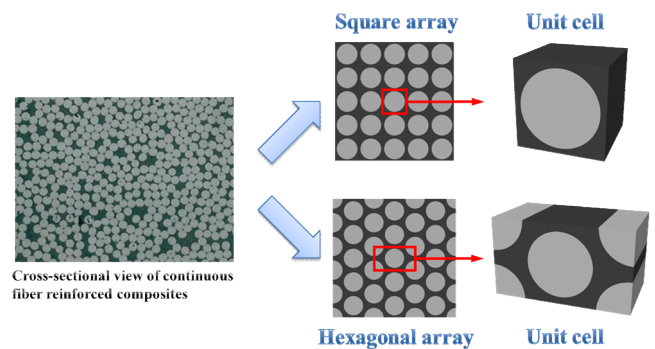


## Theory

**Representative elementary volume (RVE)** is the smallest volume over which a measurement can be made that will yield a value representative of the whole. In the case of periodic materials, one simply chooses a periodic unit cell (which, however, may be non-unique), but in random media, the situation is much more complicated.



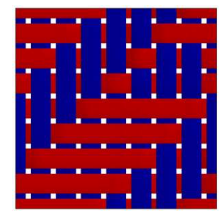
## Material properties

### □ Weave

|                |             |
|----------------|-------------|
| Brand          | SK Chemical |
| Pattern        | Woven       |
| Fiber material | Carbon      |
| Lay up type    | Multi layer |

### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | GPa               | 101   |
| Poisson's ratio | -                 | 0.27  |
| Density         | g/mm <sup>3</sup> | 1.79  |



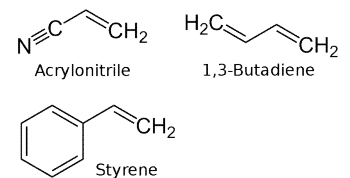
### □ Resin

|      |    |
|------|----|
| Type | PA |
|------|----|



### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | MPa               | 594   |
| Poisson's ratio | -                 | 0.28  |
| Density         | g/mm <sup>3</sup> | 1.66  |

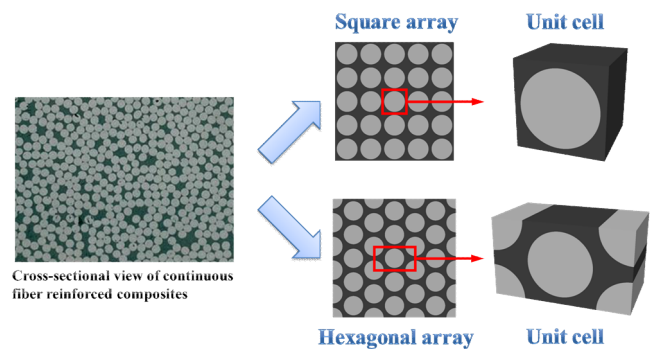


## Property according to direction(XYZ)

| No. | Symbol     | Properties                        | Unit              | Value     | Notes                      |
|-----|------------|-----------------------------------|-------------------|-----------|----------------------------|
| 1   | $\rho$     | Density                           | g/mm <sup>3</sup> | 1.730E-09 | -                          |
| 2   | $E_1$      | Young's Modulus X                 | MPa               | 162226.9  | Longitudinal modulus       |
| 3   | $E_2$      | Young's Modulus Y                 | MPa               | 12163.984 | Transverse Modulus         |
| 4   | $E_3$      | Young's Modulus Z                 | MPa               | 12254.76  | -                          |
| 5   | $\nu_{12}$ | Poisson's ratio XY                | MPa               | 0.4285335 | -                          |
| 6   | $\nu_{13}$ | Poisson's ratio YZ                | MPa               | 0.495369  | -                          |
| 7   | $\nu_{23}$ | Poisson's ratio XZ                | MPa               | 0.350697  | -                          |
| 8   | $G_{12}$   | Shear Modulus XY                  | MPa               | 4821.692  | In-plane shear modulus     |
| 9   | $G_{13}$   | Shear Modulus YZ                  | MPa               | 4365.586  | Out-of-plane shear modulus |
| 10  | $G_{23}$   | Shear Modulus XZ                  | MPa               | 4618.798  | Out-of-plane shear modulus |
| 11  | $S_{11T}$  | Longitudinal Tensile strength     | MPa               | 3991.482  | Strain: 0.03%              |
| 12  | $S_{11C}$  | Longitudinal Compressive strength | MPa               | -5111.898 | Strain: 0.03%              |
| 13  | $S_{22T}$  | Transverse Tensile strength       | MPa               | 3213.494  | Strain: 0.03%              |
| 14  | $S_{22C}$  | Transverse compressive strength   | MPa               | -275.0533 | Strain: 0.03%              |
| 15  | $S_{33T}$  | Tensile strength                  | MPa               | 296.8397  | Strain: 0.03%              |
| 16  | $S_{33C}$  | Compressive strength              | MPa               | -340.4125 | Strain: 0.03%              |
| 17  | $S_{12S}$  | Out-of-plane shear strength       | MPa               | 136.296   | -                          |
| 18  | $S_{23S}$  | Shear strength                    | MPa               | 154.4688  | -                          |
| 19  | k          | Thermal conductivity              | W/m-K             | 455.131   |                            |
| 20  | $C_p$      | Specific heat                     | kJ/kg-K           | 420.195   |                            |

## Theory

**Representative elementary volume (RVE)** is the smallest volume over which a measurement can be made that will yield a value representative of the whole. In the case of periodic materials, one simply chooses a periodic unit cell (which, however, may be non-unique), but in random media, the situation is much more complicated.



