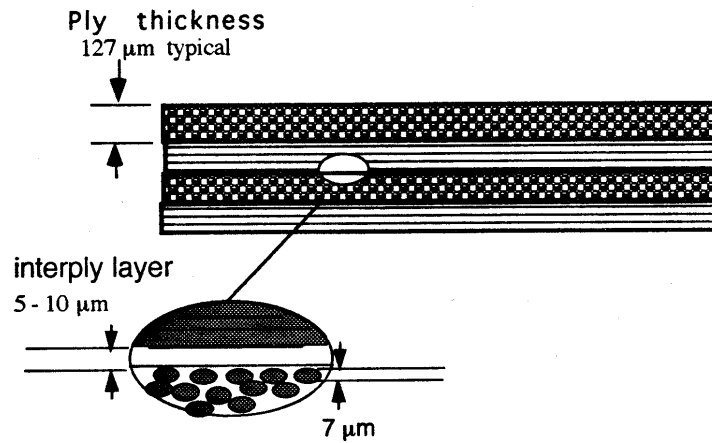


## ADVANCED COMPOSITES HAVE:

- High performance fibers
- > 50 % fiber content by volume
- Controlled fiber orientation
- Matrix binder

## EXAMPLE STRUCTURE:

- 60 % carbon fiber
- 40 % epoxy
- Unidirectional tape
- 0°/90° Layup



## DISTINCTIVE FEATURES OF COMPOSITES

### POSITIVE

High Strength  
High Modulus  
Low Density  
Anisotropy  
Impact Resistance  
Fatigue Resistance  
Corrosion Resistance  
Damping  
Radar Transparency  
Tailorability  
Parts Integration  
Ease of Prototyping  
Portability

### NEGATIVE

High Cost  
Slow Processing  
Flammability  
Smoke  
Toxicity  
Labor Intensive  
Lack of Knowledge  
Temperature Sensitive  
Moisture Sensitive  
NDTE  
Repairability

## REINFORCED PLASTICS SHIPMENTS

	1995 VOLUME*	GROWTH RATE
	(million lbs)	(%/yr, 7yrs)
<b>MARKET</b>		
Land Transportation	984	6.7
Construction	627	3.2
Corrosion Resistant Equipment	395	3.1
Marine	375	-0.8
Electrical/Electronic	315	5.5
Consumer Products	184	1.9
Appliance/Business Equipment	167	1.7
Miscellaneous	106	3.0
Aircraft/Aerospace/Military	24	-7.7

\*Composites Design & Application, 2/96

**TABLE 1.1 Tensile Properties of Some Metallic and Structural Composite Materials**

Material <sup>a</sup>	Specific gravity	Modulus, GPa (Msi)	Tensile strength, MPa (ksi)	Yield strength, MPa (ksi)	Ratio of modulus to weight, <sup>b</sup> 10 <sup>9</sup> m	Ratio of tensile strength to weight, <sup>b</sup> 10 <sup>6</sup> m
SAE 1010 steel (cold-worked)	7.87	207 (30)	365 (53)	303 (44)	2.68	4.72
AISI 4340 steel (quenched and tempered)	7.87	207 (30)	1722 (750)	1515 (220)	2.68	22.3
AL 6061-T6 aluminum alloy	2.70	68.9 (10)	310 (45)	275 (40)	2.60	11.7
AL 7178-T6 aluminum alloy	2.70	68.9 (10)	606 (88)	537 (78)	2.60	22.9
Ti-6Al-4 V titanium alloy (aged)	4.43	110 (16)	1171 (170)	1068 (155)	2.53	26.9
17-7 PH stainless steel (aged)	7.87	196 (28.5)	1619 (235)	1515 (220)	2.54	21.0
INCO 718 nickel alloy (aged)	8.2	207 (30)	1399 (203)	1247 (181)	2.57	17.4
High-strength carbon fiber-epoxy (unidirectional)	1.55	137.8 (20)	1550 (225)	--	9.06	101.9
High-modulus carbon fiber-epoxy (unidirectional)	1.63	215 (31.2)	1240 (180)	--	13.44	77.5
E-glass fiber-epoxy (unidirectional)	1.85	39.3 (5.7)	965 (140)	--	2.16	53.2
Kevlar 49 fiber-epoxy (unidirectional)	1.38	75.8 (11)	1378 (200)	--	5.60	101.8
Boron fiber-6061 A1 alloy (annealed)	2.35	220 (32)	1109 (161)	--	9.54	48.1
Carbon fiber-epoxy (quasi-isotropic)	1.55	45.5 (6.6)	579 (84)	--	2.99	38

<sup>a</sup>For unidirectional composites, the reported modulus and tensile strength values are measured in the direction of fibers.

<sup>b</sup>The modulus-weight ratio and the strength-weight ratios are obtained by dividing the absolute values with the specific weight of the respective material. Specific weight is defined as weight per unit volume. It is obtained by multiplying density by the acceleration due to gravity.

