Title : Springs

helical spring

- stress

$$\tau = K_s \frac{8FD}{\pi d^3}$$

maximum force

allowable shear stress

$$F_s = \frac{S_{sy} \pi d^3}{8 K_B D}$$

where

$$K_s = \frac{2C + 1}{2C}$$

C, spring index.

$$K_B = \frac{4C + 2}{4C - 3}$$

$$C = \frac{D}{d}$$

- deflection

spring rate :

$$k = \frac{d^4 G}{8 D^3 N}$$

N_a

Title :

– material strength.

· tensile strength

$$S_{ut} = \frac{A}{d^m}$$

· torsional yield strength.

$$0.6 \cdot S_{ut} \leq S_y \leq 0.9\, S_{ut}$$

$$0.35\, S_{ut} \leq S_{sy} \leq 0.52\, S_{ut}$$

· absolute stability

$$L_o < \frac{\pi D}{\alpha} \cdot \left[\frac{2(E-G)}{2G+E} \right]^{\frac{1}{2}}$$

for steel,

$$L_o < 2.63 \frac{D}{\alpha}$$

criterion

end-condition constant [Table 10-2]

Table 10–2

End-Condition Constants α for Helical Compression Springs*

End Condition	Constant α
Spring supported between flat parallel surfaces (fixed ends)	0.5
One end supported by flat surface perpendicular to spring axis (fixed); other end pivoted (hinged)	0.707
Both ends pivoted (hinged)	1
One end clamped; other end free	2

*Ends supported by flat surfaces must be squared and ground.

for calculation,

$$L_o = y + L_s = \frac{F}{k} + L_s$$

[Table 10-1]

Table 10–1

Formulas for the Dimensional Characteristics of Compression-Springs. (N_a = Number of Active Coils)

Source: From *Design Handbook*, 1987, p. 32. Courtesy of Associated Spring.

	Type of Spring Ends			
Term	Plain	Plain and Ground	Squared or Closed	Squared and Ground
End coils, N_e	0	1	2	2
Total coils, N_t	N_a	$N_a + 1$	$N_a + 2$	$N_a + 2$
Free length, L_0	$pN_a + d$	$p(N_a + 1)$	$pN_a + 3d$	$pN_a + 2d$
Solid length, L_s	$d(N_t + 1)$	dN_t	$d(N_t + 1)$	dN_t
Pitch, p	$(L_0 - d)/N_a$	$L_0/(N_a + 1)$	$(L_0 - 3d)/N_a$	$(L_0 - 2d)/N_a$

Title : static loading

STATIC SPRING DESIGN

Choose d

Over-a-rod — As-wound or set

$D = d_{\text{rod}} + d + \text{allow}$

Free

- As-wound

$S_{sy} = \text{const}(A)/d^{m\dagger}$

Table 10-6

$$C = \frac{2\alpha - \beta}{4\beta} + \sqrt{\left(\frac{2\alpha - \beta}{4\beta}\right)^2 - \frac{3\alpha}{4\beta}}$$

$$\alpha = \frac{S_{sy}}{n_s} \qquad \beta = \frac{8(1+\xi)F_{\max}}{\pi d^2}$$

$$D = Cd$$

- Set removed

$S_{sy} = 0.65A/d^m$

$$D = \frac{S_{sy}\pi d^3}{8n_s(1+\xi)F_{\max}}$$

In-a-hole — As-wound or set

$D = d_{\text{hole}} - d - \text{allow}$

$$C = D/d$$

$$K_B = (4C+2)/(4C-3)$$

$$\tau_s = 8K_B(1+\xi)F_{\max}D/(\pi d^3)$$

$$n_s = S_{sy}/\tau_s$$

$$\text{OD} = D + d$$

$$\text{ID} = D - d$$

$$N_a = Gd^4 y_{\max}/(8D^3 F_{\max})$$

N_t: Table 10–1

L_s: Table 10–1

L_O: Table 10–1

$(L_O)_{cr} = 2.63D/\alpha$

end - condition constant [Table 10-2]

$$\text{fom} = -(\text{rel. cost})\gamma\pi^2 d^2 N_t D/4$$

check :

$$4 \le C \le 12$$

$$3 \le N_a \le 15$$

$$\xi \ge 0.15$$

$$n_s \ge 1.2$$

Title : Fatigue loading

- surface treatement

  - unpeened

    $S_{sa} = 241$ MPa $\quad S_{sm} = 379$ MPa.

  - peened

    $S_{sa} = 398$ MPa $\quad S_{sm} = 534$ MPa.

- fatigue analysis

  - F_m

    $$F_m = \frac{F_{max} + F_{min}}{2}$$

  - F_a

    $$F_a = \left| \frac{F_{max} - F_{min}}{2} \right|$$