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Material.	E	G	K	n
C.I.	6,000 - 10,000	2500 - 4000	6000	30 to 47
W.I.	11,000 - 13,000	5000 - 6000	8800	3.6
STEEL.	13,000 - 14,000	5000 - 6000	11,000	36 to 46
BRASS.	4000	2000	6400	5.1 to 3.3

E, G, & K in tons per square in.

Rulers Formulae for long struts

$$P = \frac{\pi^2 EI}{L^2}$$

where

- P = buckling load (total)
- E = Young's modulus
- I = least moment of inertia of section
- L = length of strut in inches (with rounded ends)

Examples on the preceding

A tie bar is 1" dia. What is the stress in the material due to a load of 4 tons and what is the extension on a 6' length if the bar is of steel (E=14000) and work done :-

stress = $\frac{W}{a} = \frac{4}{.7854} = 5.1$ tons per square in

extension = x and l = 6'

$$\frac{\frac{W}{a}}{l} = E \cdot \frac{x}{72} = 14,000$$

$$\frac{5.1 \times 72}{14,000} = x = .026''$$

work done = $\frac{.026 \times 4}{12 \times 2}$ ft. lbs

14/35

2 What load must be applied to a cube of brass of 4" side to compress it $\frac{1}{1000}$ "

$$E = \frac{\text{stress}}{\text{strain}}$$

$$\text{stress} = \frac{W}{a} = \frac{W}{16} \text{ tons per sq. in.}$$

$$\text{strain} = \frac{1}{1000 \times 4}$$

$$E = 4000$$

$$\frac{W}{16} = \frac{1}{1000 \times 4} \times 4000$$

$$\therefore W = 16 \text{ tons.}$$

3) A ferro concrete column is 10" square and has 4 - $\frac{1}{4}$ " bars dia. throughout its length. If the load on the column is 40 tons find the relative stresses in the steel and concrete.

$$1 \text{ Area of steel} = 4 \times \frac{1}{4} \text{ " } \odot$$

$$= 4.9 \text{ " }^2$$

$$2 \text{ Area of concrete} = 95.1 \text{ " }^2$$

$$E_1 = 14000$$

$$E_2 = 900$$

$$\text{Euler Formulae } P = \frac{\pi^2 EI}{L^2}$$

where $P =$ buckling load
 $E =$ modulus of elasticity
 $I =$ moment of inertia of cross section

$L =$ length of strut.

when struts have a greater ratio (of length to least radius of gyration) than 120 the above formula should be used.

When less use the Rankine Gordon formula viz.

$$\text{Safe load} = \frac{FA}{1 + \frac{a}{n} \left(\frac{l}{k}\right)^2}$$

where $a =$ constant (~~see~~ ^{see} table)
 $n =$ do

$l =$ length of strut

$k =$ least radius of gyration of cross section

$F =$ safe compressive load

$A =$ area of cross-section

	a	ends	n
Steel	$\frac{1}{7500}$	both fixed	$= 4$
S.I.	$\frac{1}{1600}$	1 fixed one free	$= \frac{1}{4}$
W.I.	$\frac{1}{9000}$	" " guided	$= 2$
Timber	$\frac{1}{750}$	both free	$= 1$

$$\text{Torque} = \frac{F \cdot I_p}{R} \quad \text{where -}$$

F = stress per square in

I_p = polar moment of inertia

$\frac{I_p}{R} = Z$ = polar modulus of section

$$= \frac{\pi D^3}{16} \quad \text{for solid circular shaft.}$$

$$\& \frac{\pi}{16} \left(\frac{D^4 - d^4}{D} \right) \quad \text{for hollow shaft.}$$

Strain in a shaft subjected to torsion is measured in the usual way = $\frac{\text{stress}}{\text{strain}} = \frac{F \cdot l}{b} = G$

If θ be the angle of twist in circular measure $\theta = \frac{b}{r} = \frac{F \cdot l}{G \cdot r}$

If G is known we can find the angle of twist in unit length of shaft radius r . We know that $F = \frac{16T}{\pi D^3}$ and $\therefore \theta = \frac{32 \cdot T \cdot l}{\pi G \cdot D^4} = \frac{10.2 T \cdot l}{G \cdot D^4}$

which gives angle of twist in radians (in terms of twisting moment). Angle in degrees = $\frac{583.6 \times T \times L}{D^4 \times G}$

Cyl. Stresses in P_2 & P_3
 Type Engine = $\frac{400 \times 3\frac{3}{4}}{2 \times \sqrt{32}}$

3430

Approx $1\frac{1}{2}$ tons per \square "

250
~~1500~~ $\times .25$ 34,800
 $2 \times .036$
 .032

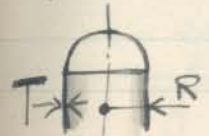


Strength of boiler shells or thin pipes etc.

$$F = \frac{P \cdot D}{2T} \quad \text{where}$$

- F = stress per square in
- P = pressure in lbs. per \square "
- D = dia. in inches.
- T = thickness in inches.

For a flat, dished or hemi-spherical end plate $F = \frac{PR}{2T}$



For thick cylinders.

$$F = P \frac{R^2 + r^2}{R^2 - r^2}$$

R = external dia. r = internal dia.

Compound stresses.

To find max. stress due to bending (and compression) calculate compression stress due to bend and add to direct compression stress.

IMPERIAL WIRE GAUGE.

1 .300	11 .116	21 .032
2 .276	12 .104	22 .028
3 .252	13 .092	23 .024
4 .232	14 .081	24 .022
5 .212	15 .072	25 .020
6 .192	16 .064	26 .018
7 .176	17 .056	27 .016
8 .160	18 .048	28 .014
9 .144	19 .040	29 .013
10 .128	20 .036	30 .012

Compound stresses.

Torsion and bending.

Equivalent twisting moment =
 $M + \sqrt{M^2 + T^2}$ Equivalent bending moment =
 $M + \frac{\sqrt{M^2 + T^2}}{2}$ where

2 bending

M = simple twisting moment

T = simple twisting moment.

Helical Springs.

extension = Δ

$$\Delta = \frac{64WR^3N}{Gd^4}$$

where W = load in lbs.

R = mean radius of coils.

N = no. of coils

G = 12,000,000 (steel) 5000000 (brass)

d⁴ = dia. of wire.

$$W = \frac{G \cdot d^4}{8D^3N} = \text{load per in. of } \Delta.$$

Safe loads for steel wire

$$= \frac{27,500 d^3}{D} \text{ for } \frac{1}{4} \text{ dia wire}$$

$$\frac{23,500 d^3}{D} \text{ for } \frac{3}{8} \text{ dia wire}$$

$$\frac{19,600 d^3}{D} \text{ for } \frac{1}{2} \text{ dia wire}$$