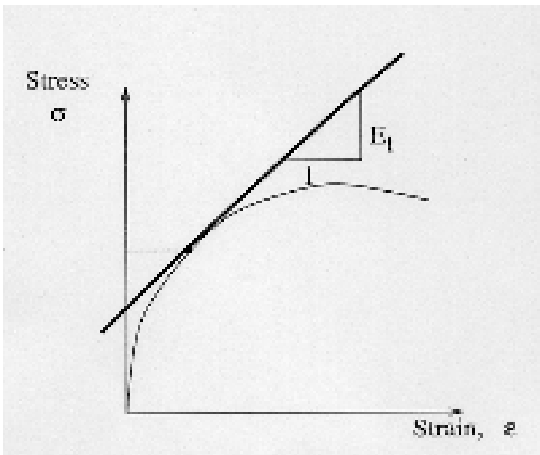


Figure 2

The secant modulus represents the actual deformation at a selected point. Figure 3 shows that the secant modulus is drawn from the origin to any point on the stress-strain curve. This method is most widely used because there are no uncertainties in determining its value from the diagram.

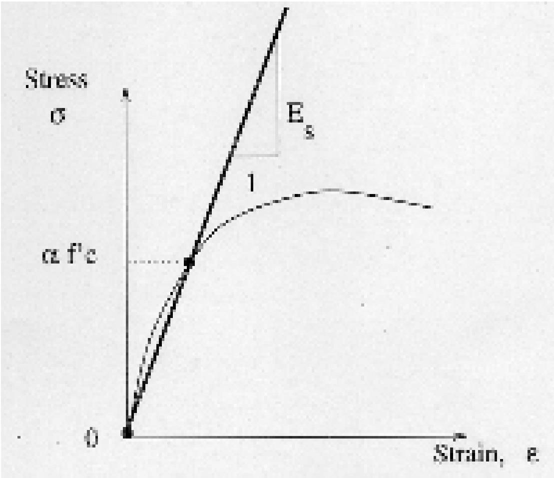


Figure 3