

직조 적층 수의 방향에 따른 엔지니어링 물성 (300개)

○ 시험 개요

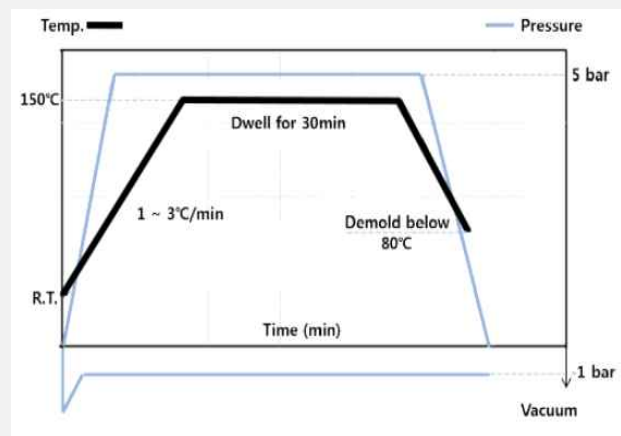
탄소섬유 강화 복합재료에 대한 시뮬레이션 물성 라이브러리를 구축하기 위해, 다양한 복합구조체의 섬유 방향과 적층수와 수지 종류에 따른 재료 물성 차이를 조사하고, 이에 따른 결과를 데이터 베이스(Data Base, DB) 구축하는 것이 목적임.

○ 시험규격 (ASTM D3039, ASTM D695, ASTM D5379)

시험 장비는 20톤 용량의 Shimadzu사 만능재료시험기를 사용하여 재료 물성을 평가하였으며, 하중 변위 속도는 분당 2mm의 변위제어 속도로 최대 하중의 50% 하중 저하가 발생하면 자동으로 종료되도록 설정함.

○ 성형 조건 및 시험 환경

시험환경은 대기온도 25℃, 습도 20%에서 시험.



<성형조건>

○ 시험장비(만능재료시험기)



• 직조 1층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.39E-09
2	E_1	Young's Modulus X	MPa	1.57E+05
3	E_2	Young's Modulus Y	MPa	1.29E+04
4	E_3	Young's Modulus Z	MPa	1.18E+04
5	ν_{12}	Poisson's ratio XY	MPa	4.59E-01
6	ν_{13}	Poisson's ratio YZ	MPa	4.29E-01
7	ν_{23}	Poisson's ratio XZ	MPa	2.94E-01
8	G_{12}	Shear Modulus XY	MPa	3.49E+03
9	G_{13}	Shear Modulus YZ	MPa	3.41E+03
10	G_{23}	Shear Modulus XZ	MPa	3.98E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	2.87E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.45E+03
13	S_{22T}	Transverse Tensile strength	MPa	3.59E+03
14	S_{22C}	Transverse compressive strength	MPa	-3.68E+02
15	S_{33T}	Tensile strength	MPa	3.83E+02
16	S_{33C}	Compressive strength	MPa	-3.08E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.50E+02
18	S_{23S}	Shear strength	MPa	1.28E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	3.33E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.47E+02

• 직조 2층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.89E-09
2	E_1	Young's Modulus X	MPa	1.33E+05
3	E_2	Young's Modulus Y	MPa	1.09E+04
4	E_3	Young's Modulus Z	MPa	1.03E+04
5	ν_{12}	Poisson's ratio XY	MPa	4.86E-01
6	ν_{13}	Poisson's ratio YZ	MPa	4.13E-01
7	ν_{23}	Poisson's ratio XZ	MPa	2.63E-01
8	G_{12}	Shear Modulus XY	MPa	3.04E+03
9	G_{13}	Shear Modulus YZ	MPa	3.69E+03
10	G_{23}	Shear Modulus XZ	MPa	4.42E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.43E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.34E+03
13	S_{22T}	Transverse Tensile strength	MPa	2.90E+03
14	S_{22C}	Transverse compressive strength	MPa	-4.20E+02
15	S_{33T}	Tensile strength	MPa	3.99E+02
16	S_{33C}	Compressive strength	MPa	-3.12E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.33E+02
18	S_{23S}	Shear strength	MPa	1.25E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	3.53E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.24E+02

• 직조 3층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.66E-09
2	E_1	Young's Modulus X	MPa	1.65E+05
3	E_2	Young's Modulus Y	MPa	1.27E+04
4	E_3	Young's Modulus Z	MPa	9.66E+03
5	ν_{12}	Poisson's ratio XY	MPa	5.08E-01
6	ν_{13}	Poisson's ratio YZ	MPa	3.61E-01
7	ν_{23}	Poisson's ratio XZ	MPa	3.25E-01
8	G_{12}	Shear Modulus XY	MPa	3.04E+03
9	G_{13}	Shear Modulus YZ	MPa	3.02E+03
10	G_{23}	Shear Modulus XZ	MPa	4.56E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	2.98E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.64E+03
13	S_{22T}	Transverse Tensile strength	MPa	2.80E+03
14	S_{22C}	Transverse compressive strength	MPa	-4.20E+02
15	S_{33T}	Tensile strength	MPa	3.83E+02
16	S_{33C}	Compressive strength	MPa	-2.70E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.48E+02
18	S_{23S}	Shear strength	MPa	1.38E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	3.29E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.56E+02

