**1. Calculation**

**1.1 Symbols Used in Spring Design Formulae**

Symbols used in spring design formulae are shown in Table 1.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning of Symbols</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>Diameter of Material</td>
<td>mm</td>
</tr>
<tr>
<td>D1</td>
<td>Inner Diameter of a Coil</td>
<td>mm</td>
</tr>
<tr>
<td>D2</td>
<td>Outer Diameter of a Coil</td>
<td>mm</td>
</tr>
<tr>
<td>D</td>
<td>Coil Mean Diameter</td>
<td>mm</td>
</tr>
<tr>
<td>N0</td>
<td>Initial Number of Winding</td>
<td>—</td>
</tr>
<tr>
<td>Na</td>
<td>Number of Active Winding</td>
<td>—</td>
</tr>
<tr>
<td>L</td>
<td>Free Length (Length)</td>
<td>mm</td>
</tr>
<tr>
<td>N</td>
<td>Solid Length</td>
<td>mm</td>
</tr>
<tr>
<td>P</td>
<td>Pitch</td>
<td>mm</td>
</tr>
<tr>
<td>P1</td>
<td>Pitch 1</td>
<td>mm</td>
</tr>
<tr>
<td>P2</td>
<td>Pitch 2</td>
<td>mm</td>
</tr>
<tr>
<td>D1+D2</td>
<td>Coils Mean Diameter</td>
<td>mm</td>
</tr>
<tr>
<td>D1+D2C</td>
<td>Coils Mean Diameter</td>
<td>mm</td>
</tr>
<tr>
<td>k</td>
<td>Stress Correction Factor</td>
<td>—</td>
</tr>
<tr>
<td>k1</td>
<td>Stress Correction Factor</td>
<td>—</td>
</tr>
<tr>
<td>k2</td>
<td>Stress Correction Factor</td>
<td>—</td>
</tr>
<tr>
<td>0</td>
<td>Initial Tension</td>
<td>N</td>
</tr>
<tr>
<td>G</td>
<td>Shear Modulus of Elasticity</td>
<td>N/mm²</td>
</tr>
<tr>
<td>P</td>
<td>Load on Spring</td>
<td>N</td>
</tr>
<tr>
<td>c</td>
<td>Frequency Hz</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>Stress Correction Factor</td>
<td>—</td>
</tr>
<tr>
<td>S</td>
<td>Per Unit Volume Material Weight</td>
<td>kg/mm³</td>
</tr>
<tr>
<td>b</td>
<td>Machinability</td>
<td>100</td>
</tr>
<tr>
<td>Gf</td>
<td>Hardness Coefficient</td>
<td>—</td>
</tr>
<tr>
<td>D</td>
<td>Average Dia.</td>
<td>mm</td>
</tr>
<tr>
<td>Pi</td>
<td>Initial Stress</td>
<td>N/mm²</td>
</tr>
<tr>
<td>a</td>
<td>External Tension</td>
<td>N</td>
</tr>
<tr>
<td>n</td>
<td>Tensile Stress</td>
<td>N/mm²</td>
</tr>
<tr>
<td>P0</td>
<td>Initial Stress</td>
<td>N</td>
</tr>
<tr>
<td>N</td>
<td>Per Unit Volume Material Weight</td>
<td>kg/mm³</td>
</tr>
<tr>
<td>2</td>
<td>Initial Stress</td>
<td>N/mm²</td>
</tr>
<tr>
<td>Pi</td>
<td>Initial Stress</td>
<td>N</td>
</tr>
<tr>
<td>a</td>
<td>External Tension</td>
<td>N</td>
</tr>
<tr>
<td>n</td>
<td>Tensile Stress</td>
<td>N/mm²</td>
</tr>
<tr>
<td>P0</td>
<td>Initial Stress</td>
<td>N</td>
</tr>
</tbody>
</table>