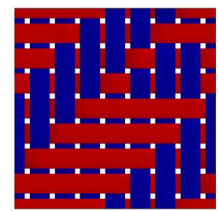
## Material properties

### □ Weave

|                |             |
|----------------|-------------|
| Brand          | SK Chemical |
| Pattern        | Woven       |
| Fiber material | Carbon      |
| Lay up type    | Multi layer |

### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | GPa               | 128   |
| Poisson's ratio | -                 | 0.29  |
| Density         | g/mm <sup>3</sup> | 1.75  |



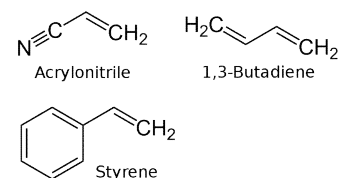
### □ Resin

|      |    |
|------|----|
| Type | PA |
|------|----|



### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | MPa               | 550   |
| Poisson's ratio | -                 | 0.27  |
| Density         | g/mm <sup>3</sup> | 1.75  |

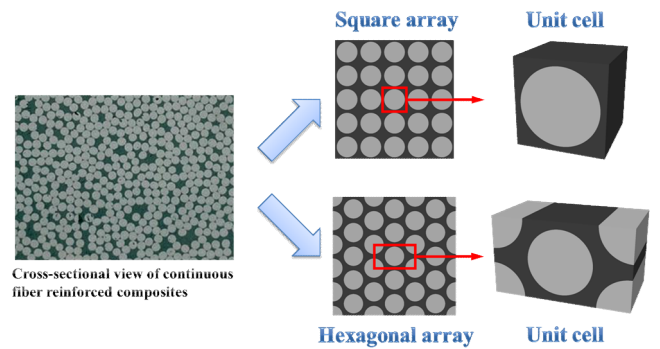


## Property according to direction(XYZ)

| No. | Symbol     | Properties                        | Unit              | Value     | Notes                      |
|-----|------------|-----------------------------------|-------------------|-----------|----------------------------|
| 1   | $\rho$     | Density                           | g/mm <sup>3</sup> | 1.844E-09 | -                          |
| 2   | $E_1$      | Young's Modulus X                 | MPa               | 162226.9  | Longitudinal modulus       |
| 3   | $E_2$      | Young's Modulus Y                 | MPa               | 10530.016 | Transverse Modulus         |
| 4   | $E_3$      | Young's Modulus Z                 | MPa               | 13434.848 | -                          |
| 5   | $\nu_{12}$ | Poisson's ratio XY                | MPa               | 0.3970815 | -                          |
| 6   | $\nu_{13}$ | Poisson's ratio YZ                | MPa               | 0.5228895 | -                          |
| 7   | $\nu_{23}$ | Poisson's ratio XZ                | MPa               | 0.3555342 | -                          |
| 8   | $G_{12}$   | Shear Modulus XY                  | MPa               | 4593.639  | In-plane shear modulus     |
| 9   | $G_{13}$   | Shear Modulus YZ                  | MPa               | 4430.744  | Out-of-plane shear modulus |
| 10  | $G_{23}$   | Shear Modulus XZ                  | MPa               | 3785.9    | Out-of-plane shear modulus |
| 11  | $S_{11T}$  | Longitudinal Tensile strength     | MPa               | 4236.573  | Strain: 0.03%              |
| 12  | $S_{11C}$  | Longitudinal Compressive strength | MPa               | -4726.755 | Strain: 0.03%              |
| 13  | $S_{22T}$  | Transverse Tensile strength       | MPa               | 3649.222  | Strain: 0.03%              |
| 14  | $S_{22C}$  | Transverse compressive strength   | MPa               | -405.7717 | Strain: 0.03%              |
| 15  | $S_{33T}$  | Tensile strength                  | MPa               | 334.9659  | Strain: 0.03%              |
| 16  | $S_{33C}$  | Compressive strength              | MPa               | -321.3494 | Strain: 0.03%              |
| 17  | $S_{12S}$  | Out-of-plane shear strength       | MPa               | 148.7898  | -                          |
| 18  | $S_{23S}$  | Shear strength                    | MPa               | 157.8762  | -                          |
| 19  | k          | Thermal conductivity              | W/m-K             | 441.545   |                            |
| 20  | $C_p$      | Specific heat                     | kJ/kg-K           | 435.615   |                            |

## Theory

**Representative elementary volume (RVE)** is the smallest volume over which a measurement can be made that will yield a value representative of the whole. In the case of periodic materials, one simply chooses a periodic unit cell (which, however, may be non-unique), but in random media, the situation is much more complicated.



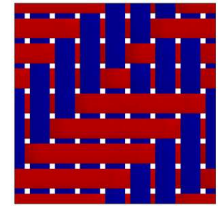
## Material properties

### □ Weave

|                |             |
|----------------|-------------|
| Brand          | SK Chemical |
| Pattern        | Woven       |
| Fiber material | Carbon      |
| Lay up type    | Multi layer |

### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | GPa               | 113   |
| Poisson's ratio | -                 | 0.29  |
| Density         | g/mm <sup>3</sup> | 1.51  |



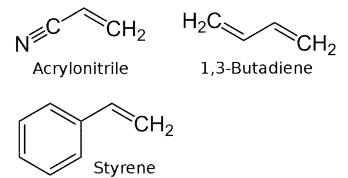
### □ Resin

|      |    |
|------|----|
| Type | PA |
|------|----|



### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | MPa               | 571   |
| Poisson's ratio | -                 | 0.3   |
| Density         | g/mm <sup>3</sup> | 1.65  |

