Table 13.4.1 Description of the input variables to the program **FEM2D**.

• **Data Card 1**

TITLE Title of the problem being solved (80 characters)

• **Data Card 2**

ITYPE Problem type
- ITYPE = 0 Single variable problems
- ITYPE = 1 Viscous incompressible flow problems
- ITYPE = 2 Plane elasticity problems
- ITYPE = 3 Plate bending problems by FSDT
- ITYPE = 4 Plate bending problems by CPT(N)
- ITYPE = 5 Plate bending problems by CPT(C)

IGRAD Indicator for computing the gradient of the solution or stresses in the postprocessor
- IGRAD = 0 No postprocessing is required
- IGRAD > 0 Postprocessing is required

When ITYPE = 0 and IGRAD = 1, the gradient is computed as in Eq. (13.4.2); for ITYPE = 0 and IGRAD > 1 the gradient is computed by Eq. (13.4.3)

ITEM Indicator for dynamic analysis
- ITEM = 0 Static analysis is required
- ITEM > 0 Either eigenvalue or transient analysis is required:
  - ITEM = 1 Parabolic equation
  - ITEM = 2 Hyperbolic equation

NEIGN Indicator for eigenvalue analysis
- NEIGN = 0 Static or transient analysis
- NEIGN > 0 Eigenvalue analysis:
  - NEIGN = 1 Vibration analysis
  - NEIGN > 1 Stability of plates

Skip card 3 if NEIGN = 0.

• **Data Card 3**

NVALU Number of eigenvalues to be printed

NVCTR Indicator for printing eigenvectors:
- NVCTR = 0 Do not print eigenvectors
- NVCTR > 0 Print eigenvectors

• **Data Card 4**

IELTYP Element type used in the analysis
- IELTYP = 0 Triangular elements
- IELTYP > 0 Quadrilateral elements

NPE Nodes per element
- NPE = 3 Linear triangle (IELTYP = 0)
- NPE = 4 Linear quadrilateral (IELTYP > 0)
- NPE = 6 Quadratic triangle (IELTYP = 0)
- NPE = 8 or 9 Quadratic quadrilateral (IELTYP > 0)

MESH Indicator for mesh generation by the program
- MESH = 0 Mesh is not generated by the program
- MESH = 1 Mesh is generated by the program for rectangular domains by **MESH2DR**
- MESH >1 Mesh is generated by the program for nonrectangular domains by **MESH2DG**

NPRNT Indicator for printing certain output
- NPRNT = 0 Not print array NOD, element matrices or global matrices
- NPRNT = 1 Print array NOD and element 1 matrices ELK and ELF

(**Table 13.4.1** continued)

	NPRNT = 2 Print array NOD and assembled matrices GLK and GLF
	NPRNT > 2 Combination of NPRNT = 1 and 2

Skip card 5 if MESH = 1.

• Data Card 5

NEM	Number of elements in the mesh when the user inputs the mesh or the mesh is generated by **MESH2DG**
NNM	Number of nodes in the mesh when the user inputs the mesh or the mesh is generated by **MESH2DG**

Skip cards 6 and 7 if MESH ≠ 0; otherwise, read card 6 in a loop on the number of elements (N = 1, NEM) and card 7 in loops on I and J.

• Data Card 6

NOD(N, I)	Connectivity for the Nth element (I=1, NPE)

• Data Card 7

GLXY(I, J)	Global x and y coordinates of the Ith global node in the mesh (J = 1, x coordinate; J = 2, y coordinate) Loops on I and J are: [(J = 1, 2), I = 1, NNM]; the NNM pairs of (x, y) coordinates are read sequentially

Cards 8–11 are read in **MESH2DG**. Skip them unless MESH > 1.

