SMAP ® - 3D

Structure Medium Analysis Program

3-D Static, Consolidation and Dynamic
Analysis for Dry, Saturated and
Partially Saturated Soils
and Rock Mass

Example Problems

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Contents

Introduction

Example Problems are mainly provided:

- To give you some guide in preparing input data.
- To demonstrate the validity of SMAP programs.

Section 2 describes methods of preparing Mesh Files which represent the geometry of structures to be analyzed.

Section 3 describes two different methods of running main- and post-processing programs.

Section 4 illustrates SMAP-3D main example problems as summarized in Table 1.1. First 9 problems are presented to demonstrate the accuracy and validity of SMAP-3D main- processing program.

Section 5 illustrates Group Mesh examples. Group Mesh Generator is a two dimensional CAD program specially designed to build group mesh which can be used to generate finite element mesh with the aid of program ADDRGN-2D.

Section 6 illustrates Block Mesh examples. Block Mesh Generator is a three dimensional CAD program specially designed to build block mesh which can be used to generate finite element mesh with the aid of program PRESMAP-GP.

Section 7 illustrates PRESMAP examples which are used to generate two and three dimensional Mesh Files.

Section 8 illustrates ADDRGN examples which are used to combine or modify existing Mesh Files. ADDGRN-2D has a powerful mesh generation feature as demonstrated in sub section 8.1.3.

Section 9 illustrates SUPPLEMENT examples which are useful to prepare input data for pre- and main-processing programs.

Section 10 illustrates LOAD examples which are used to generate external nodal loads in two and three dimensional coordinate systems.

Section 11 illustrates XY Graph examples. XY Graph is a two dimensional graph consisting of lines connecting each pair of data points, which can be plotted by PLOT-XY or Excel.

Table 1.1 List of SMAP-3D example problem

Problem Number	Project File Name	Run Time Pent. III 850	Description
1	VP1.dat	0.01 min.	Undrained uniaxial strain compression. Check: • Static • Fully coupled two-phase medium
2	VP2.dat	0.03	Terzaghi's linear consolidation Check: • Consolidation • Gravity load
	VP2-1.dat	0.10	Using linear wedge element
3	VP3.dat	0.37	Planar compression wave propagation Check: • Dynamic two-phase response
	VP3-1.dat	0.13	Using transmitting boundary
4	VP4.dat	0.35	Circular tunnel in Drucker-Prager medium Check: • 3-D elasto-plastic matrix of Generalized Hoek and Brown Model
	VP4-1.dat		Using element surface load
	VP4-2.dat		Using linear wedge element
5	VP5.dat	0.15	Laminated beam with slip interface Check: • Joint element • Joint model
	VP5-1.dat	0.98	Thin layer joint element, NM=4 Joint thickness by CARD 5.3.2.4.11

Table 1.1 List of SMAP-3D example problem, continued

Problem Number	Project File Name	Run Time Pent. III 850	Description
6	VP6.dat	0.02 min.	Gibson's construction pore pressure Check: • Consolidation • Variable time step • Moving boundary
	VP6-1.dat		Using linear wedge element
7	VP7.dat	0.01	Drained triaxial compression test Check: • Modified Cam Clay Model • Drained triaxial compression path
8	VP8.dat	0.01	Undrained plane strain comp. test. Check: • Modified Cam Clay Model • Undrained plane compression path
9	VP9.dat	0.01	Volumetric creep in isotropic undrained test. Check: • Modified Cam Clay Model • Volumetric creep
10	VP10.dat	0.01	Space truss analysis
11	VP11.dat	0.01	Fixed end beam analysis
12	VP12.dat	0.01	Beam dynamic analysis
13	VP13.dat	0.85	William's toggled beam analysis
14	VP14.dat	0.02	Plane strain tunnel analysis
15	VP15.dat	0.01	Hemispherical shell
	VP15-1.dat		Using triangular shell element
16	VP16.dat	0.02	Simply supported plate analysis

