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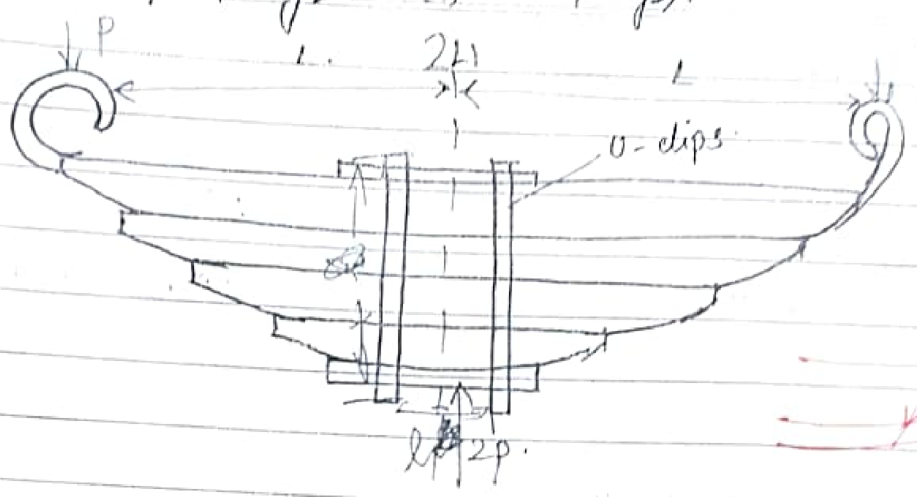
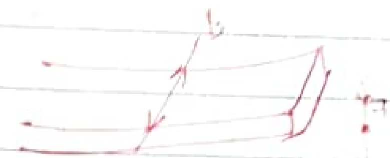
Leaf springs. (flat springs).





2p - load on spring.
y - deflection of spring.
L - length of cantilever beam.
b - width of leaf.
t - thickness of leaf.
n - no. of leaves in the spring.
n_g - no. of graduated leaves in the spring.
n_e - no. of full length leaves in the spring.
σ - bending stress
σ_{bg} - bending stress in graduated leaves.
σ_{be} - bending stress in extra full length leaves.
E - Modulus of elasticity.

General Design procedure of leaf spring.

1) Thickness & width of leaves.

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$$\sigma_b = \frac{6PL}{n \times b \times t^3}$$

normal leaves.

$$\sigma_{be} = \frac{18PL}{bt^2(3n_e + 2n_g)}$$

extra full length leaves

2) Deflection of spring

$$y = \frac{6PL^3}{E n b t^3}$$

$$y = \frac{12PL^3}{Ebt^3(3n_e + 2n_g)}$$

L extra full length leaves.

[PSG D.B 7.104]

3) To find the no. of graduated leaves (n_g).

$$n_g = n - n_e$$

4) To find the Initial gap b/w full length & graduated leaf.

$$C = \frac{2PL^3}{n \times E \times b \times t^3}$$

5) To find the length of leaves (L).

$$\text{length of smallest leaf} = \frac{\text{Effective length}}{n-1} + \text{Ineffective length.}$$

3) Free length of spring (L_f).

$$L_f = n \times d + (n-1)$$

$$= 12 \times 17.2 + (12-1)$$

$$\boxed{L_f = 217.4 \text{ mm}}$$

4) pitch of coil (p).

$$p = \frac{\text{free length}}{n_t - 1}$$

$$= \frac{217.4}{13 - 1}$$

$$\boxed{p = 18.11 \text{ mm}}$$

Helical springs subjected to variable loads:

$$\text{Mean load } (P_m) = \frac{P_{max} + P_{min}}{2}$$

$$\text{Amplitude load } (P_a) = \frac{P_{max} - P_{min}}{2}$$

$$\text{Mean torsional shear stress } (\tau_m) = K_{sh} \times \frac{8 P_m \times D}{\pi d^3}$$

PSG D.B 7.102.
$$= K_{sh} \times \frac{8 \times P_m \times C}{\pi d^2}$$

K_{sh} - direct shear factor.

$$K_{sh} = 1 + \frac{0.615}{C}$$

$$\text{Amplitude shear stress } (\tau_a) = K_s \times \frac{8 \times P_a \times D}{\pi d^3}$$

PSG D.B 7.102.
$$= K_s \times \frac{8 \times P_a \times C}{\pi d^2}$$

K_s - Wahl's stress factor.

$K_s = K_{sh} \times K_c$. — PSG D.B 7.102.

K_c - Curvature factor — PSG D.B 7.102.

b) Radius to which the leaves should be Initially bent.

$$y(2R - y) = (L)^2$$

y - deflection.
R - Radius of spring to which leaves should bent.

Problems on leaf spring.

1). A truck spring has 12 number of leaves two of which are full length leaves. The spring supports are 1.05 m apart & the central band is 85mm wide. The central load is to be 5.4 KN with a permissible stress of 280 Mpa. Determine the thickness & width of steel spring leaves. The ratio of total depth to width of spring is 3. Also determine the deflection of spring.

Sol:

$n = 12$ $n_e = 2$

$2L = 1.05\,m = 1050\,mm$.

