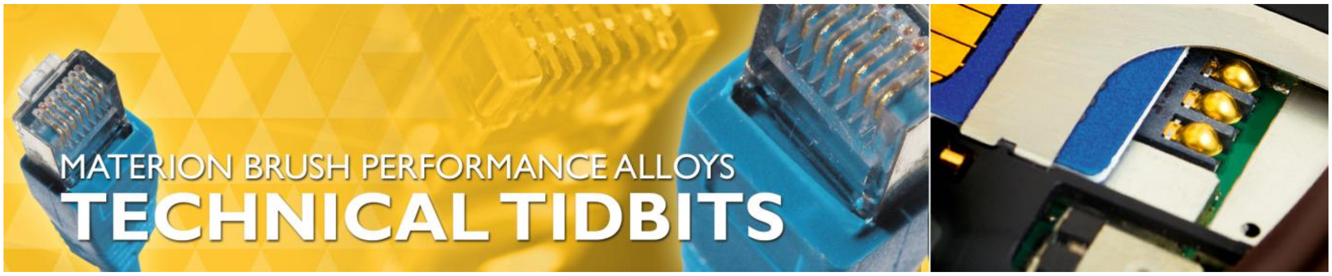
MATERION BRUSH PERFORMANCE ALLOYS
TECHNICAL TIDBITS

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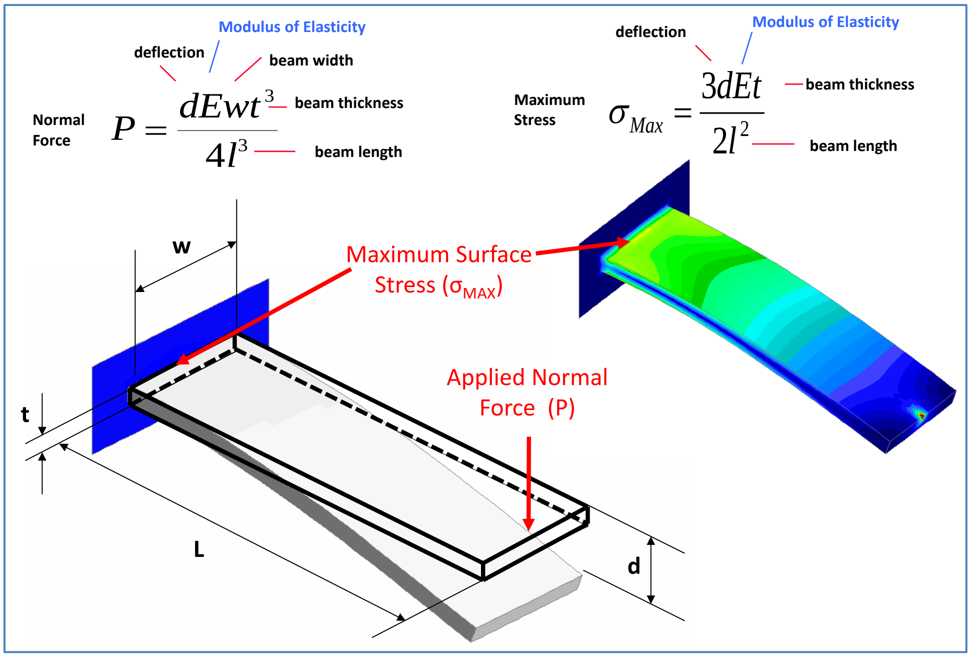
Dive into a spring type that Frank Lloyd Wright would have loved – Contact springs that are functionally equivalent to the cantilever beam.

- **Cantilever / Cantilevered Beam**
- **Buckling Beam**

Spring Types Part 1 - Cantilever Beams

This series of six or so editions of Technical Tidbits will discuss various types of springs used in electrical contacts or sensors, and group them into six broad categories of similar function (cantilever beams, simply supported beams, torsion bars, Belleville washers, coil springs, and bellows & diaphragms). This month we will focus on the cantilever beam. This will be a quick review, as this spring type has been covered in great detail in previous issues of Technical Tidbits.

