SPRINGS

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All Equations and Figures From: Shigley & Mischke. Mechanical Engineering Design. Fifth Edition, 2002.

Helical Springs

- Compression
- Torsion
- Extension

Compression Springs

Note: compression produces shear stress in the spring

Governing equation: F=k*y

$$y = \frac{8 \cdot F \cdot D^3 \cdot N}{d^4 \cdot G} \cdot \left[1 + \frac{1}{2 \cdot C^2}\right]; \text{ eqn. 10-8}$$

Spring Rate k:

$$K = \frac{d^4 \cdot G}{8 \cdot D^3 \cdot N}; \text{ eqn. 10-9}$$

End Conditions:

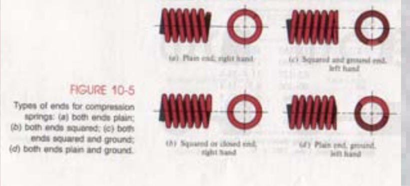

FIGURE 10-5 Types of ends for compression springs: (a) both ends plain; (b) both ends squared; (c) both ends squared and ground; (d) both ends plain and ground.

Critical Deflection:

Critical deflection in a compression spring: This is when the deflection becomes too large and the spring buckles. The equation is shown below.

$$ycr = Lo \cdot C1 \cdot \left[1 - \left[1 - \left[\frac{C2}{\lambda eff^2}\right]\right]^{\left[\frac{1}{2}\right]}\right]; \text{ eqn. 10-11}$$

The effective slenderness ratio is given by:

; λeff = α*L/D; eqn. 10-12

The chart below describes α, which is the end condition constant.

TABLE 10-3 End-Condition Constants α for Helical Compression Springs*

END CONDITION	CONST
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)	0.7
Both ends pivoted (hinged)	1
One end clamped; other end free	2

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

$$C1 = \frac{E}{2 \cdot (E - G)} \quad \text{eqn. 10-13}$$

$$C2 = \frac{2 \cdot \pi^2 \cdot (E - G)}{2 \cdot G + E}; \text{ eqn. 10-14}$$

$$Lo < \frac{\pi \cdot D}{\alpha} \cdot \left[\frac{2 \cdot (E \cdot G)}{2 \cdot G + E}\right]^{\left[\frac{1}{2}\right]}; \text{ eqn. 10-15}$$

This is the free length of the spring.

Torsion Springs

Note: Twisting the Torsion Spring creates a normal stress in the spring.

Helical Torsion Springs:

Helical torsion springs are wound in the same manner as extension and compression springs. For torsion springs, the ends are designed to transmit torque.

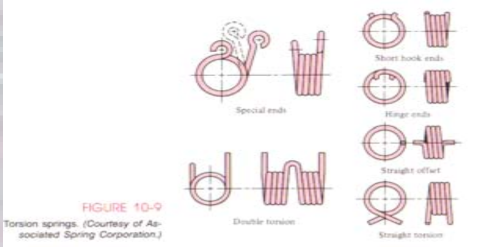

FIGURE 10-9 Torsion springs. (Courtesy of Associated Spring Corporation.)

Stress Concentration Factor on inside of the Spring Ki:

$$Ki = \frac{4 \cdot C^2 - C - 1}{4 \cdot C \cdot (C - 1)}; \text{ eqn. 10-32}$$

Bending stress for a round wire torsion spring:

$$\sigma = \frac{Ki \cdot 32 \cdot F \cdot r}{\pi \cdot d^3}; \text{ eqn.10-33}$$

Displacement in torsion springs is described in radians.

$$\theta = \frac{64 \cdot F \cdot r \cdot D \cdot N}{d^4 \cdot E}; \text{ 10-34}$$

The spring rate, taking into account the curvature of the wire:

$$k` = \frac{d^4 \cdot E}{10.8 \cdot D \cdot N}; \text{ 10-37}$$

Extension Springs

Note: Loading the Extension Spring creates a shear stress in the spring.

Extension Springs: These must have a way of transferring load from a support to the body of the spring. Using Springs with a hooked end, stress concentration must be considered. This is shown below. The lower spring has a decreased stress concentration because the moment arm is smaller.

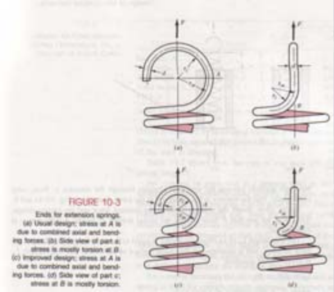

FIGURE 10-3 Ends for extension springs. (a) Usual design; stress at A is due to combined axial and bending forces. (b) Side view of part a; stress is mostly torsion at B. (c) Improved design; stress at A is due to combined axial and bending forces. (d) Side view of part c; stress at B is mostly torsion.

TABLE 10-1 Preferred Range of Torsional Stresses Due to Initial Tension for Steel Helical Extension Springs

INDEX C	STRESS RANGE MPa	STRESS RANGE kpsi
4	115–183	16.7–26.6
6	95–160	13.8–23.2
8	82–127	11.9–18.4
10	60–106	8.71–15.4
12	48–86	6.97–12.5
14	37–60	5.37–8.71
16	25–50	3.63–7.26

Source: Associated Spring–Barnes Group, Design Handbook, Bristol, Conn., 1981, p. 50.

Stress Concentration Factor:

$$K = \frac{r\_m}{r\_i}; \text{ eqn. 10-10}$$

Fatigue Loading

Spring Fatigue Loading:

Some springs are subjected to fatigue loading. It must be determined whether the spring will need to have infinite life or finite life. Helical springs are never designed to be used in both compression and tension.

Alternating stress Fa:

$$Fa = \frac{F\_max - F\_min}{2}; \text{ eqn. 10-26}$$

Mean stress Fm:

$$Fm = \frac{F\_max + F\_min}{2}; \text{ eqn. 10-27}$$

Stress Amplitude τa:

$$\tau a = \frac{Kb \cdot 8 \cdot Fm \cdot D}{\pi \cdot d^3}; \text{ eqn. 10-28}$$

Mean Stress τm:

$$\tau m = \frac{Ks \cdot 8 \cdot Fm \cdot D}{\pi \cdot d^3}; \text{ eqn. 10-29}$$