Material.	E	G	K	n
C.I.	6,000-10000	2500-4000	6000	3.0 to 4.7
W.I.	11,000-13,000	5000-6000	8800	3.6
STEEL.	13,000-14000	5000-6000	11,000	3.6 to 4.6
BRASS.	4000	2000	6400	3.1 to 3.3

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

Eulers Formulae for long struts

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

where

P = buckling load (total)
E = Youngs 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 $l = 6'$

$$\frac{\frac{W}{a}}{\frac{x}{l}} = E, \quad \frac{5.1}{\frac{x}{72}} = 14,000$$

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

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

14/35

14
.026
.364

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

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

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

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

$E = 4000$

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

$\therefore W = 16$ tons.

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

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

$= 4.9$ □"

2 Area of concrete $= 95.1$ □"

$E_1 = 14000$

$E_2 = 900$

Euler Formulae $P = \frac{\pi^2 E.I}{L^2}$

where P = buckling load
E = moduli 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.

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

where = a is constant (~~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	= 1/7500	both fixed	= 4
C.I	= 1/1600	1 fixed one free	= 1/4
W.I.	= 1/9000	1 " " guided	= 2
Timber.	= 1/750	both free.	= 1

Torque $= \dfrac{F . I_P}{R}$ where –

F = stress per square in

I_P = polar moment of inertia

$\dfrac{I_P}{R} = Z$ = polar modulus of section

$= \dfrac{\pi D^3}{16}$ for solid circular shaft.

or $\dfrac{\pi}{16}\left(\dfrac{D^4 - d^4}{D}\right)$ for hollow shaft.

Strain in a shaft subjected to torsion is mearsured in the usual way $= \dfrac{\text{stress}}{\text{strain}} = \dfrac{F\,l}{b} = G$

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

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

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

Cyl. Stresses in P_2 & P_3 type Engine $= \dfrac{400 \times 3\frac{3}{4}}{2 \times 7/32''}$

3430

Approx $1\frac{1}{2}$ tons per □"

$$\frac{\overset{250}{\cancel{400 \times .25}}}{2 \times .036} \quad 34{,}80$$

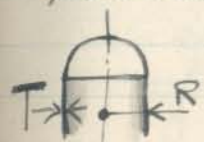
.032

Strength of boiler shells or thin pipes etc.

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

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

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



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 =

$$\frac{M + \sqrt{M^2 + T^2}}{2}$$ where

M = simple ~~twisting~~ bending moment

T = simple twisting moment.

Helical Springs.

extension = $\cancel{\delta}\,\Delta\,\delta$

$$\delta = \frac{64 W R^3 N}{G d^4}$$

where W = load in lbs.

R = mean radius of coils.

N = no. of coils

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

d^4 = dia. of wire.

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

Safe loads for steel wire

$= \frac{27.500\, d^3}{D}$ for 1/4" dia wire

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

$\frac{19600\, d^3}{D}$ for 1/2" dia wire