Table 1.1 List of SMAP-3D example problem, continued

Problem Number	Project File Name	Run Time Pent. III 850	Description
17	VP17.dat	0.01 min.	Heated beam modeled by shell
	VP17-1.dat		Heated beam modeled by beam
	VP17-2.dat		Heated beam modeled by continuum
18	VP18.dat	0.01	Thin pipe subjected to internal pressure using double precision
	VP18-1.dat		Using single precision with FACBD = $1x10^6$
19	VP19.dat	24.12	Preload consolidation & excavation
20	VP20.dat	16.93	Seismic tunnel analysis
21	VP21.dat	0.01	Frames with hinge connection Modeled by beam element
	VP21-1.dat		Modeled by shell element
22	VP22.dat		Embedded rebars with slip
23	VP23.dat		Pseudo dynamic embankment fill
24	VP24.dat		Plane strain tunnel in jointed continuum
25	VP25.dat		Spring analysis
26	VP26.dat		Nonlinear truss analysis
27	VP27.dat		SDOF System To Ground Acceleration
28	VP28.dat		Frames with Rotational Spring Connection
29	VP29.dat		Reinforced Concrete Beam
30	VP30.dat		Reinforced Concrete Cylinder

Pre-Processing Programs

Pre-Processing programs are mainly used to generate Mesh File described in Section 4.3 of SMAP-3D User's Manual. The Mesh File represents the geometry of the structure to be analyzed. This file contains information about nodal coordinates, element indexes, material property numbers, and boundary codes. In SMAP-3D, you may generate such Mesh Files using the following methods:

Method 1

First, generate 2D Mesh File representing a typical two dimensional section using Group Mesh Generator, Block Mesh Generator, or 2D PRESMAP. Modify this 2D Mesh File using ADDRGN-2D if you need to do it. And then extend the 2D mesh into 3D mesh using GEN-3D.

1. Generate 2D Mesh File

   GROUP MESH GENERATOR
   BLOCK MESH GENERATOR
   PRESMAP-2D NATM-2D
   CIRCLE-2D PRESMAP-GP

2. Modify 2D Mesh File

   ADDRGN-2D

3. Extend into 3D Mesh File

   GEN-3D

Method 2

Generate 3D Mesh Files using Block Mesh Generator or 3D PRESMAP. Then combine or modify these 3D Mesh Files using ADDRGN-3D if you need to do it.

1. Generate 3D Mesh File

    BLOCK MESH GENERATOR
    PRESMAP-3D CROSS-3D
    PRESMAP-GP

2. Combine or modify 3D Mesh File

    ADDRGN-3D

Above two methods can be combined to make a final 3D Mesh File representing the structure to be analyzed.

To view the Mesh Files, you can use PLOT-3D by selecting following order:
Plot → Mesh → F. E. Mesh → Open

Boundary codes can affect analysis result significantly so that it is strongly recommended for you to double check those codes to avoid solving wrong problems.

Main- and Post-Processing Programs

Main-Processing program reads Mesh and Main Files as input and performs static, consolidation, or dynamic analysis. Post-Processing programs read Post File along with analysis results from Main-Processing program and then produce graphical output.

Mesh Files can be generated using Pre-Processing programs as outlined in the previous Section 2. Main and Post Files can be created according to Section 4.4 and 4.5, respectively, in SMAP-3D User's Manual. Normally, they can copy existing Main or Post Files which are similar to the problem to be analyzed and modify those files using Text Editor.

Main- and Post-Processing programs can be executed using the following methods:

Method 1

Prepare Mesh, Main, and Post Files. Run EXECUTE menu to get analysis results. And run PLOT menu to view graphical output of analysis results.

1. Prepare All Input Files

   Mesh, Main and Post Files

2. Get Analysis Results

   RUN → SMAP → EXECUTE

3. View Graphical Output

   PLOT → RESULT → PLOT-XY, PLOT-2D, PLOT-3D

Method 2

Prepare Mesh, Main, and Blank Post Files. Run EXECUTE menu to get analysis results. Now, prepare Post File according to Section 4.5 in SMAP-3D User's Manual. Run PRE EXECUTE menu to obtain intermediate plotting information files. And then run PLOT menu to view graphical output of analysis results. Note that Blank Post File consists of following 3 lines:

```
┌  0,  1,  2
│  0
└  0,  4.5
```

1. Prepare Mesh and Main Files

Mesh, Main and Blank Post Files

2. Get Analysis Results

RUN → SMAP → EXECUTE Menu

3. Prepare Post File

Post File in Section 4.5 of User's Manual

4. Get Plotting Information Files

RUN → SMAP → PreEXECUTE

5. View Graphical Output

PLOT → RESULT → PLOT-XY, PLOT-2D, PLOT-3D

Method 2 is particularly useful when you are running large problems which take long execution time. You have to care in preparing Card Group 10 in Main File since Post File can only address those data requested in Card Group 10. You can repeat Steps 3 and 4 as long as your Post File addresses the output data within the range specified in Card Group 10 in Main File.

