MEC-E1050 Finite Element Method in Solids; Mathematica

"Structure is a collection of *elements* (earlier structural parts) connected by *nodes* (earlier connection points)". Displacement of the structure is defined by nodal translations and rotations of which some are known and some unknown."

Structure

$prb = \{ele, fun\}$ where

$ele = \{prt_1, prt_2, \ldots\}$ .... elements

$fun = \{val_1, val_2, \ldots\}$ .... nodes

Elements

$prt = \{typ, pro, geo\}$ where

$typ =$ BEAM | PLATE | SOLID | RIGID |…| .... model

$pro = \{p_1, p_2, \ldots, p_n\}$ ....properties

$geo = \text{Point}[\{n_1\}] \,|\, \text{Line}[\{n_1, n_2\}] \,|\, \text{Polygon}[\{n_1, n_2, n_3\}] \,|\, \ldots |$ ....geometry

Nodes

$val = \{crd, tra, rot\}$ where

$crd = \{X, Y, Z\}$ ....structural coordinates

$tra = \{u_X, u_Y, u_Z\}$ .... translation components

$rot = \{\theta_X, \theta_Y, \theta_Z\}$ ....rotation components

Elements

Constraint

$\{\text{JOINT}, \{\} \,|\, \{\{\underline{u}_X, \underline{u}_Y, \underline{u}_Z\}\}, \text{Point}[\{n_1\}]\}$ ....displacement constraint

$\{\text{JOINT}, \{\}, \text{Line}[\{n_1, n_2\}]\}$ ....displacement constraint

$\{\text{RIGID}, \{\} \,|\, \{\{\underline{u}_X, \underline{u}_Y, \underline{u}_Z\}, \{\underline{\theta}_X, \underline{\theta}_Y, \underline{\theta}_Z\}\}, \text{Point}[\{n_1\}]\}$ ....displacement/rotation constraint

$\{\text{RIGID}, \{\}, \text{Line}[\{n_1, n_2\}]\}$ ....rigid constraint

$\{\text{SLIDER}, \{n_X, n_Y, n_Z\}, \text{Point}[\{n_1\}]\}$ .... slider constraint

Force

$\{\text{FORCE}, \{F_X, F_Y, F_Z\}, \text{Point}[\{n_1\}]\}$ .... point force

$\{\text{FORCE}, \{F_X, F_Y, F_Z, M_X, M_Y, M_Z\}, \text{Point}[\{n_1\}]\}$ ....point load

$\{\text{FORCE}, \{f_X, f_Y, f_Z\}, \text{Line}[\{n_1, n_2\}]\}$ ....distributed force

$\{\text{FORCE},\{f_X, f_Y, f_Z\},\text{Polygon}[\{n_1,n_2,n_3\}]\}$ ....distributed force

Beam model

$\{\text{BAR},\{\{E\},\{A\},\{f_X, f_Y, f_Z\}\},\text{Line}[\{n_1,n_2\}]\}$ ....bar mode

$\{\text{TORSION},\{\{G\},\{J\},\{\{m_X, m_Y, m_Z\}\}\},\text{Line}[\{n_1,n_2\}]\}$ .... torsion mode

$\{\text{BEAM},\{\{E,G\},\{A,I_{yy},I_{zz}\},\{f_X, f_Y, f_Z\}\},\text{Line}[\{n_1,n_2\}]\}$ ....beam

$\{\text{BEAM},\{\{E,G\},\{A,I_{yy},I_{zz},\{j_X, j_Y, j_Z\}\},\{f_X, f_Y, f_Z\}\},\text{Line}[\{n_1,n_2\}]\}$ ....beam

Plate model

$\{\text{PLANE},\{\{E,\nu\},\{t\},\{f_X, f_Y, f_Z\}\},\text{Polygon}[\{n_1,n_2,n_3\}]\}$ .... thin slab mode

$\{\text{PLATE},\{\{E,\nu\},\{t\},\{f_X, f_Y, f_Z\}\},\text{Polygon}[\{n_1,n_2,n_3\}]\}$ .... bending mode

$\{\text{SHELL},\{\{E,\nu\},\{t\},\{f_X, f_Y, f_Z\}\},\text{Polygon}[\{n_1,n_2,n_3\}]\}$ ....plate

Solid model

$\{\text{SOLID},\{\{E,\nu\},\{f_X, f_Y, f_Z\}\},\text{Tetrahedron}[\{n_1,n_2,n_3,n_4\}]\}$ ....solid

$\{\text{SOLID},\{\{E,\nu\},\{f_X, f_Y, f_Z\}\},\text{Hexahedron}[\{n_1,n_2,n_3,n_4,n_5,n_6,n_7,n_8\}]\}$ ....solid

$\{\text{SOLID},\{\{E,\nu\},\{f_X, f_Y, f_Z, m_X, m_Y, m_Z,\}\},\text{Tetrahedron}[\{n_1,n_2,n_3,n_4\}]\}$ ....solid

Operations

$prb = \text{REFINE}[prb]$ .... refine structure representation

$\text{Out} = \text{FORMATTED}[prb]$ ....display problem definition

$\text{Out} = \text{STANDARDFORM}[prb]$ ....display virtual work expression

$\text{sol} = \text{SOLVE}[prb]$ ....solve the unknowns