• 직조 4층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.37E-09
2	E_1	Young's Modulus X	MPa	1.58E+05
3	E_2	Young's Modulus Y	MPa	1.02E+04
4	E_3	Young's Modulus Z	MPa	1.29E+04
5	ν_{12}	Poisson's ratio XY	MPa	4.48E-01
6	ν_{13}	Poisson's ratio YZ	MPa	3.37E-01
7	ν_{23}	Poisson's ratio XZ	MPa	2.82E-01
8	G_{12}	Shear Modulus XY	MPa	3.52E+03
9	G_{13}	Shear Modulus YZ	MPa	3.55E+03
10	G_{23}	Shear Modulus XZ	MPa	3.75E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.61E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.79E+03
13	S_{22T}	Transverse Tensile strength	MPa	3.23E+03
14	S_{22C}	Transverse compressive strength	MPa	-3.88E+02
15	S_{33T}	Tensile strength	MPa	3.63E+02
16	S_{33C}	Compressive strength	MPa	-2.89E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.64E+02
18	S_{23S}	Shear strength	MPa	1.34E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	4.33E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.65E+02

• 직조 5층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.70E-09
2	E_1	Young's Modulus X	MPa	1.33E+05
3	E_2	Young's Modulus Y	MPa	1.10E+04
4	E_3	Young's Modulus Z	MPa	1.10E+04
5	ν_{12}	Poisson's ratio XY	MPa	4.43E-01
6	ν_{13}	Poisson's ratio YZ	MPa	3.81E-01
7	ν_{23}	Poisson's ratio XZ	MPa	2.85E-01
8	G_{12}	Shear Modulus XY	MPa	3.04E+03
9	G_{13}	Shear Modulus YZ	MPa	2.88E+03
10	G_{23}	Shear Modulus XZ	MPa	4.82E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.64E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.01E+03
13	S_{22T}	Transverse Tensile strength	MPa	3.33E+03
14	S_{22C}	Transverse compressive strength	MPa	-3.80E+02
15	S_{33T}	Tensile strength	MPa	4.39E+02
16	S_{33C}	Compressive strength	MPa	-3.41E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.45E+02
18	S_{23S}	Shear strength	MPa	1.23E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	3.65E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.96E+02

• 직조 6층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.89E-09
2	E_1	Young's Modulus X	MPa	1.66E+05
3	E_2	Young's Modulus Y	MPa	9.93E+03
4	E_3	Young's Modulus Z	MPa	1.03E+04
5	ν_{12}	Poisson's ratio XY	MPa	4.86E-01
6	ν_{13}	Poisson's ratio YZ	MPa	3.85E-01
7	ν_{23}	Poisson's ratio XZ	MPa	3.25E-01
8	G_{12}	Shear Modulus XY	MPa	3.63E+03
9	G_{13}	Shear Modulus YZ	MPa	3.34E+03
10	G_{23}	Shear Modulus XZ	MPa	3.57E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.54E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.30E+03
13	S_{22T}	Transverse Tensile strength	MPa	2.80E+03
14	S_{22C}	Transverse compressive strength	MPa	-3.52E+02
15	S_{33T}	Tensile strength	MPa	3.35E+02
16	S_{33C}	Compressive strength	MPa	-3.21E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.37E+02
18	S_{23S}	Shear strength	MPa	1.46E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	3.41E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	3.79E+02

• 직조 7층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.46E-09
2	E_1	Young's Modulus X	MPa	1.30E+05
3	E_2	Young's Modulus Y	MPa	1.14E+04
4	E_3	Young's Modulus Z	MPa	1.16E+04
5	ν_{12}	Poisson's ratio XY	MPa	4.43E-01
6	ν_{13}	Poisson's ratio YZ	MPa	3.65E-01
7	ν_{23}	Poisson's ratio XZ	MPa	2.72E-01
8	G_{12}	Shear Modulus XY	MPa	3.11E+03
9	G_{13}	Shear Modulus YZ	MPa	2.98E+03
10	G_{23}	Shear Modulus XZ	MPa	4.78E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.57E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.08E+03
13	S_{22T}	Transverse Tensile strength	MPa	3.56E+03
14	S_{22C}	Transverse compressive strength	MPa	-3.52E+02
15	S_{33T}	Tensile strength	MPa	4.35E+02
16	S_{33C}	Compressive strength	MPa	-2.86E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.47E+02
18	S_{23S}	Shear strength	MPa	1.23E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	4.09E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.78E+02