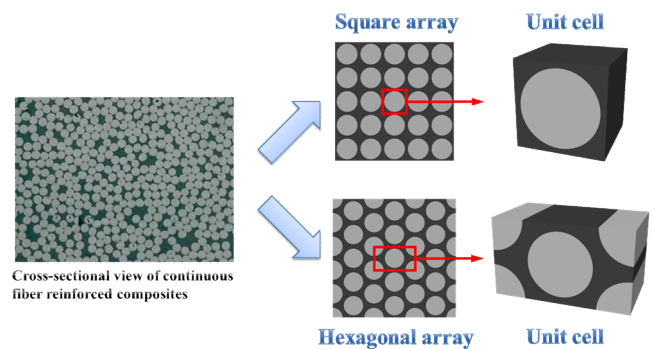


## Property according to direction(XYZ)

| No. | Symbol     | Properties                        | Unit              | Value     | Notes                      |
|-----|------------|-----------------------------------|-------------------|-----------|----------------------------|
| 1   | $\rho$     | Density                           | g/mm <sup>3</sup> | 2.087E-09 | -                          |
| 2   | $E_1$      | Young's Modulus X                 | MPa               | 169229.5  | Longitudinal modulus       |
| 3   | $E_2$      | Young's Modulus Y                 | MPa               | 10257.688 | Transverse Modulus         |
| 4   | $E_3$      | Young's Modulus Z                 | MPa               | 11800.88  | -                          |
| 5   | $\nu_{12}$ | Poisson's ratio XY                | MPa               | 0.4757115 | -                          |
| 6   | $\nu_{13}$ | Poisson's ratio YZ                | MPa               | 0.424602  | -                          |
| 7   | $\nu_{23}$ | Poisson's ratio XZ                | MPa               | 0.253953  | -                          |
| 8   | $G_{12}$   | Shear Modulus XY                  | MPa               | 4886.85   | In-plane shear modulus     |
| 9   | $G_{13}$   | Shear Modulus YZ                  | MPa               | 4398.165  | Out-of-plane shear modulus |
| 10  | $G_{23}$   | Shear Modulus XZ                  | MPa               | 4770.234  | Out-of-plane shear modulus |
| 11  | $S_{11T}$  | Longitudinal Tensile strength     | MPa               | 4306.599  | Strain: 0.03%              |
| 12  | $S_{11C}$  | Longitudinal Compressive strength | MPa               | -3816.417 | Strain: 0.03%              |
| 13  | $S_{22T}$  | Transverse Tensile strength       | MPa               | 2968.397  | Strain: 0.03%              |
| 14  | $S_{22C}$  | Transverse compressive strength   | MPa               | -302.2863 | Strain: 0.03%              |
| 15  | $S_{33T}$  | Tensile strength                  | MPa               | 291.3931  | Strain: 0.03%              |
| 16  | $S_{33C}$  | Compressive strength              | MPa               | -321.3494 | Strain: 0.03%              |
| 17  | $S_{12S}$  | Out-of-plane shear strength       | MPa               | 162.4194  | -                          |
| 18  | $S_{23S}$  | Shear strength                    | MPa               | 139.7034  | -                          |
| 19  | k          | Thermal conductivity              | W/m-K             | 441.545   |                            |
| 20  | $C_p$      | Specific heat                     | kJ/kg-K           | 393.21    |                            |

## Theory

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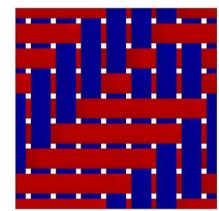
## Material properties

### □ Weave

|                |             |
|----------------|-------------|
| Brand          | SK Chemical |
| Pattern        | Woven       |
| Fiber material | Carbon      |
| Lay up type    | Multi layer |

### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | GPa               | 119   |
| Poisson's ratio | -                 | 0.25  |
| Density         | g/mm <sup>3</sup> | 1.71  |



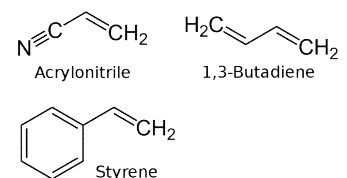
### □ Resin

|      |    |
|------|----|
| Type | PA |
|------|----|



### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | MPa               | 560   |
| Poisson's ratio | -                 | 0.27  |
| Density         | g/mm <sup>3</sup> | 1.87  |