$L = 525\,mm$.

$l = 85\,mm$.

$2p = 5.4\,kN = 5400\,N$.

$p = 2700\,N$.

$\sigma = 280\,Mpa = 280\,N/mm^2$. $\frac{nt}{b} = 3$

To find:

1) Thickness of spring (t) 2) Width of spring (b). 3) deflection of spring (y)

Solution:

1) Thickness & width of spring leaves

$$\frac{n \times t}{b} = 3$$

$$b = n \times t / 3$$

$$= \frac{12 \times t}{3}$$

$$\boxed{b = 4t}$$

Effective length of spring.

$$= 2L - l$$

$$= 1050 - 85$$

$$2L = 965$$

$$\boxed{L = 482.5 \text{ mm}}$$

No. of graduated leaves (n_g)

$$\boxed{n_g = n - n_e}$$

$$= 12 - 2$$

$$\boxed{n_g = 10}$$

$$\sigma = \frac{18\,PL}{bt^2(3n_e + 2n_g)}$$ — PSG D.B 7.104.

$$280 = \frac{18 \times 2700 \times 482.5}{4t \times t^2 (3\times2 + 2\times10)}$$

$t = 9.3 \cong 10$ ✓ $\boxed{t = 10\,mm}$

$\boxed{b = 4t = 4\times10 = 40\,mm}$

Deflection of spring (y).

(7.104)

(Take $E = 210\times10^3\ N/mm^2$).

$$y = \frac{12\,PL^3}{Ebt^3(3n_e + 2n_g)}$$

$$= \frac{12 \times 2700 \times (482.5)^3}{210\times10^3 \times 40 \times (10)^3 \times (3\times2 + 2\times10)}$$

$\boxed{y = 16.7\,mm}$

2) A

2) A semi-elliptical laminated vehicle spring to carry a load of 6000N is to consist of seven leaves 65mm wide, two of leaves extending full length of the spring. The spring is to be 1.1m in length & attached to axle by two U-bolts 80mm apart. The bolts hold the central position of the spring so rigidly that they may be considered equivalent to a band having a width equal to distance between bolts. Assume design stress for spring mat as 350 Mpa. Determine.

1) Thickness of spring 2) Deflection of spring 3) length of leaves
4) Radius to which leaves should be initially bent
5) Initial gap b/ Load exerted on the spring. Sketch the semi-elliptical leaf spring.

Gn/.

$2P = 6000N$

$P = 3000N$

$n = 7$

$b = 65mm.$

$n_e = 2$

$l = 80mm.$

$2L = 1.1m = 1100\ mm$

$\sigma = 350\ Mpa = 350N/mm^2$

Sol/.

1). Thickness of spring. (t)

Effective length of spring = $2L - l$

$= 1100 - 80$

$2L = 1020$

$\boxed{L = 510\ mm.}$

no. of graduated leaves (ng).

$$n_g = n - n_e$$
$$= 7-2$$
$$n_g = 5$$

To find thickness of leaf:

$$\sigma = \frac{18 P L}{b t^2 (3 n_e + 2 n_g)} \quad \text{— (PSG D.B 7.104)}$$

$$350 = \frac{18 \times 3000 \times 510}{65 \times t^2 (3\times2 + 2\times5)}$$

$$t = 8.7 \simeq 9 \text{ mm}$$

2) Deflection of spring (y)

$$y = \frac{12 P L^3}{E b t^3 (2 n_g + 3 n_e)} \quad \text{— (PSG D.B 7.104)}$$

$$= \frac{12 \times 3000 \times (510)^3}{210\times10^3 \times 65 \times 9^3 (2\times5 + 3\times2)}$$

$$y = 30 \text{ mm}$$

3) length of leaves

$$\text{length of smallest leaf} = \frac{\text{Eff. length}}{n-1} + \text{In-eff length.}$$

$$= \frac{1020}{7-1} + 80$$

$$= 250 \text{ mm.}$$

length of 2nd leaf $= \frac{1020}{7-1} \times 2 + 80$

$$= 420 \text{ mm.}$$

⋮

length of 6th leaf $= \frac{1020}{7-1} \times 6 + 80$

$$= 1100 \text{ mm.}$$

4) Radius to which the leaves should be initially bent.

$$y(2R - y) = L_1^2$$

$$30(2R - 30) = (550)^2$$

$$\boxed{R = 5056.5 \text{ mm.}}$$

5) Initial gap (c)

Assume $E = 210 \times 10^3$ MPa.

$$c = \frac{2PL^3}{n \times E \times b \times t^3}$$

$$= \frac{2 \times 3000 \times (510)^3}{7 \times 210 \times 10^3 \times 65 \times (9)^3}$$

$$\boxed{c = 11.42 \text{ mm.}}$$

b) Load exerted on the spring (P_b).

$$P_b = \frac{2 \times n_e \times n_g \times P}{n(2 \times n_g + 3 \times n_e)}$$

$$= \frac{2 \times 2 \times 5 \times 3000}{7(2 \times 5 + 3 \times 2)}$$

$$\boxed{P_b = 535.714 N.}$$