## POLYMER PROPERTIES

<u>PROPERTY</u>	<u>POLYESTER</u>	<u>EPOXY</u>	<u>PEEK</u>	<u>PP</u>	<u>PET</u>
Specific Gravity	1.2	1.2	1.3	0.9	1.3
Tensile Modulus, msi	0.4	0.5	0.5	0.3	0.5
Tensile Strength, ksi	7.0	9.0	11.0	5.0	9.0
Cost, \$/lb	0.55	1.20	23.00	0.35	0.60

## FIBER PROPERTIES

<u>PROPERTY</u>	<u>E GLASS</u>	<u>S GLASS</u>	<u>CARBON(AS 4)</u>
Diameter, microns	10	10	8
Specific Gravity	2.5	2.5	1.8
Tensile Modulus, msi	10.5	12.6	32.0
Tensile Strength, ksi	500	625	450
Cost, \$/lb	0.80	3.00 ?	15.00

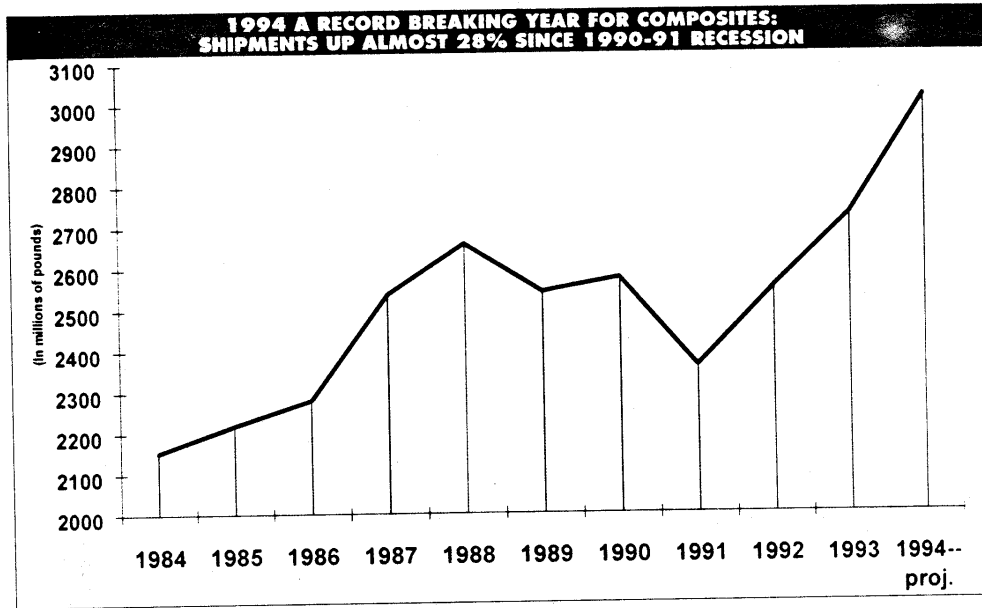
## STEEL AND COMPOSITE PROPERTIES

<u>PROPERTY</u>	<u>STEEL</u>	<u>EP/CF</u>	<u>EP/CF</u>	<u>EP/EG</u>	<u>GMT</u>
Specific Gravity	7.87	1.6	1.6	1.8	1.2
Fiber Content, volume %	0	60	60	60	19
Fiber Orientation	NA	0°	QI*	0°	Random
Tensile Modulus, msi	30	20	6.6	5.7	0.8
Tensile Strength, ksi	53	225	84	140	12

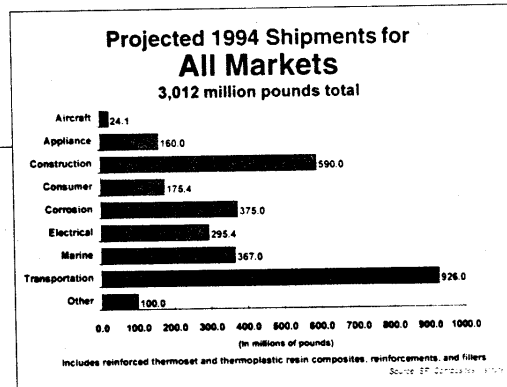
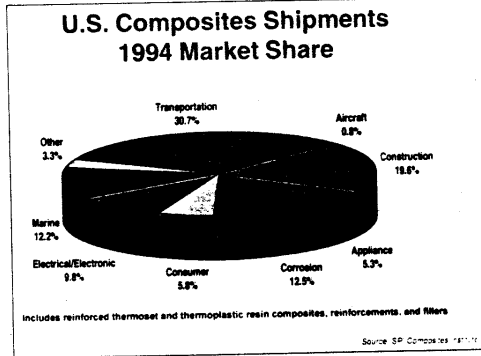
\* Quasi-isotropic: (0°/+45°/90°/-45°)n

# STATISTICS

## BREAKING RECORDS



**Total shipments projected for 1994 are 3 billion pounds, a 10.5% increase over 1993.**



These figures were developed by CI for the recent Composites Institute semiannual statistical report, available at no charge to members of SPI. For a copy, contact CI at 212-351-5410 or via fax at 212-370-1731. Cost to non-members of SPI is \$20 prepaid.