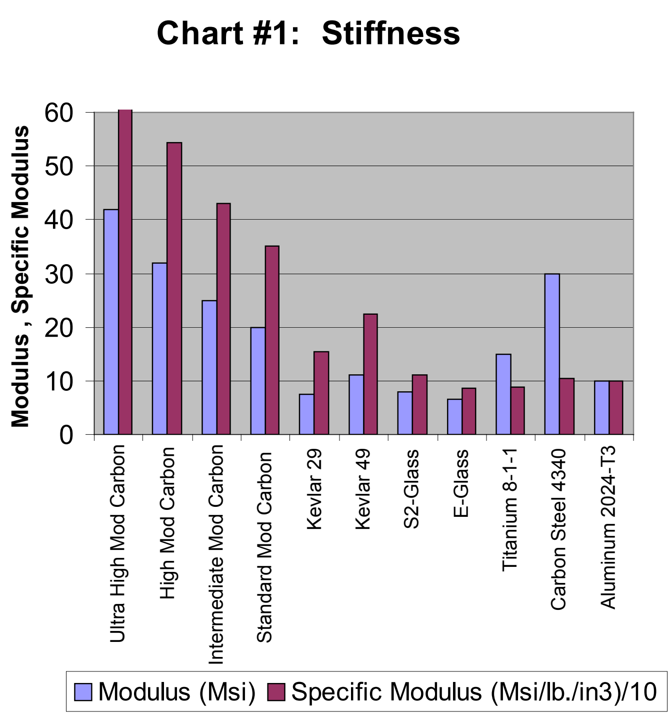
DESIGN TIPS No. 01

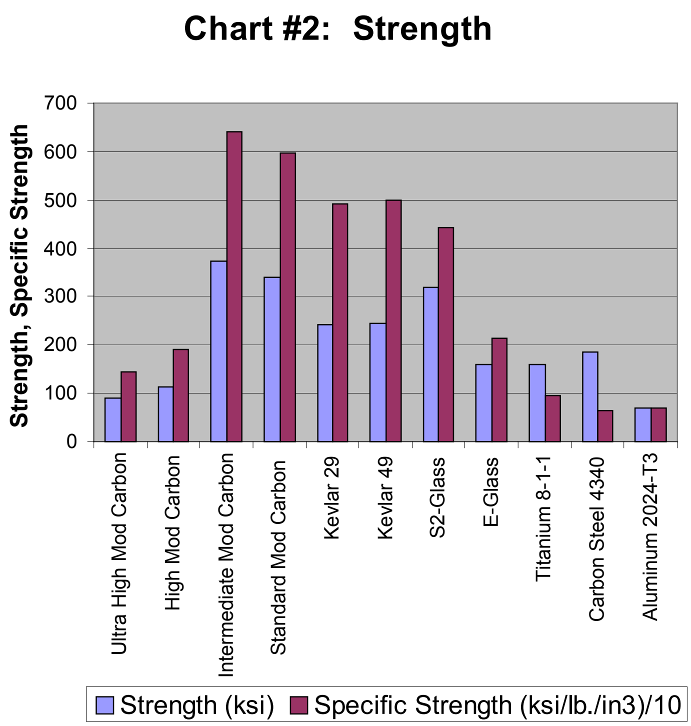
Selecting The Right Fiber:
The Lightweight, High Strength and Stiffness Solution

Fibers used in composite components take one of three forms: milled fiber (almost like dust), chopped short fiber (up to ½ inches long), and long continuous fiber. The longer the a fiber is in a composite material, the stiffer and stronger the material will be, up to a limit, of course. This DESIGN TIP applies mainly to long continuous fiber composites. Although there are many kinds of fibers that can be used to form composite components, the three dominant ones used in industry are fiberglass, carbon and aramid (Kevlar being an aramid fiber). Only these three fibers are considered herein. The main functions of fiber in a composite material are to give the composite its stiffness (resistance to bending and deflection) and its strength (resistance to breakage under loading).



First, consider the stiffness of various fibers when compared to titanium, steel, and aluminum (see Chart #1). The fiber stiffnesses shown have been adjusted to account for the containment of the fibers in an epoxy resin (60% fiber volume), forming a uni-directional composite material. As can be seen, ultra high modulus carbon fiber is capable of having a stiffness or modulus 1.5 times that of steel and standard modulus fiber has a stiffness 2 times that of aluminum. The specific modulus is simply the modulus of the material divided by the material density, and is an indication of the stiffness of a material per unit weight. High specific moduli translates into materials which give the lowest deflection for the lowest weight. Composites, almost without exception, give the most stiffness for the lowest weight. If a particular product requires low deflections or high vibration frequency, Chart #1 can be used to choose the best fiber for the job.

The other main consideration for selecting a fiber is the material strength. Chart #2 similarly shows the strength for various fibers as compared to metallics. Again, the strengths have been adjusted to compensate for a 60% fiber volume uni-directional



composite. The tensile strength of all of the fibers considered here exceed that of aluminum by as much as 4 times. For the most part, carbon, Kevlar and fiberglass fibers also exceed the strength of steel by as much as 2 times. The specific strength of all of the fibers well exceed the metallics by as much as 10 times. Carbon, Kevlar and fiberglass fibers offer superior strength at a lower weight when compared to metallics, and one need only determine how much strength is required for a particular component to select the best fiber to use.

In addition, certain fibers are better suited for particular uses than are others. Table 1 shows some of the advantages and disadvantages of the three fiber types; carbon, fiberglass and aramid.

Table 1: Fiber Performance Characteristics

Characteristic	Performance		
	Carbon	Fiberglass	Aramid
Cost	Highest	Lowest	
Electrical Resistivity		Best	
Electrical Conductivity	Best		
Thermal Conductivity	Best	Poor	
Dampening	Good		Best
Compressive Strength			Poor
Machineability	Best	Good	Poor
Toughness			Best
High Temp Strength	Best		Poor
Thermal Expansion	Near Zero	Positive	Negative
Fatigue Resistance	Best		
Impact Strength	Poor		
Environmental Stability	Best	Good	Poor

Knowing the performance requirements of a structure or component, a fiber which is best suited for the application can be selected, based upon its stiffness, strength and other factors listed above.