• Data Card 8

NRECL	Number of line records to be read in the mesh

• Data Card 9

Read the following variables NRECL times:

NOD1	First global node number of the line segment
NODL	Last global node number of the line segment
NODINC	Node increment on the line
X1	The global x coordinate of the NOD1
Y1	The global y coordinate of the NOD1
XL	The global x coordinate of NODL
YL	The global y coordinate of NODL
RATIO	The ratio of the first element length to the last element length

• Data Card 10

NRECEL	Number of rows of elements to be read in the mesh

• Data Card 11

Read the following variables NRECEL times:

NEL1	First element number of the row
NELL	Last element number of the row
IELINC	Increment of element number in the row
NODINC	Increment of the global node number in the row
NPE	Number of nodes in each element
NODE(I)	Connectivity array of the first element in the row (I=1, NPE)

Skip cards 12–14 if MESH ≠ 1.

• Data Card 12

NX	Number of elements in the x direction
NY	Number of elements in the y direction

• Data Card 13

X0	The x coordinate of global node 1
DX(I)	The x dimension of the Ith element (I = 1, NX)

(**Table 13.4.1** continued)

• **Data Card 14**

Y0	The y coordinate of gobal node 1
DY(I)	The y dimension of the Ith element (I = 1, NY)

• **Data Card 15**

NSPV	The number of specified primary variables

Skip card 16 if NSPV = 0

• **Data Card 16**

ISPV(I, J)	Node number and local degree of freedom (DOF) number of the Ith specified primary variable ISPV(I, 1) = Node number ISPV(I, 2) = Local DOF number The do-loops on I and J are: [(J = 1, 2), I = 1, NSPV]

Skip card 17 if NSPV = 0 or NEIGN ≠ 0.

• **Data Card 17**

VSPV(I)	Specified value of the Ith primary variable (I = 1, NSPV)

Skip card 18 if NEIGN ≠ 0.

• **Data Card 18**

NSSV	Number of (nonzero) specified secondary variables

Skip card 19 if NSSV = 0 or NEIGN ≠ 0.

• **Data Card 19**

ISSV(I, J)	Node number and local DOF number of the Ith specified secondary variable ISSV(I, 1) = Node number ISSV(I, 2) = Local DOF number The loops on I and J are: ((J = 1, 2), I = 1, NSSV)

Skip card 20 if NSSV = 0 or NEIGN ≠ 0.

• **Data Card 20**

VSSV(I)	Specified value of the Ith secondary variable (I = 1, NSSV)

Data Cards 21–27 are for the single variable problems (ITYPE = 0).

• **Data Card 21**

A10	Coefficients of the differential equation
A1X	
A1Y	a11 = A10 + A1X*X + A1Y*Y

• **Data Card 22**

A20	Coefficients of the differential equation
A2X	
A2Y	a22 = A20 + A2X*X + A2Y*Y

• **Data Card 23**

A00	Coefficient of the differential equation

• **Data Card 24**

ICONV	Indicator for convection boundary conditions ICONV = 0 No convection boundary conditions ICONV > 0 Convection boundary conditions present

• **Data Card 25**

NBE	Number elements with convection

• **Data Card 26**

The following cards are read for each I, I = 1, NBE:

IBN(I)	Ith element number with convection
BETA(I)	Film coefficient for convection on Ith element
TINF(I)	Ambient temperature of the Ith element

(**Table 13.4.1** continued)

• **Data Card 27**

INOD(I, J)	Local node numbers of the side with convection (J = 1, 2; for quadratic elements, give end nodes) Loops on I and J are: [(J = 1, 2), I = 1, NBE]

Data Card 28 is for viscous fluid flows (ITYPE = 1) only.

• **Data Card 28**

VISCSITY	Viscosity of the fluid
PENALTY	Value of the penalty parameter

Data Cards 29 and 30 are for plane elasticity problems (ITYPE = 2) only.

• **Data Card 29**

LNSTRS	Flag for plane stress or plane strain problems LNSTRS = 0 Plane strain elastic problems LNSTRS > 0 Plane stress elastic problems

• **Data Card 30**

E1	Young's moduli along the global x axis
E2	Young's moduli along the global y axis
ANU12	Poisson's ratio in the xy plane
G12	Shear modulus in the xy plane
THKNS	Thickness of the plane elastic body analyzed

Data Card 31 is for plate bending problems (ITYPE = 3 to 5) only.