Post-Processing programs are mainly used to show graphical output of the analysis results.

PLOT-XY reads Card Group 12 in Post File and plots time histories of stresses, strains, and displacements. Once you run PLOT-XY , you will obtain intermediate plotting information file (PLOTXY.Lin). PLOTXY.Lin file can be modified as it will be described in Section 11 of SMAP Examples.

PLOT-2D reads Card Group 11 in Post File and plots two dimensional snap shots. Once you run PLOT-2D in PLOT menu, you will obtain intermediate plotting information file (PLOT2D.DAT).

PLOT-3D does not need any Post File.
This program plots following three dimensional snapshots:

- Finite element mesh
- Deformed shape
- Principal stress distribution
- Section forces in beam element
- Extreme fiber stresses/strains in beam elements (2D)
- Axial force/stress/strain in truss element
- Contours of stresses, strains and factor of safety
- 3D iso surface of stresses and strains

PRESMAP
Example Problem

PRESMAP menu includes six Pre-Processing programs: PRESMAP-2D, NATM-2D, CIRCLE-2D, PRESMAP-3D, CROSS-3D, GEN-3D, and PRESMAP-GP. These Pre-Processing programs are mainly used to generate Mesh File described in Section 4.3 of User's Manual. Refer to SMAP-3D User's Manual:

- Section 5 for input parameters for PRESMAP programs.
- Section 3.2.2 for running PRESMAP programs.

7.1 PRESMAP-2D

PRESMAP-2D includes Model 1, 2, 3, and 4. Model 1 is basic pre-processor which can be applied to model various types of problem geometry.

Model 2 is the special pre-processor developed to model near-field around underground openings such as tunnels, culverts, etc. Model 3 is the special pre-processor developed to model triangular and rectangular shape geometry. Model 4 is the useful pre-processor to generate layered embankments having slope.

7.1.1 Model 1

A typical underground tunnel is chosen here to illustrate mesh generations using PRESMAP-2D Model 1 and 2. Figure 7.1 shows geological condition around tunnel consisting of four layers: weathered soil, weathered rock, soft rock, and hard rock. Figure 7.2 shows in detail tunnel cross section including shotcrete and rock bolt dimensions.

For convenience, the tunnel problem geometry is divided into three regions as shown in Figure 7.3; Core, Near-field, and Far-field regions. By symmetry, only right half of the tunnel geometry is considered. Model 1 is used to generate Core and Far-field region meshes. And Model 2 is used to generate Near-field region mesh. Near-field region mesh generation will be explained in the next section. And assembly of Core, Near-field, and Far-field regions will be explained in ADDRGN-2D Example Problems in Section 8.1.

