Dimensions and Units for Finite Element Analyses

PolymerFEM.com Tutorial

Background:

Finite element programs do not consider the units of given quantities , it is the user's responsibility to ensure that the given numbers have consistent units. There are numerous different sets of units that can be used when performing FE simulations. The best set of units will depend on the problem, typically the most accurate results are obtained if the units are chosen such that the values of the input quantities to the FE simulation are close to unity. By having the input quantities close to 1, the influence of round-off errors and truncation errors are reduced.

Case 1: SI units

Base dimensions:
- Length in meters (m)
- Force in Newtons (N)
- Time in seconds (s)

The following dimensions need to be used:

[Pressure] =	N/m^2 = Pa
[Stress] =	N/m^2 = Pa
[Velocity] =	m/s
[Acceleration] =	m/s^2
[Mass] =	kg
[Volume] =	m^3
[Density] =	kg / m^3
[Energy] =	Nm = J

Case 2: SI units (small parts)

Base dimensions:
- Length in millimeters (mm)
- Force in Newton (N)
- Time is seconds (s)

The following dimensions need to be used:

[Pressure] =	N/mm^2 = 1e6 Pa = MPa
[Stress] =	N/mm^2 = 1e6 Pa = MPa
[Velocity] =	mm/s = 1e-3 m/s
[Acceleration] =	mm/s^2 = 1e-3 m/s^2
[Mass] =	Mg = 1e3 kg
[Volume] =	mm^3 = 1e-9 m^3
[Density] =	Mg/mm^3 = 1e12 kg/m^3
[Energy] =	1e-3 J = mJ

Usage example: if the density = 1000 kg/m^3, then in the FE program specify the density as 1000e-12.

Case 3: SI units (small loads)

Base dimensions:
- Length in micrometers (µm)
- Force in micro Newtons (µN)
- Time in seconds (s)

The following dimensions need to be used:

[Pressure] =	1e6 Pa = MPa
[Stress] =	1e6 Pa = MPa
[Velocity] =	1e-6 m/s = µm/s
[Acceleration] =	1e-6 m/s^2 = $µm/s^2$
[Mass] =	kg
[Volume] =	1e-18 m^3
[Density] =	1e18 kg / m^3
[Energy] =	1e-12 Nm = pJ