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

$typ = \text{BAR} \mid \text{TORSION} \mid \text{BEAM} \mid \text{RIGID} \mid \ldots \mid$ ..... model

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

$geo = \text{Point}[\{n_1\}] \mid \text{Line}[\{n_1, n_2\}] \mid \text{Triangle}[\{n_1, n_2, n_3\}] \mid \ldots \mid$ .....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

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

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

$\{\text{RIGID}, \{\} \mid \{\{\underline{u}_X, \underline{u}_Y, \underline{u}_Z\}, \{\underline{\theta}_X, \underline{\theta}_Y, \underline{\theta}_Z\}\}, \text{Point}[\{n_1\}]\}$ .....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

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

Beam model

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

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

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

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

Plate model

{PLANE,{{E,ν},{t},{f_X, f_Y, f_Z}},Polygon[{n_1,n_2,n_3}]} ..... thin slab mode

{PLANE,{{E,ν},{t},{f_X, f_Y, f_Z}},Polygon[{n_1,n_2,n_3,n_4}]} ..... thin slab mode

{PLATE,{{E,ν},{t},{f_X, f_Y, f_Z}},Polygon[{n_1,n_2,n_3}]} ..... bending mode

{SHELL,{{E,ν},{t},{f_X, f_Y, f_Z}},Polygon[{n_1,n_2,n_3}]} .....plate

Solid model

{SOLID,{{E,ν},{f_X, f_Y, f_Z}},Tetrahedron[{n_1,n_2,n_3,n_4}]} .....solid

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

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

Operations

prb = REFINE[prb] ..... refine structure representation

Out = FORMATTED[prb] .....display problem definition

Out = STANDARDFORM[prb] ..... display virtual work expression

sol = SOLVE[prb] .....solve the unknowns