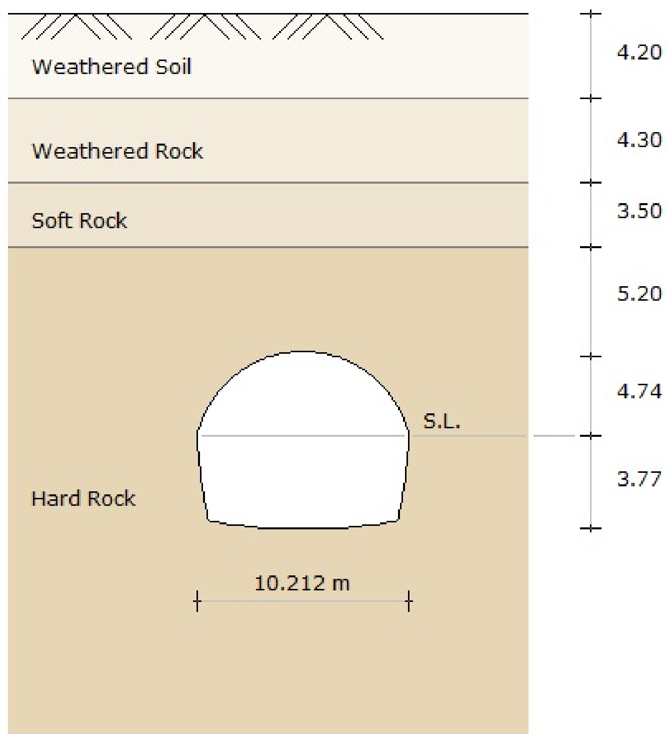
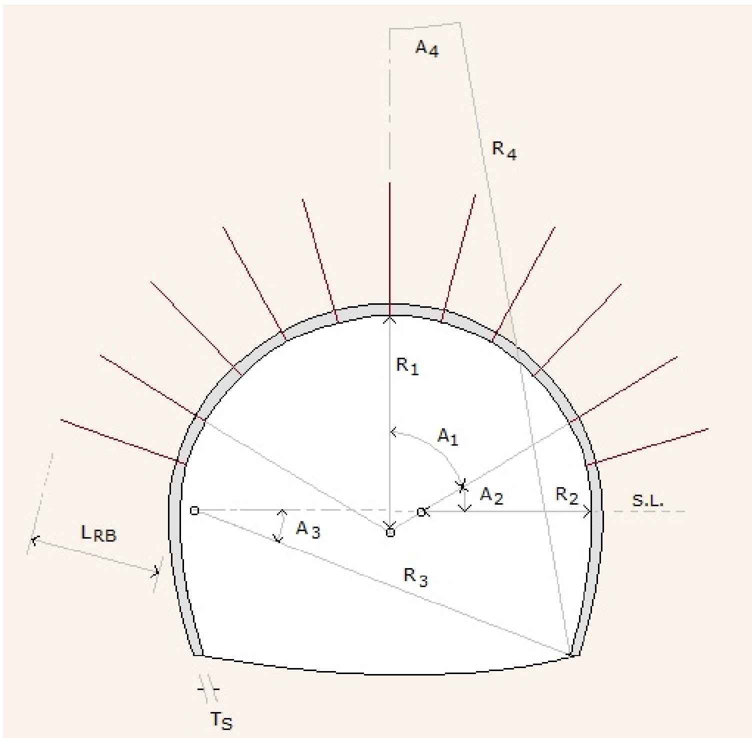


Figure 7.1 Geological condition



R_1 =	5.24 m	A_1	= 60°
R_2 =	4.24 m	A_2	= 30°
R_3 =	9.86 m	A_3	= 19.781°
R_4 =	23.86 m		

Number of Rock Bolts (NUMRB)	=	11
Length of Rock Bolts (LRB)	=	3.0 m
Spacing of Rock Bolts (TSPACING)	=	1.2 m
Thickness of Shotcrete (TS)	=	15 Cm
Thickness of Liner (TL)	=	30 Cm
Reinforcing Bar Area (ASI)	=	22 Cm^2
Reinforcing Bar Area (ASO)	=	22 Cm^2