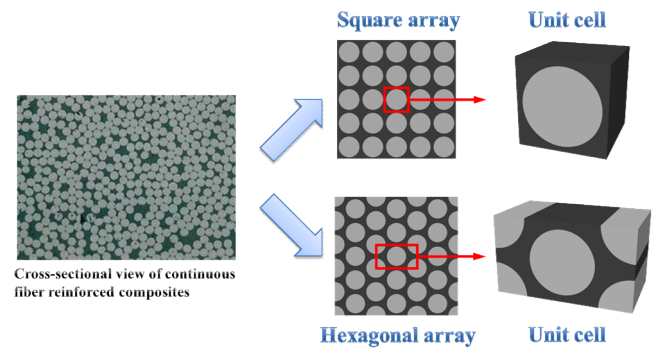


## Property according to direction(XYZ)

| No. | Symbol     | Properties                        | Unit              | Value     | Notes                      |
|-----|------------|-----------------------------------|-------------------|-----------|----------------------------|
| 1   | $\rho$     | Density                           | g/mm <sup>3</sup> | 1.558E-09 | -                          |
| 2   | $E_1$      | Young's Modulus X                 | MPa               | 161059.8  | Longitudinal modulus       |
| 3   | $E_2$      | Young's Modulus Y                 | MPa               | 10076.136 | Transverse Modulus         |
| 4   | $E_3$      | Young's Modulus Z                 | MPa               | 12436.312 | -                          |
| 5   | $\nu_{12}$ | Poisson's ratio XY                | MPa               | 0.456054  | -                          |
| 6   | $\nu_{13}$ | Poisson's ratio YZ                | MPa               | 0.5543415 | -                          |
| 7   | $\nu_{23}$ | Poisson's ratio XZ                | MPa               | 0.2829762 | -                          |
| 8   | $G_{12}$   | Shear Modulus XY                  | MPa               | 3485.953  | In-plane shear modulus     |
| 9   | $G_{13}$   | Shear Modulus YZ                  | MPa               | 4007.217  | Out-of-plane shear modulus |
| 10  | $G_{23}$   | Shear Modulus XZ                  | MPa               | 3975.195  | Out-of-plane shear modulus |
| 11  | $S_{11T}$  | Longitudinal Tensile strength     | MPa               | 4866.807  | Strain: 0.03%              |
| 12  | $S_{11C}$  | Longitudinal Compressive strength | MPa               | -4411.638 | Strain: 0.03%              |
| 13  | $S_{22T}$  | Transverse Tensile strength       | MPa               | 3730.921  | Strain: 0.03%              |
| 14  | $S_{22C}$  | Transverse compressive strength   | MPa               | -291.3931 | Strain: 0.03%              |
| 15  | $S_{33T}$  | Tensile strength                  | MPa               | 315.9028  | Strain: 0.03%              |
| 16  | $S_{33C}$  | Compressive strength              | MPa               | -307.7329 | Strain: 0.03%              |
| 17  | $S_{12S}$  | Out-of-plane shear strength       | MPa               | 127.2096  | -                          |
| 18  | $S_{23S}$  | Shear strength                    | MPa               | 166.9626  | -                          |
| 19  | k          | Thermal conductivity              | W/m-K             | 363.4255  |                            |
| 20  | $C_p$      | Specific heat                     | kJ/kg-K           | 424.05    |                            |

## Theory

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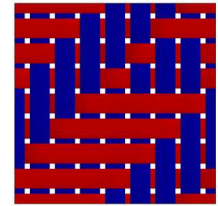
## Material properties

### □ Weave

|                |             |
|----------------|-------------|
| Brand          | SK Chemical |
| Pattern        | Woven       |
| Fiber material | Carbon      |
| Lay up type    | Multi layer |

### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | GPa               | 125   |
| Poisson's ratio | -                 | 0.3   |
| Density         | g/mm <sup>3</sup> | 1.62  |



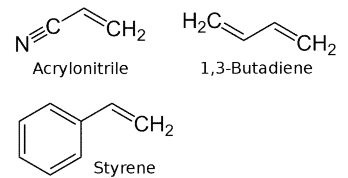
### □ Resin

|      |    |
|------|----|
| Type | PA |
|------|----|



### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | MPa               | 418   |
| Poisson's ratio | -                 | 0.29  |
| Density         | g/mm <sup>3</sup> | 1.82  |

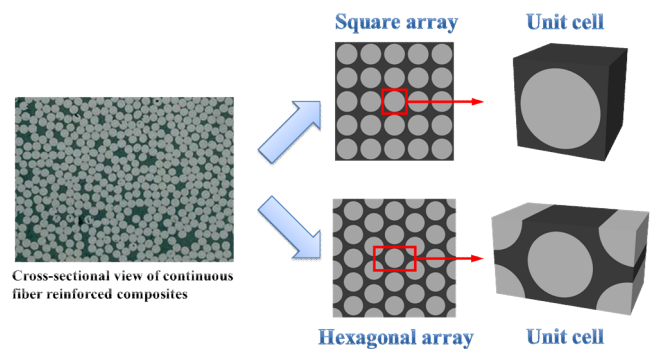


## Property according to direction(XYZ)

| No. | Symbol     | Properties                        | Unit              | Value     | Notes                      |
|-----|------------|-----------------------------------|-------------------|-----------|----------------------------|
| 1   | $\rho$     | Density                           | g/mm <sup>3</sup> | 1.630E-09 | -                          |
| 2   | $E_1$      | Young's Modulus X                 | MPa               | 155224.3  | Longitudinal modulus       |
| 3   | $E_2$      | Young's Modulus Y                 | MPa               | 10983.896 | Transverse Modulus         |
| 4   | $E_3$      | Young's Modulus Z                 | MPa               | 12799.416 | -                          |
| 5   | $\nu_{12}$ | Poisson's ratio XY                | MPa               | 0.4993005 | -                          |
| 6   | $\nu_{13}$ | Poisson's ratio YZ                | MPa               | 0.448191  | -                          |
| 7   | $\nu_{23}$ | Poisson's ratio XZ                | MPa               | 0.3531156 | -                          |
| 8   | $G_{12}$   | Shear Modulus XY                  | MPa               | 4170.112  | In-plane shear modulus     |
| 9   | $G_{13}$   | Shear Modulus YZ                  | MPa               | 4821.692  | Out-of-plane shear modulus |
| 10  | $G_{23}$   | Shear Modulus XZ                  | MPa               | 5224.542  | Out-of-plane shear modulus |
| 11  | $S_{11T}$  | Longitudinal Tensile strength     | MPa               | 5181.924  | Strain: 0.03%              |
| 12  | $S_{11C}$  | Longitudinal Compressive strength | MPa               | -4516.677 | Strain: 0.03%              |
| 13  | $S_{22T}$  | Transverse Tensile strength       | MPa               | 3458.591  | Strain: 0.03%              |
| 14  | $S_{22C}$  | Transverse compressive strength   | MPa               | -337.6892 | Strain: 0.03%              |
| 15  | $S_{33T}$  | Tensile strength                  | MPa               | 321.3494  | Strain: 0.03%              |
| 16  | $S_{33C}$  | Compressive strength              | MPa               | -310.4562 | Strain: 0.03%              |
| 17  | $S_{12S}$  | Out-of-plane shear strength       | MPa               | 114.7158  | -                          |
| 18  | $S_{23S}$  | Shear strength                    | MPa               | 129.4812  | -                          |
| 19  | k          | Thermal conductivity              | W/m-K             | 478.9065  |                            |
| 20  | $C_p$      | Specific heat                     | kJ/kg-K           | 497.295   |                            |