**1.2 Basic Formulae Used in Designing of Springs**

**1.2.1 Compression Springs, and Tension Springs without Initial Tension**

\[
\frac{P}{Gd} = \frac{4}{k} \cdot \frac{N_a \cdot D}{P} = \frac{4}{k} \cdot \frac{N_a \cdot D}{P}
\]

\[
\frac{P}{Gd} = \frac{4}{k} \cdot \frac{N_a \cdot D}{P}
\]

\[
\frac{P}{Gd} = \frac{4}{k} \cdot \frac{N_a \cdot D}{P}
\]

**1.2.2 Tension Springs with Initial Tension**

\[
\frac{P}{i} = \frac{4}{k} \cdot \frac{N_a \cdot D}{P}
\]

\[
\frac{P}{i} = \frac{4}{k} \cdot \frac{N_a \cdot D}{P}
\]

\[
\frac{P}{i} = \frac{4}{k} \cdot \frac{N_a \cdot D}{P}
\]

**1.3 Points to Note when Designing Springs**

**1.3.1 Shear Modulus of Elasticity**

Shear modulus of elasticity (G) listed in Table 2 is recommended for the designing of springs.

**1.3.2 Number of Active Winding**

The number of active winding can be determined as follows.

\[
Na = Nt - X1 - X2
\]

Where: X1 and X2: are the number of turns at each end of the coil.

\[
X1 = X2 = 1
\]

\[
X1 = X2 = 1
\]

**1.3.3 Stress Correction Factor**

The stress correction factor relative to the spring index (C) can be determined by using the following formula or based on Fig.1.

\[
C = \frac{Gd \cdot D}{P}
\]

\[
C = \frac{Gd \cdot D}{P}
\]

\[
C = \frac{Gd \cdot D}{P}
\]

**1.4 Solid Length**

The solid length of a spring can normally be obtained by using the following simplified formula. Generally, the purchase of a compression spring does not specify the solid length of the spring.

\[
Hs = Nt \cdot d_{max}
\]

**1.5 Initial Tension of Tension Springs**

Cold-formed solid-cored tension springs are subjected to initial tension (P0). The initial tension can be obtained using the following formula.

\[
P0 = \frac{Na \cdot D}{k} \cdot \frac{N_a \cdot D}{P}
\]

On solid-cored piano wire, hard steel wire, and other steel wires that are not temperature-annealed, the initial stress occurs within the hatched range shown in Fig. 2. However, if materials other than steel wire are used, or the wire is specified in low-temperature temperature annealed, the initial stress taken from within the hatched range in Fig. 2 should be corrected as follows.

\[
\frac{P}{i} = \frac{4}{k} \cdot \frac{N_a \cdot D}{P}
\]

**1.6 Other Points to Note**

In spring design calculations, the following points should also be taken into account.

**1.6.1 Stress Correction Factor**

The stress correction factor relative to the spring index (C) can be determined by using the following formula or based on Fig.1.

\[
C = \frac{Gd \cdot D}{P}
\]

\[
C = \frac{Gd \cdot D}{P}
\]

\[
C = \frac{Gd \cdot D}{P}
\]

**1.6.2 Surging**

In order to prevent surging, the spring selected should be such that its natural frequency does not resonate with the natural frequencies that may act upon the spring.

The total frequency can be obtained using the following formula.

\[
\frac{f}{T} = \frac{\sqrt[3]{256}}{D}
\]

Where: \( t \) when both spring ends are either free or fixed and

\[
\frac{f}{T} = \frac{\sqrt[3]{256}}{D}
\]

**1.6.3 Other Points to Note**

In spring design calculations, the following points should also be taken into account.

**1.6.3.1 Spring Index**

The spring index is recommended for the designing of springs. Generally, the purchase of a compression spring does not specify the solid length of the spring.

The solid length of a spring can normally be obtained by using the following simplified formula. Generally, the purchase of a compression spring does not specify the solid length of the spring.