Figure 7.2 PD-2 tunnel section detail

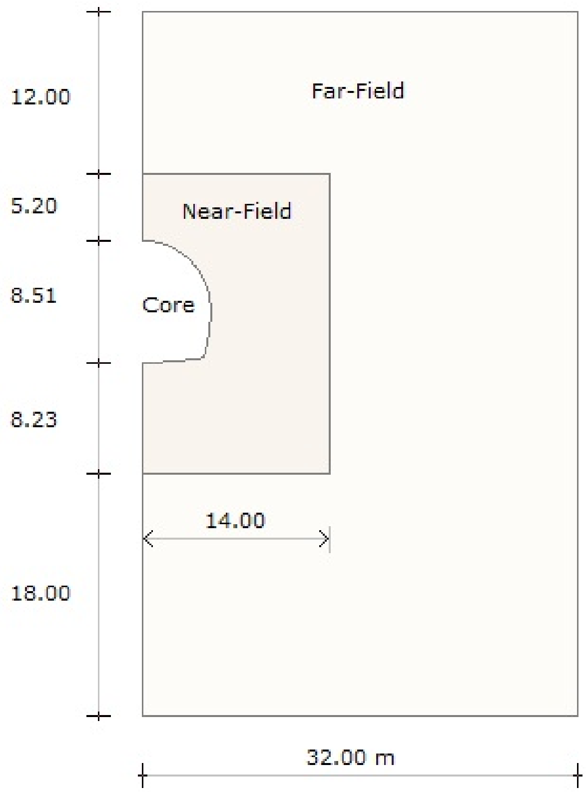


Figure 7.3 Core, Near-field, and Far-field regions

7.1.1.1 Core Region Mesh Generation

Figure 7.4 shows the block diagram for the Core region. Three blocks are used in the horizontal direction (NBX=3) and four blocks in the vertical direction (NBY=4). Block numbers should be in order from top to bottom and left to right. Top 9 blocks (Block numbers 1,2,3,5,6,7,9,10, and 11) represent upper half of tunnel core to be excavated first and bottom 3 blocks (Block numbers 4,8, and 12) represent lower half of tunnel core to be excavated later.

Each block can be consisted of 4 to 9 block nodes depending on whether you can include side and center block nodes. For those blocks facing the tunnel wall of the Core region, side block nodes are included to form the curve. Note that when the side block node is not specified, the straight line will be formed along that side.

Block index should be specified in counterclockwise. For example, the index of Block 4 can be written as I_1=11, I_2 =4, I_3=5, I_4=12, M_5=0, M_6=0, M_7 =7, M_8=0, M_9=0. Next, each block is further divided into elements. For example, Block 4 has 2 elements in the horizontal direction (NDX=2) and 6 elements in the vertical direction (NDY=6). It should be noted that to be compatible, the same number of divisions be specified along the two adjacent blocks. For example, Blocks 4, 8, and 12 have 6 elements in the vertical direction so that the generated elements can share the same nodal points along the boundaries of these blocks.

Since the tunnel is symmetry about y axis, the boundary condition along the y axis is specified as the roller which allows the displacement in the y direction and the boundary condition at all other nodes is specified to be free. And material number.4 representing hard rock is specified for all blocks since the Core region belongs to the hard rock layer as shown in Figure 7.1.

Table 7.1 shows the listing of input file, CORE.Rgn, which has been prepared according to the PRESMAP-2D Model 1 in Section 7.2.1 of User's Manual. Note that the format of the PRESMAP-2D output file is the same as that of Mesh File in SMAP-2D User's Manual. Graphical outputs are shown in Figure 7.5.