## Theory

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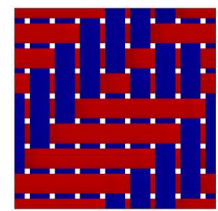
## Material properties

### □ Weave

|                |             |
|----------------|-------------|
| Brand          | SK Chemical |
| Pattern        | Woven       |
| Fiber material | Carbon      |
| Lay up type    | Multi layer |

### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | GPa               | 117   |
| Poisson's ratio | -                 | 0.28  |
| Density         | g/mm <sup>3</sup> | 1.8   |



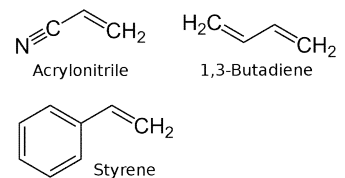
### □ Resin

|      |    |
|------|----|
| Type | PA |
|------|----|



### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | MPa               | 374   |
| Poisson's ratio | -                 | 0.29  |
| Density         | g/mm <sup>3</sup> | 1.88  |

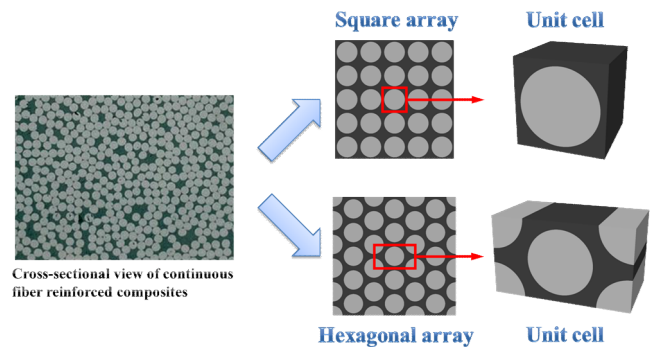


## Property according to direction(XYZ)

| No. | Symbol     | Properties                        | Unit              | Value     | Notes                      |
|-----|------------|-----------------------------------|-------------------|-----------|----------------------------|
| 1   | $\rho$     | Density                           | g/mm <sup>3</sup> | 2.087E-09 | -                          |
| 2   | $E_1$      | Young's Modulus X                 | MPa               | 120211.3  | Longitudinal modulus       |
| 3   | $E_2$      | Young's Modulus Y                 | MPa               | 13253.296 | Transverse Modulus         |
| 4   | $E_3$      | Young's Modulus Z                 | MPa               | 12617.864 | -                          |
| 5   | $\nu_{12}$ | Poisson's ratio XY                | MPa               | 0.5543415 | -                          |
| 6   | $\nu_{13}$ | Poisson's ratio YZ                | MPa               | 0.581862  | -                          |
| 7   | $\nu_{23}$ | Poisson's ratio XZ                | MPa               | 0.3434412 | -                          |
| 8   | $G_{12}$   | Shear Modulus XY                  | MPa               | 4854.271  | In-plane shear modulus     |
| 9   | $G_{13}$   | Shear Modulus YZ                  | MPa               | 3746.585  | Out-of-plane shear modulus |
| 10  | $G_{23}$   | Shear Modulus XZ                  | MPa               | 4694.516  | Out-of-plane shear modulus |
| 11  | $S_{11T}$  | Longitudinal Tensile strength     | MPa               | 4866.807  | Strain: 0.03%              |
| 12  | $S_{11C}$  | Longitudinal Compressive strength | MPa               | -4341.612 | Strain: 0.03%              |
| 13  | $S_{22T}$  | Transverse Tensile strength       | MPa               | 3295.193  | Strain: 0.03%              |
| 14  | $S_{22C}$  | Transverse compressive strength   | MPa               | -370.3688 | Strain: 0.03%              |
| 15  | $S_{33T}$  | Tensile strength                  | MPa               | 302.2863  | Strain: 0.03%              |
| 16  | $S_{33C}$  | Compressive strength              | MPa               | -332.2426 | Strain: 0.03%              |
| 17  | $S_{12S}$  | Out-of-plane shear strength       | MPa               | 165.8268  | -                          |
| 18  | $S_{23S}$  | Shear strength                    | MPa               | 128.3454  | -                          |
| 19  | k          | Thermal conductivity              | W/m-K             | 353.236   |                            |
| 20  | $C_p$      | Specific heat                     | kJ/kg-K           | 497.295   |                            |

## Theory

**Representative elementary volume (RVE)** is the smallest volume over which a measurement can be made that will yield a value representative of the whole. In the case of periodic materials, one simply chooses a periodic unit cell (which, however, may be non-unique), but in random media, the situation is much more complicated.



