Silk - Properties - Comparison

Chemical, physical and mechanical properties:

<table>
<thead>
<tr>
<th></th>
<th>Elongation at break %</th>
<th>Modulus n/m²</th>
<th>Strength N/m²</th>
<th>Energy to break J/Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk - Bombyx</td>
<td>15-35</td>
<td>5x10^9</td>
<td>6x10^8</td>
<td>6x10^4</td>
</tr>
<tr>
<td>Nylon</td>
<td>18-26</td>
<td>3x10^9</td>
<td>5x10^8</td>
<td>8x10^4</td>
</tr>
<tr>
<td>Cotton</td>
<td>5.6-7.1</td>
<td>6-11x10^9</td>
<td>3-7x10^8</td>
<td>5-15x10^3</td>
</tr>
<tr>
<td>Kevlar</td>
<td>4</td>
<td>1x10^11</td>
<td>4x10^9</td>
<td>3x10^4</td>
</tr>
<tr>
<td>Steel</td>
<td>8</td>
<td>1x10^11</td>
<td>4x10^9</td>
<td>2x10^3</td>
</tr>
</tbody>
</table>

**Toughness**
The toughness of degummed silk fibres is comparable to that of nylon and Kevlar fibres. The elongation at break of silk fibres ranges from 15% to 35%, values that are notably higher than those of cotton and Kevlar and comparable to nylon.

**Strength**
The breaking force is higher than that of cotton, Kevlar and nylon fibres.

**Flexural rigidity**
Relatively high, greater than wool and acetate fibres.

**Torsional rigidity**
The average values are similar to those of wool and cotton.

**Wear resistance**
Subjecting the fibres to repeated bending, silk has a resistance between that of wool and cotton.

**A combination of strength and toughness**
Silk fibres display an unusual combination of strength and toughness that distinguishes them from other natural and synthetic fibres. Silk fibres behave uniquely with respect to mechanical stress. Normally as the tensile deformation rate increases, the strength and modulus increase while the elongation at break decreases. In contrast, silk fibres show an increase in the values of the latter parameter. Therefore, the work to break is greater the higher the deformation rate. This means that silk fibres have an excellent ability to absorb energy at high loading speed rates.

**Tensile strength**
Superior to that of cotton and nylon. Silk fibre is stronger than an equal thickness of steel wire and, more importantly, does not show the phenomenon of yielding before breaking.

**Flexibility**
Silk has excellent flexibility, enabling the fibres to withstand deformation of 20-25% of their initial length. Up to deformations of -2%, silk completely recovers its size if the stress is removed. The fibres are completely elastic.

**Other characteristics**
Silk is the lightest among natural fibres.
The fibre decomposes when exposed to a heat of 171°C. It has a high resistance to creasing due to the good resilience of the fibres and their ability to recover rapidly from other deformations.
Silk fibres have a low thermal conductivity coefficient.
Thanks to its natural protein formulation, silk is the most hypoallergenic fibre. Silk fabrics are warm and cosy in the winter and comfortably cool when the temperature rises. Its natural heat regulation properties confer this exceptional paradoxical ability to be both warm and cool. Silk is highly absorbent (high hygroscopicity - ability to absorb water-,
making it clearly superior to other fibres like cotton, cellulose acetate, polyester and nylon) and dries quickly.  
It can absorb up to 30% of its weight in moisture without feeling damp.  
Silk is able to absorb perspiration while letting the skin breathe. In addition, silk blends well with other plant and animal fibres.

**Interesting facts**

- The silkworm (Bombyx mori, Latin for “silkworm of the mulberry tree”) is technically not a worm but the larva or caterpillar of a moth.
- The diet of a silkworm consists exclusively of plant leaves (from the mulberry species).
- The life of the silkworm is now entirely dependent on humans and their natural reproduction no longer occurs in nature.
- The female silkworm deposits approximately 400 eggs at a time. In an area the size of a computer screen, approximately 100 moths can deposit more than 40,000 eggs, each having the size of a pinhead.
- The female dies almost immediately after depositing her eggs, the male after a few hours. The adult does not eat during its brief existence.
- After growing to its maximum size (about 6 weeks) the larva weighs approximately 10,000 times more than when it hatches.
- A hectare of mulberry trees produces approximately 11 tonnes of leaves, which in turn produces approximately 450 kg of cocoons and 85 kg of raw silk.
- The cocoon is composed of a continuous thread of raw silk that can be up to 1 km long.
- 2,000 to 3,000 cocoons are needed to make 1 kg of raw silk and 750 g of silk waste. A kg of silk represents approximately 1,500 km of filament.
- At least 2,000 cocoons are needed to produce one kimono.
- The annual world production represents 115 billion km, a distance equal to 300 round-trip voyages to the sun.
- Based on a filament length of 1 km per cocoon, approximately ten cocoons could in theory be vertically extended to reach the height of Mount Everest.
- The iridescent appearance for which silk is prized comes from the triangular prismatic structure of the fibre, which enables it to refract light coming from different angles.
- Silk fibres are very fine, having a diameter of approximately 10 nanometres.
- Comparable to steel in terms of tensile strength, silk is the strongest natural fibre known to man.