• 직조 8층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.39E-09
2	E_1	Young's Modulus X	MPa	1.33E+05
3	E_2	Young's Modulus Y	MPa	1.03E+04
4	E_3	Young's Modulus Z	MPa	1.01E+04
5	ν_{12}	Poisson's ratio XY	MPa	5.85E-01
6	ν_{13}	Poisson's ratio YZ	MPa	3.89E-01
7	ν_{23}	Poisson's ratio XZ	MPa	3.03E-01
8	G_{12}	Shear Modulus XY	MPa	3.76E+03
9	G_{13}	Shear Modulus YZ	MPa	3.30E+03
10	G_{23}	Shear Modulus XZ	MPa	3.62E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.05E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.08E+03
13	S_{22T}	Transverse Tensile strength	MPa	2.97E+03
14	S_{22C}	Transverse compressive strength	MPa	-4.00E+02
15	S_{33T}	Tensile strength	MPa	3.22E+02
16	S_{33C}	Compressive strength	MPa	-2.99E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.71E+02
18	S_{23S}	Shear strength	MPa	1.40E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	3.21E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.19E+02

• 직조 9층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.73E-09
2	E_1	Young's Modulus X	MPa	1.53E+05
3	E_2	Young's Modulus Y	MPa	1.02E+04
4	E_3	Young's Modulus Z	MPa	1.29E+04
5	ν_{12}	Poisson's ratio XY	MPa	5.36E-01
6	ν_{13}	Poisson's ratio YZ	MPa	3.53E-01
7	ν_{23}	Poisson's ratio XZ	MPa	3.16E-01
8	G_{12}	Shear Modulus XY	MPa	3.21E+03
9	G_{13}	Shear Modulus YZ	MPa	2.88E+03
10	G_{23}	Shear Modulus XZ	MPa	4.74E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	2.98E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.15E+03
13	S_{22T}	Transverse Tensile strength	MPa	3.46E+03
14	S_{22C}	Transverse compressive strength	MPa	-3.92E+02
15	S_{33T}	Tensile strength	MPa	4.19E+02
16	S_{33C}	Compressive strength	MPa	-3.12E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.48E+02
18	S_{23S}	Shear strength	MPa	1.41E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	4.33E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.06E+02

• 직조 10층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.48E-09
2	E_1	Young's Modulus X	MPa	1.46E+05
3	E_2	Young's Modulus Y	MPa	1.07E+04
4	E_3	Young's Modulus Z	MPa	1.09E+04
5	ν_{12}	Poisson's ratio XY	MPa	5.46E-01
6	ν_{13}	Poisson's ratio YZ	MPa	4.01E-01
7	ν_{23}	Poisson's ratio XZ	MPa	2.91E-01
8	G_{12}	Shear Modulus XY	MPa	3.32E+03
9	G_{13}	Shear Modulus YZ	MPa	3.76E+03
10	G_{23}	Shear Modulus XZ	MPa	4.91E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.57E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.01E+03
13	S_{22T}	Transverse Tensile strength	MPa	2.83E+03
14	S_{22C}	Transverse compressive strength	MPa	-3.24E+02
15	S_{33T}	Tensile strength	MPa	3.35E+02
16	S_{33C}	Compressive strength	MPa	-2.86E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.31E+02
18	S_{23S}	Shear strength	MPa	1.21E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	3.61E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	3.79E+02

• 직조 11층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.70E-09
2	E_1	Young's Modulus X	MPa	1.36E+05
3	E_2	Young's Modulus Y	MPa	1.34E+04
4	E_3	Young's Modulus Z	MPa	1.28E+04
5	ν_{12}	Poisson's ratio XY	MPa	5.63E-01
6	ν_{13}	Poisson's ratio YZ	MPa	4.33E-01
7	ν_{23}	Poisson's ratio XZ	MPa	2.79E-01
8	G_{12}	Shear Modulus XY	MPa	2.97E+03
9	G_{13}	Shear Modulus YZ	MPa	3.02E+03
10	G_{23}	Shear Modulus XZ	MPa	4.87E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.29E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.19E+03
13	S_{22T}	Transverse Tensile strength	MPa	2.74E+03
14	S_{22C}	Transverse compressive strength	MPa	-3.84E+02
15	S_{33T}	Tensile strength	MPa	3.99E+02
16	S_{33C}	Compressive strength	MPa	-3.08E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.47E+02
18	S_{23S}	Shear strength	MPa	1.59E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	3.97E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.42E+02