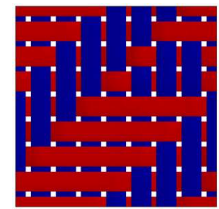
## Material properties

### □ Weave

|                |             |
|----------------|-------------|
| Brand          | SK Chemical |
| Pattern        | Woven       |
| Fiber material | Carbon      |
| Lay up type    | Multi layer |

### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | GPa               | 110   |
| Poisson's ratio | -                 | 0.27  |
| Density         | g/mm <sup>3</sup> | 1.78  |



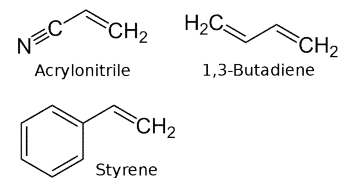
### □ Resin

|      |    |
|------|----|
| Type | PA |
|------|----|



### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | MPa               | 567   |
| Poisson's ratio | -                 | 0.28  |
| Density         | g/mm <sup>3</sup> | 1.82  |

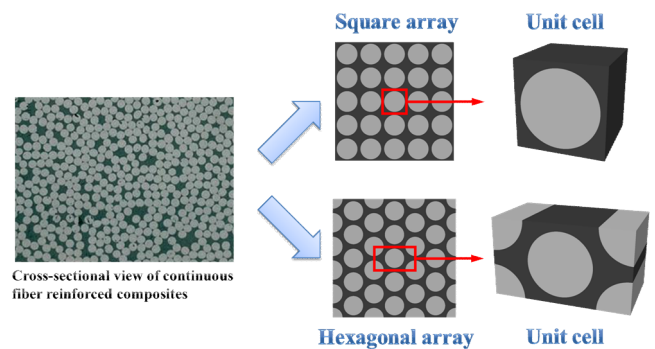


## Property according to direction(XYZ)

| No. | Symbol     | Properties                        | Unit              | Value     | Notes                      |
|-----|------------|-----------------------------------|-------------------|-----------|----------------------------|
| 1   | $\rho$     | Density                           | g/mm <sup>3</sup> | 2.116E-09 | -                          |
| 2   | $E_1$      | Young's Modulus X                 | MPa               | 158725.6  | Longitudinal modulus       |
| 3   | $E_2$      | Young's Modulus Y                 | MPa               | 10530.016 | Transverse Modulus         |
| 4   | $E_3$      | Young's Modulus Z                 | MPa               | 10166.912 | -                          |
| 5   | $\nu_{12}$ | Poisson's ratio XY                | MPa               | 0.463917  | -                          |
| 6   | $\nu_{13}$ | Poisson's ratio YZ                | MPa               | 0.4914375 | -                          |
| 7   | $\nu_{23}$ | Poisson's ratio XZ                | MPa               | 0.2515344 | -                          |
| 8   | $G_{12}$   | Shear Modulus XY                  | MPa               | 4170.112  | In-plane shear modulus     |
| 9   | $G_{13}$   | Shear Modulus YZ                  | MPa               | 4658.797  | Out-of-plane shear modulus |
| 10  | $G_{23}$   | Shear Modulus XZ                  | MPa               | 5224.542  | Out-of-plane shear modulus |
| 11  | $S_{11T}$  | Longitudinal Tensile strength     | MPa               | 4551.69   | Strain: 0.03%              |
| 12  | $S_{11C}$  | Longitudinal Compressive strength | MPa               | -4096.521 | Strain: 0.03%              |
| 13  | $S_{22T}$  | Transverse Tensile strength       | MPa               | 3921.552  | Strain: 0.03%              |
| 14  | $S_{22C}$  | Transverse compressive strength   | MPa               | -334.9659 | Strain: 0.03%              |
| 15  | $S_{33T}$  | Tensile strength                  | MPa               | 305.0096  | Strain: 0.03%              |
| 16  | $S_{33C}$  | Compressive strength              | MPa               | -340.4125 | Strain: 0.03%              |
| 17  | $S_{12S}$  | Out-of-plane shear strength       | MPa               | 124.938   | -                          |
| 18  | $S_{23S}$  | Shear strength                    | MPa               | 163.5552  | -                          |
| 19  | k          | Thermal conductivity              | W/m-K             | 414.373   |                            |
| 20  | $C_p$      | Specific heat                     | kJ/kg-K           | 566.685   |                            |

## Theory

**Representative elementary volume (RVE)** is the smallest volume over which a measurement can be made that will yield a value representative of the whole. In the case of periodic materials, one simply chooses a periodic unit cell (which, however, may be non-unique), but in random media, the situation is much more complicated.



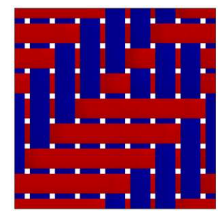
## Material properties

### □ Weave

|                |             |
|----------------|-------------|
| Brand          | SK Chemical |
| Pattern        | Woven       |
| Fiber material | Carbon      |
| Lay up type    | Multi layer |

### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | GPa               | 107   |
| Poisson's ratio | -                 | 0.28  |
| Density         | g/mm <sup>3</sup> | 1.82  |



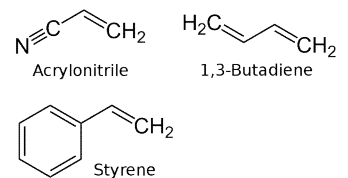
### □ Resin

|      |    |
|------|----|
| Type | PA |
|------|----|



### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | MPa               | 453   |
| Poisson's ratio | -                 | 0.28  |
| Density         | g/mm <sup>3</sup> | 1.68  |