The **cantilever beam** (or **cantilevered beam**) may be the simplest of all spring structures. It is nothing more than a spring that is fixed while the other end is deflected perpendicularly to the long axis of the beam. When the cross section is rectangular, the spring resembles a diving board, as shown in Figure 1.



$$P = \frac{dEwt^3}{4l^3}$$

$$\sigma_{Max} = \frac{3dEt}{2l^2}$$

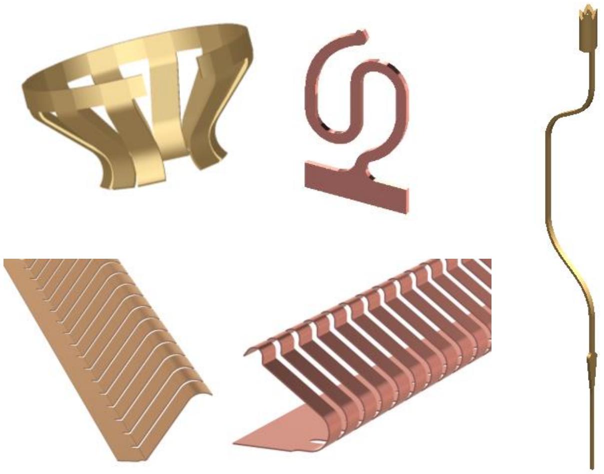
Figure 2. Cantilever Beam Spring Type and Relevant Equations for Rectangular Cross Sections. The cantilever beam is fixed at one end (represented by the blue wall in the diagram above), and is deflected at the other end. This deflection results in an opposing normal force (P), and a maximum tensile stress along the top surface at the fixed edge. An equal compressive stress can be found on the bottom surface at the fixed edge. These equations are valid as long as the stress is linear and elastic (σ_{Max} < yield strength), and the deflections are small (on the order of the thickness, sin $\theta \approx \theta$ and cos $\theta \approx 1$). The stress shown at the beam tip is an artificial concentration due to an applied point load in the finite element model used.

The equations that govern the spring behavior of the cantilever beam are simple. They are shown in Figure 1, solved for constant, rectangular cross sections, which are most common. (Such spring designs are usually stamped or photochemically machined out of strip material.) The thicknesses of such parts are constant (unless the edges are coined). Usually, if any dimension varies down the length of the spring it would be the width, and these simple equations would no longer apply. Note that beam width affects force, but not stress. Force is a cubic function of the thickness, but stress is a linear function of the thickness. Length has an inverse cubic relationship with force and an inverse square relationship with stress.

The next issue of Technical Tidbits will continue the discussion on various spring types, focusing on the simply supported (arch) beam type.

Cantilever Beam Springs (continued)

The generic form of the cantilever beam equations are shown to the right of figure 2. Here, I is the moment of inertia of the cross section and y_{max} is the maximum distance from the neutral axis to the outer surface, and the other variables have the same meanings as in Figure 1.



$$P = \frac{3 \cdot E \cdot I}{L^3} \cdot d$$

$$\sigma_{\max} = \frac{3 \cdot E \cdot d}{L^2} \cdot y_{\max}$$

Figure 1. Cantilever Beams in Electrical Connectors and EMI Shielding. These electrical and shielding contacts may look different, but at heart they are all cantilever beams, being held fixed at one end and deflected at the other. In each case, the primary mode of stress and force generation is bending. The special case (far right) where the load is applied along the axis and the beam bends perpendicularly to the axis is known as a **buckling beam**. In all cases pictured above, the equations for contact force and stress generated for a given deflection would be quite complex, and in some cases virtually impossible to derive.

If the contacts are made from bent wire or rod, then the cross section would be round, and the governing equations would have to be adjusted based on the new moment of inertia. In fact, the equations in figure 2 would apply for any cantilever beam of constant cross section (such as hexagonal), as long as you can compute the appropriate moment of inertia and location of the neutral axis in bending.

The cantilever beam is the most common type of spring used for electrical contacts and connectors. This publication was intended as a refresher on cantilever beams in the context of a quick overview of various common spring types. For a much more detailed treatment of the implications of the equations in Figures 1 and 2, see Technical Tidbits issues number 20, 21, 22, 30 and 48.

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