• 직조 12층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.80E-09
2	E_1	Young's Modulus X	MPa	1.65E+05
3	E_2	Young's Modulus Y	MPa	1.31E+04
4	E_3	Young's Modulus Z	MPa	1.09E+04
5	ν_{12}	Poisson's ratio XY	MPa	5.08E-01
6	ν_{13}	Poisson's ratio YZ	MPa	3.69E-01
7	ν_{23}	Poisson's ratio XZ	MPa	2.60E-01
8	G_{12}	Shear Modulus XY	MPa	3.38E+03
9	G_{13}	Shear Modulus YZ	MPa	3.59E+03
10	G_{23}	Shear Modulus XZ	MPa	4.33E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.22E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.56E+03
13	S_{22T}	Transverse Tensile strength	MPa	3.59E+03
14	S_{22C}	Transverse compressive strength	MPa	-4.00E+02
15	S_{33T}	Tensile strength	MPa	3.26E+02
16	S_{33C}	Compressive strength	MPa	-3.12E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.72E+02
18	S_{23S}	Shear strength	MPa	1.23E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	3.93E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.42E+02

• 직조 13층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.78E-09
2	E_1	Young's Modulus X	MPa	1.42E+05
3	E_2	Young's Modulus Y	MPa	1.18E+04
4	E_3	Young's Modulus Z	MPa	1.21E+04
5	ν_{12}	Poisson's ratio XY	MPa	4.97E-01
6	ν_{13}	Poisson's ratio YZ	MPa	4.13E-01
7	ν_{23}	Poisson's ratio XZ	MPa	3.19E-01
8	G_{12}	Shear Modulus XY	MPa	2.80E+03
9	G_{13}	Shear Modulus YZ	MPa	3.23E+03
10	G_{23}	Shear Modulus XZ	MPa	4.47E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.78E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.19E+03
13	S_{22T}	Transverse Tensile strength	MPa	3.46E+03
14	S_{22C}	Transverse compressive strength	MPa	-4.00E+02
15	S_{33T}	Tensile strength	MPa	4.35E+02
16	S_{33C}	Compressive strength	MPa	-3.47E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.53E+02
18	S_{23S}	Shear strength	MPa	1.31E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	3.57E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	3.79E+02

• 직조 14층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.72E-09
2	E_1	Young's Modulus X	MPa	1.69E+05
3	E_2	Young's Modulus Y	MPa	1.27E+04
4	E_3	Young's Modulus Z	MPa	1.32E+04
5	ν_{12}	Poisson's ratio XY	MPa	5.19E-01
6	ν_{13}	Poisson's ratio YZ	MPa	4.01E-01
7	ν_{23}	Poisson's ratio XZ	MPa	3.25E-01
8	G_{12}	Shear Modulus XY	MPa	3.49E+03
9	G_{13}	Shear Modulus YZ	MPa	3.23E+03
10	G_{23}	Shear Modulus XZ	MPa	3.71E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.78E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.15E+03
13	S_{22T}	Transverse Tensile strength	MPa	2.87E+03
14	S_{22C}	Transverse compressive strength	MPa	-3.40E+02
15	S_{33T}	Tensile strength	MPa	4.35E+02
16	S_{33C}	Compressive strength	MPa	-2.89E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.74E+02
18	S_{23S}	Shear strength	MPa	1.53E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	4.25E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.83E+02

- 직조 15층의 방향에 따른 엔지니어링 물성

No.	Symbol	Properties	Unit	Value
1	ρ	Density	g/mm^3	1.75E-09
2	E_1	Young's Modulus X	MPa	1.49E+05
3	E_2	Young's Modulus Y	MPa	1.04E+04
4	E_3	Young's Modulus Z	MPa	1.06E+04
5	ν_{12}	Poisson's ratio XY	MPa	4.75E-01
6	ν_{13}	Poisson's ratio YZ	MPa	3.45E-01
7	ν_{23}	Poisson's ratio XZ	MPa	3.41E-01
8	G_{12}	Shear Modulus XY	MPa	3.66E+03
9	G_{13}	Shear Modulus YZ	MPa	3.55E+03
10	G_{23}	Shear Modulus XZ	MPa	3.62E+03
11	S_{11T}	Longitudinal Tensile strength	MPa	3.43E+03
12	S_{11C}	Longitudinal Compressive strength	MPa	-3.45E+03
13	S_{22T}	Transverse Tensile strength	MPa	2.83E+03
14	S_{22C}	Transverse compressive strength	MPa	-4.28E+02
15	S_{33T}	Tensile strength	MPa	3.51E+02
16	S_{33C}	Compressive strength	MPa	-3.37E+02
17	S_{12S}	Out-of-plane shear strength	MPa	1.37E+02
18	S_{23S}	Shear strength	MPa	1.40E+02
19	k	Thermal conductivity	$\text{W/m} \cdot \text{K}$	3.73E+02
20	C_p	Specific heat	$\text{kJ/kg} \cdot \text{K}$	4.24E+02