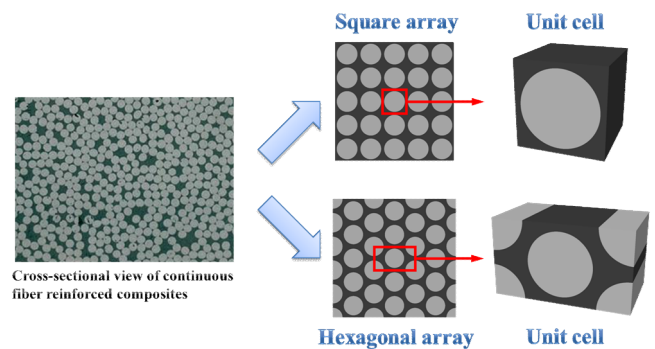


## Property according to direction(XYZ)

| No. | Symbol     | Properties                        | Unit              | Value     | Notes                      |
|-----|------------|-----------------------------------|-------------------|-----------|----------------------------|
| 1   | $\rho$     | Density                           | g/mm <sup>3</sup> | 2.002E-09 | -                          |
| 2   | $E_1$      | Young's Modulus X                 | MPa               | 156391.4  | Longitudinal modulus       |
| 3   | $E_2$      | Young's Modulus Y                 | MPa               | 12345.536 | Transverse Modulus         |
| 4   | $E_3$      | Young's Modulus Z                 | MPa               | 11074.672 | -                          |
| 5   | $\nu_{12}$ | Poisson's ratio XY                | MPa               | 0.456054  | -                          |
| 6   | $\nu_{13}$ | Poisson's ratio YZ                | MPa               | 0.4363965 | -                          |
| 7   | $\nu_{23}$ | Poisson's ratio XZ                | MPa               | 0.302325  | -                          |
| 8   | $G_{12}$   | Shear Modulus XY                  | MPa               | 3420.795  | In-plane shear modulus     |
| 9   | $G_{13}$   | Shear Modulus YZ                  | MPa               | 3779.164  | Out-of-plane shear modulus |
| 10  | $G_{23}$   | Shear Modulus XZ                  | MPa               | 3899.477  | Out-of-plane shear modulus |
| 11  | $S_{11T}$  | Longitudinal Tensile strength     | MPa               | 4446.651  | Strain: 0.03%              |
| 12  | $S_{11C}$  | Longitudinal Compressive strength | MPa               | -4446.651 | Strain: 0.03%              |
| 13  | $S_{22T}$  | Transverse Tensile strength       | MPa               | 2995.63   | Strain: 0.03%              |
| 14  | $S_{22C}$  | Transverse compressive strength   | MPa               | -315.9028 | Strain: 0.03%              |
| 15  | $S_{33T}$  | Tensile strength                  | MPa               | 392.1552  | Strain: 0.03%              |
| 16  | $S_{33C}$  | Compressive strength              | MPa               | -326.796  | Strain: 0.03%              |
| 17  | $S_{12S}$  | Out-of-plane shear strength       | MPa               | 168.0984  | -                          |
| 18  | $S_{23S}$  | Shear strength                    | MPa               | 129.4812  | -                          |
| 19  | k          | Thermal conductivity              | W/m-K             | 475.51    |                            |
| 20  | $C_p$      | Specific heat                     | kJ/kg-K           | 524.28    |                            |

## Theory

**Representative elementary volume (RVE)** is the smallest volume over which a measurement can be made that will yield a value representative of the whole. In the case of periodic materials, one simply chooses a periodic unit cell (which, however, may be non-unique), but in random media, the situation is much more complicated.



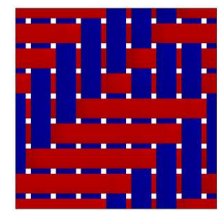
## Material properties

### □ Weave

|                |             |
|----------------|-------------|
| Brand          | SK Chemical |
| Pattern        | Woven       |
| Fiber material | Carbon      |
| Lay up type    | Multi layer |

### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | GPa               | 127   |
| Poisson's ratio | -                 | 0.28  |
| Density         | g/mm <sup>3</sup> | 1.82  |



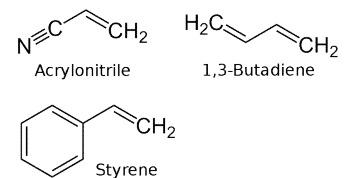
### □ Resin

|      |    |
|------|----|
| Type | PA |
|------|----|



### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | MPa               | 522   |
| Poisson's ratio | -                 | 0.26  |
| Density         | g/mm <sup>3</sup> | 1.66  |