• **Data Card 31**

E1	Young's moduli along the global x axis
E2	Young's moduli along the global y axis
ANU12	Poisson's ratio in the xy plane
G12	Shear modulus in the xy plane
G13	Shear modulus in the xz plane
G23	Shear modulus in the yz plane
THKNS	Thickness of the plate analyzed

*** Remaining data cards are for all problem types. ***

Skip card 32 if NEIGN ≠ 0.

• **Data Card 32**

F0	Coefficients to define the source term
FX	
FY	f(x, y) = F0 + FX*x + FY*y

*** Cards 33–37 are for transient analysis (ITEM ≠ 0) only. ***

Skip card 33 if ITEM = 0.

• **Data Card 33**

C0	Coefficients defining the temporal parts of the
CX	differential equations, as defined below:
CY	
	CT = C0 + CX*X + CY*Y when ITYPE = 0 or 1 CT = (C0 + CX*X + CY*Y)*THKNS when ITYPE = 2 I0 = C0*THKNS, I2 = C0*(THKNS**3)/12 and CX and CY are not used (when NEIGH ≤ 1 and ITYPE = 3 to 5) C0, CX, and CY denote the buckling parameters when ITYPE = 3 and NEIGN > 1

Skip card 34 if ITEM = 0 or NEIGN ≠ 0.

(**Table 13.4.1** continued)

• **Data Card 34**

NTIME	Number of time steps for the transient solution
NSTP	Time step number at which the source is removed
INTVL	Time step interval at which to print the solution
INTIAL	Indicator for nature of initial conditions INTIAL = 0 Zero initial conditions are used INTIAL > 0 Nonzero initial conditions are used

Skip card 35 if ITEM = 0 or NEIGN ≠ 0.

• **Data Card 35**

DT	Time step used for the transient solution
ALFA	Parameter in the alfa-family of time approximation used for parabolic equations: ALFA = 0 The forward difference scheme (C.S.)† ALFA = 0.5 The Crank–Nicolson scheme (stable) ALFA = 2/3 The Galerkin scheme (stable) ALFA = 1 The backward difference scheme (stable) †C.S. = conditionally stable; for all schemes with ALFA < 0.5, the time step DT is restricted to DT < 2/[MAXEGN*(1-2*ALFA)], where MAXEGN is the maximum eigenvalue of the discrete problem
GAMA	Parameter in the Newmark time integration scheme used for hyperbolic equations: GAMA = 0.5 Constant-average acceleration (stable) GAMA = 1/3 Linear acceleration scheme (C.S.) GAMA = 0.0 The central difference scheme (C.S.) ALFA = 0.5 for all schemes; For schemes for which ALFA ≤ 0.5 and GAMA < ALFA, DT is restricted to: DT < 2/SQRT[MAXEGN*(ALFA-GAMA)], MAXEGN being the maximum eigenvalue of the discrete system
EPSLN	A small parameter to check if the solution has reached a steady state

Skip card 36 if ITEM or INTIAL = 0, or NEIGN ≠ 0.

• **Data Card 36**

GLU(I)	Vector of initial value of the primary variables (I = 1, NEQ), where NEQ = Number of nodal values in the mesh

Skip card 37 if ITEM ≤ 1, NEIGN ≠ 0, or INTIAL = 0.

• **Data Card 37**

GLV(I)	Vector of the initial values of the first derivative of the primary variables (velocity) (I = 1, NEQ)

13.4.2 Description of Mesh Generators

A major limitation of the program **FEM2D** lies in the mesh generation [i.e., the computation of arrays NOD(I, J) and GLXY(I, J) for arbitrary domains]. For such problems, the user is required to input the mesh information, which can be a tedious job if many elements are used. Of course, the program can be modified to accept other mesh generation subroutines. Here we discuss the input data to the two mesh generators, namely, **MESH2DR** and **MESH2DG**.