INSTRUCTIONS

for

MEAR'S

HELICAL COIL SPRING CALCULATOR

METRIC MODEL

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Helical Coil Spring Calculator

Metric Model

This calculator designs helical coil springs in accordance with the British Standard Specification 1726 part I (converted to metric units) and will handle springs made from round, square or reactangular section wire.

One side of the instrument solves the formula for rate and deflection and the other side deals with the formula for stress. These formulae are as follows :

Springs made from round wire or bar :

$$\text{Rate:} \quad S = \frac{d^4 G}{7.85 n D^3}$$

$$\text{Stress:} \quad q = \frac{7.85\, PDK}{\pi d^3}$$

where S = axial spring rate kgf/mm
q = shear stress due to P hbar
d = dia. of wire or bar mm
D = mean dia. of coil mm
G = shear modulus hbar
n = number of working coils
P = axial load kgf
$K = \dfrac{c + 0.2}{c - 1}$
c = spring index = D/d or D/b

Springs made from Rectangular bar:

$$\text{Rate:} \quad S = \frac{\mu\, b^2 h^2 G}{0.981 n D^3}$$

$$\text{Stress:} \quad q = 0.981\,(c+1)\,(m+1)\,\lambda \frac{P}{bh}$$

and where b = radial width of rectangular section wire mm
h = axial height of rectangular section wire mm
m = b/h = ratio of sides of rectangular section
μ = rate coefficient for springs with rectangular wire section
λ = stress coefficient for springs with rectangular wire section.

ACCURACY.

The answers given by the calculator are correct to the British Standard except for the stress in rectangular wire springs where the complex variation of the stress coefficient λ with the spring index and the ratio of the sides has necessitated slight averaging to avoid undesirable complexity in the construction and use of the calculator. The maximum error on this account is plus or minus 3% for spring indices between 3 and 6 and plus or minus 5% for a spring index of 10.

COEFFICIENT 'K' FOR ROUND WIRE SPRINGS.

The above formula for stress in round wire springs is basically the formula for a straight round wire subject to torsion, with a correction factor 'K' applied to allow for the curvature due to the coiled form. This curvature imposes an increased stress on the inside diameter of the coil dependent upon the ratio of wire diameter to mean coil diameter. It is determined automatically by the calculator and then used in the next step of the calculation.

This 'K' factor as defined by the British Standard is practically identical with the Wahl correction factor used by some authorities. (The difference is less than 1%).

COEFFICIENT λ FOR RECTANGULAR WIRE SPRINGS.

This allows for the variation in stress at different points of a rectangular section in torsion and also for the increase in stress on the inside diameter due to curvature.

COEFFICIENT μ FOR RECTANGULAR WIRE SPRINGS.

This allows, in the British Standard, for the modification to the deflection resulting from variations in stress at different points of a rectangular section in torsion but it makes no allowance for curvature due to coiling as it is maintained that there is usually better agreement between rates as measured and the calculated figures, if curvature is ignored.

TOTAL NUMBER OF COILS (N) and NUMBER OF WORKING COILS (n).

The number of working coils on which design calculations are based is often less than the total number of coils as the end coils are often partially ineffective i.e.

Light springs with ends closed	$N = n + 2$ (average)
This may vary from $n + 1\frac{1}{2}$ to $n + 2\frac{1}{2}$ depending on the formation of the end coils.	
Light springs with ends open	$N = n$
Heavy springs, circular section	$N = n + 1\frac{1}{2}$
,, ,, square ,, ...	$N = n + 1\frac{5}{8}$
,, ,, rectangular ,, ...	$N = n + 2$

Light springs are up to 12 mm dia. or 12 mm × 3 mm in section
Heavy springs are larger than these sizes.

DESIGN STRESSES AND MODULUS OF RIGIDITY.

For design stresses reference should be made to Design Data Sheet No. 7 published by the Spring Research Association, Doncaster Street, Sheffield 3. This gives data for a wide range of materials with allowances for heat treatment, wire diameter, shot peening, fatigue, etc.

The values for the Modulus of Rigidity 'G' to be used in design calculations are:—

Hard drawn carbon steel Carbon steel for hardening and tempering Silicon Manganese Steel Chromium vanadium steel Martensitic stainless steel	7 900 ~~8 000~~ hbar
Austenitic Stainless steel	7 000 hbar
Phosphor bronze	4 300 ,,
Hard drawn brass wire	3 600 ,,
Copper beryllium	4 100 ,,
Monel	6 200—6 600 hbar
Inconel	7 200—7 600 ,,
Nimonic 90	7 900—8 600 ,,
Titanium alloys	3 500—4 100 ,,

Wherever possible compression springs should be so designed that they can be closed solid without exceeding the maximum permissible stress and the solid stress included in the information given to the manufacturer.

SPRING MATERIAL AND MANUFACTURE.

A wide variety of materials and manufacturing methods is used in coil spring manufacture and for further details reference is recommended to B.S. 1726 part 1 and to the comprehensive publications issued by the Spring Research Association, Doncaster Street, Sheffield 3.

EXAMPLE, INCLUDING DETERMINATION OF SPRING SIZE TO SUIT A HOLE OF GIVEN DIAMETER.

The problem often arises of designing a spring to fit in a hole of a fixed diameter which cannot be increased, e.g.
Select a spring to exert a load of 25 kgf at a stress of 40 hbar having an outside diameter of 32mm.

1. For an o.d. of 32mm a reasonable wire size would be $\frac{1}{8}$ of this, that is 4mm dia. and the mean coil dia. would then be 28mm.

2(a) On the stress side of the calculator using the red scales:
Set 4mm wire dia. to 28mm mean coil dia.

(b) Set 40 hbar stress to 25 kgf load.

3(a) Note the correction factor (opposite the red arrow) is 1.20, and opposite 1.20 on the Correction Factor scale the wire dia. is **3.63mm.**

(b) The correct wire dia. then lies between 4mm set on the red scale and the 3.63mm now found on the green scale.

Adjustment until the two are identical will give the correct answer

or : Take the difference (in this case .37mm) and add or subtract 30% of it to the green scale figure thus :
4mm — 3.63mm = .37mm
30% of .37 = .11mm
3.63 + .11 = 3.74mm **which is the correct wire dia.**

Checking with the calculator for any minute error shows this to be correct: i.e.

Set 3.74mm wire dia. to 28.26 mean coil dia.
Set 1.18 correction factor to 3.74mm wire dia.
Read **Load at 25 kgf** opposite stress of 40 hbar.

To find number of coils. Rate required say 1 kgf/mm.
Set 3.74mm wire dia. to 28.26 mean coil dia.
Set Rate arrow at 1 kgf/mm.
Read 9 coils opposite "Steel" arrow.

CONVERSION FACTORS

1 lbf	=	4.448 N = 0.4536 kgf
1 lbf/in	=	175.127 N/m = ~~0.17858~~ [0.017858] kgf/mm
1 lbf/in²	=	6895 N/m² = 6.895×10^{-4} hbar
1 kgf	=	9.807 N
1 kgf/mm²	=	9.807 MN/m² = 9.807 N/mm²
		= 0.9807 hbar
1 hbar	=	10 N/mm² = 10^7 N/m²

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