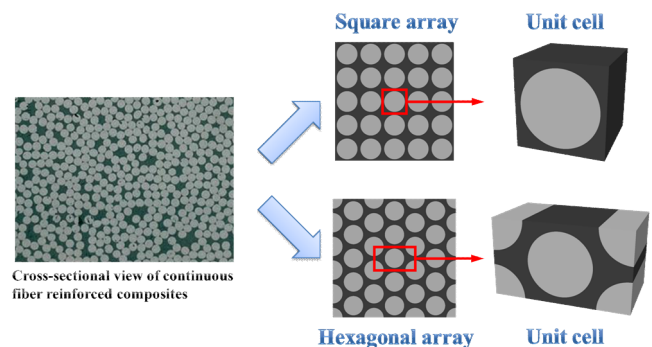


## Property according to direction(XYZ)

| No. | Symbol     | Properties                        | Unit              | Value     | Notes                      |
|-----|------------|-----------------------------------|-------------------|-----------|----------------------------|
| 1   | $\rho$     | Density                           | g/mm <sup>3</sup> | 2.130E-09 | -                          |
| 2   | $E_1$      | Young's Modulus X                 | MPa               | 117877.1  | Longitudinal modulus       |
| 3   | $E_2$      | Young's Modulus Y                 | MPa               | 13162.52  | Transverse Modulus         |
| 4   | $E_3$      | Young's Modulus Z                 | MPa               | 12980.968 | -                          |
| 5   | $\nu_{12}$ | Poisson's ratio XY                | MPa               | 0.408876  | -                          |
| 6   | $\nu_{13}$ | Poisson's ratio YZ                | MPa               | 0.4442595 | -                          |
| 7   | $\nu_{23}$ | Poisson's ratio XZ                | MPa               | 0.3095808 | -                          |
| 8   | $G_{12}$   | Shear Modulus XY                  | MPa               | 3746.585  | In-plane shear modulus     |
| 9   | $G_{13}$   | Shear Modulus YZ                  | MPa               | 4854.271  | Out-of-plane shear modulus |
| 10  | $G_{23}$   | Shear Modulus XZ                  | MPa               | 4013.054  | Out-of-plane shear modulus |
| 11  | $S_{11T}$  | Longitudinal Tensile strength     | MPa               | 3816.417  | Strain: 0.03%              |
| 12  | $S_{11C}$  | Longitudinal Compressive strength | MPa               | -3676.365 | Strain: 0.03%              |
| 13  | $S_{22T}$  | Transverse Tensile strength       | MPa               | 3022.863  | Strain: 0.03%              |
| 14  | $S_{22C}$  | Transverse compressive strength   | MPa               | -299.563  | Strain: 0.03%              |
| 15  | $S_{33T}$  | Tensile strength                  | MPa               | 383.9853  | Strain: 0.03%              |
| 16  | $S_{33C}$  | Compressive strength              | MPa               | -356.7523 | Strain: 0.03%              |
| 17  | $S_{12S}$  | Out-of-plane shear strength       | MPa               | 115.8516  | -                          |
| 18  | $S_{23S}$  | Shear strength                    | MPa               | 165.8268  | -                          |
| 19  | k          | Thermal conductivity              | W/m-K             | 489.096   |                            |
| 20  | $C_p$      | Specific heat                     | kJ/kg-K           | 400.92    |                            |

## Theory

**Representative elementary volume (RVE)** is the smallest volume over which a measurement can be made that will yield a value representative of the whole. In the case of periodic materials, one simply chooses a periodic unit cell (which, however, may be non-unique), but in random media, the situation is much more complicated.



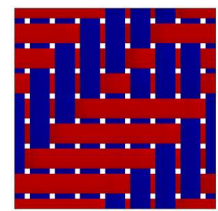
## Material properties

### □ Weave

|                |             |
|----------------|-------------|
| Brand          | SK Chemical |
| Pattern        | Woven       |
| Fiber material | Carbon      |
| Lay up type    | Multi layer |

### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | GPa               | 114   |
| Poisson's ratio | -                 | 0.25  |
| Density         | g/mm <sup>3</sup> | 1.64  |



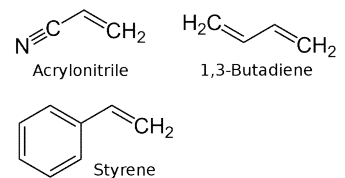
### □ Resin

|      |    |
|------|----|
| Type | PA |
|------|----|



### □ Material properties

| Property        | Unit              | Value |
|-----------------|-------------------|-------|
| E-Modulus       | MPa               | 523   |
| Poisson's ratio | -                 | 0.28  |
| Density         | g/mm <sup>3</sup> | 1.87  |



## Property according to direction(XYZ)

| No. | Symbol     | Properties                        | Unit              | Value     | Notes                      |
|-----|------------|-----------------------------------|-------------------|-----------|----------------------------|
| 1   | $\rho$     | Density                           | g/mm <sup>3</sup> | 2.059E-09 | -                          |
| 2   | $E_1$      | Young's Modulus X                 | MPa               | 165728.2  | Longitudinal modulus       |
| 3   | $E_2$      | Young's Modulus Y                 | MPa               | 11982.432 | Transverse Modulus         |
| 4   | $E_3$      | Young's Modulus Z                 | MPa               | 12436.312 | -                          |
| 5   | $\nu_{12}$ | Poisson's ratio XY                | MPa               | 0.5228895 | -                          |
| 6   | $\nu_{13}$ | Poisson's ratio YZ                | MPa               | 0.408876  | -                          |
| 7   | $\nu_{23}$ | Poisson's ratio XZ                | MPa               | 0.3410226 | -                          |
| 8   | $G_{12}$   | Shear Modulus XY                  | MPa               | 3290.479  | In-plane shear modulus     |
| 9   | $G_{13}$   | Shear Modulus YZ                  | MPa               | 3746.585  | Out-of-plane shear modulus |
| 10  | $G_{23}$   | Shear Modulus XZ                  | MPa               | 4618.798  | Out-of-plane shear modulus |
| 11  | $S_{11T}$  | Longitudinal Tensile strength     | MPa               | 4166.547  | Strain: 0.03%              |
| 12  | $S_{11C}$  | Longitudinal Compressive strength | MPa               | -3676.365 | Strain: 0.03%              |
| 13  | $S_{22T}$  | Transverse Tensile strength       | MPa               | 2723.3    | Strain: 0.03%              |
| 14  | $S_{22C}$  | Transverse compressive strength   | MPa               | -394.8785 | Strain: 0.03%              |
| 15  | $S_{33T}$  | Tensile strength                  | MPa               | 373.0921  | Strain: 0.03%              |
| 16  | $S_{33C}$  | Compressive strength              | MPa               | -367.6455 | Strain: 0.03%              |
| 17  | $S_{12S}$  | Out-of-plane shear strength       | MPa               | 163.5552  | -                          |
| 18  | $S_{23S}$  | Shear strength                    | MPa               | 118.1232  | -                          |
| 19  | k          | Thermal conductivity              | W/m-K             | 400.787   |                            |
| 20  | $C_p$      | Specific heat                     | kJ/kg-K           | 454.89    |                            |