Table 7.1 Listing of input file CORE.Rgn

```
* INPUT DATA FOR PRESMAP-2D MODEL 1
* CARD 1.1
  PD-2 CORE REGION GENERATION
* CARD 1.2
* IP
  0
* CARD 1.3
* NBLOCK  NBNODE  NSNEL  CMFAC
    12      30      1     1.0
* CARD 1.4
* NBX  NBY  MIDX  MIDY  NF  NSNODE
   3    4     0     0    1    1
* CARD 2.1
* NODE  X         Y
   1   0.0       4.74
   2   0.0       3.16
   3   0.0       1.58
   4   0.0       0.0
   5   0.0      -3.77
   6   0.684     4.695
   7   0.76     -3.7579
   8   1.356     4.562
   9   1.488     2.819
   10  1.594     1.425
   11  1.702     0.0
   12  1.517    -3.722
   13  2.005     4.341
   14  2.273    -3.662
   15  2.62      4.038
   16  2.9204    2.4907
   17  3.157     1.273
   18  3.404     0.0
   19  3.025    -3.577
   20  3.19      3.66
   21  3.776    -3.47
   22  3.705     3.205
   23  4.157     2.69
   24  4.538     2.12
   25  4.783     1.623
   26  4.962     1.097
   27  5.07      0.5534
   28  5.106     0.0
   29  4.96     -1.693
   30  4.524    -3.337
```

```
* ====================================================
* CARD 3.1
* BLNAME
  BLOCK 1
* CARD 3.2
* IBLNO
    1
* CARD 3.3
* I1  I2  I3  I4  M5  M6  M7  M8  M9
   8   1   2   9   6   0   0   0   0
* CARD 3.4
* IBASE IB1  IB2  IB3  IB4  IB5  IB6  IB7  IB8
    12    12   13   13   12   12   13   12   12
* CARD 3.5
* MATNO NDX  NDY   KS   KF
    4     2    2    0    1
* CARD 3.6
* NFSIDE
    0
* ====================================================
  BLOCK 2
  2
  9   2   3   10  0   0   0   0   0
  12  12  13  13  12  12  13  12  12
  4   2   2   0   1
  0
* ====================================================
  BLOCK 3
  3
  10  3   4   11  0   0   0   0   0
  12  12  13  13  12  12  13  12  12
  4   2   2   0   1
  0
* ====================================================
  BLOCK 4
  4  3.337
  11  4   5   12  0   0   7   0   0
  12  12  13  13  12  12  13  12  12
  4   2   6   0   1
  0
* ====================================================
  BLOCK 5
  5
  15  8   9   16  13  0   0   0   0
  12  12  12  12  12  12  12  12  12
  4   2   2   0   1
  0
```

```
* =====================================================
  BLOCK 6
  6
  16 9  10 17 0  0  0  0  0
  12 12 12 12 12 12 12 12 12
  4  2  2  0  1
  0
* =====================================================
  BLOCK 7
  7
  17 10 11 18 0  0  0  0  0
  12 12 12 12 12 12 12 12 12
  4  2  2  0  1
  0
* =====================================================
  BLOCK 6
  6
  16 9  10 17 0  0  0  0  0
  12 12 12 12 12 12 12 12 12
  4  2  2  0  1
  0
* =====================================================
  BLOCK 7
  7
  17 10 11 18 0  0  0  0  0
  12 12 12 12 12 12 12 12 12
  4  2  2  0  1
  0
* =====================================================
  BLOCK 8
  8
  18 11 12 19 0  0  14 0  0
  12 12 12 12 12 12 12 12 12
  4  2  6  0  1
  0
* =====================================================
  BLOCK 9
  9
  22 15 16 24 20 0  0  23 0
  12 12 12 12 12 12 12 12 12
  4  2  2  0  1
  0
```

```
* ====================================================
  BLOCK 10
  10
  24 16 17 26 0  0  0  25 0
  12 12 12 12 12 12 12 12 12
  4  2  2  0  1
  0
* ====================================================
  BLOCK 11
  11
  26 17 18 28 0  0  0  27 0
  12 12 12 12 12 12 12 12 12
  4  2  2  0  1
  0
* ====================================================
  BLOCK 12
  12
  28 18 19 30 0  0  21 29 0
  12 12 12 12 12 12 12 12 12
  4  2  6  0  1
  0
* ====================================================
```

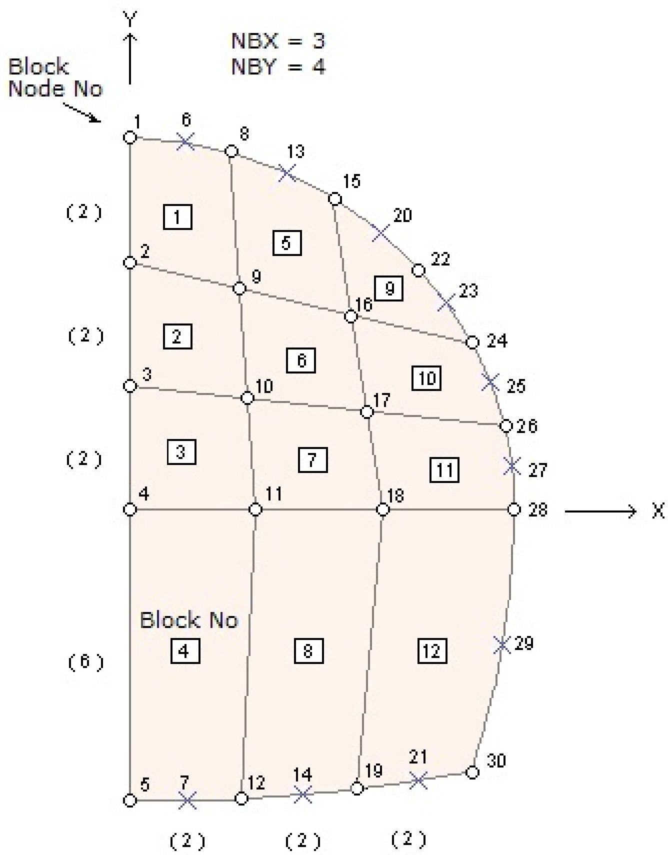


Figure 7.4 Core region block diagram

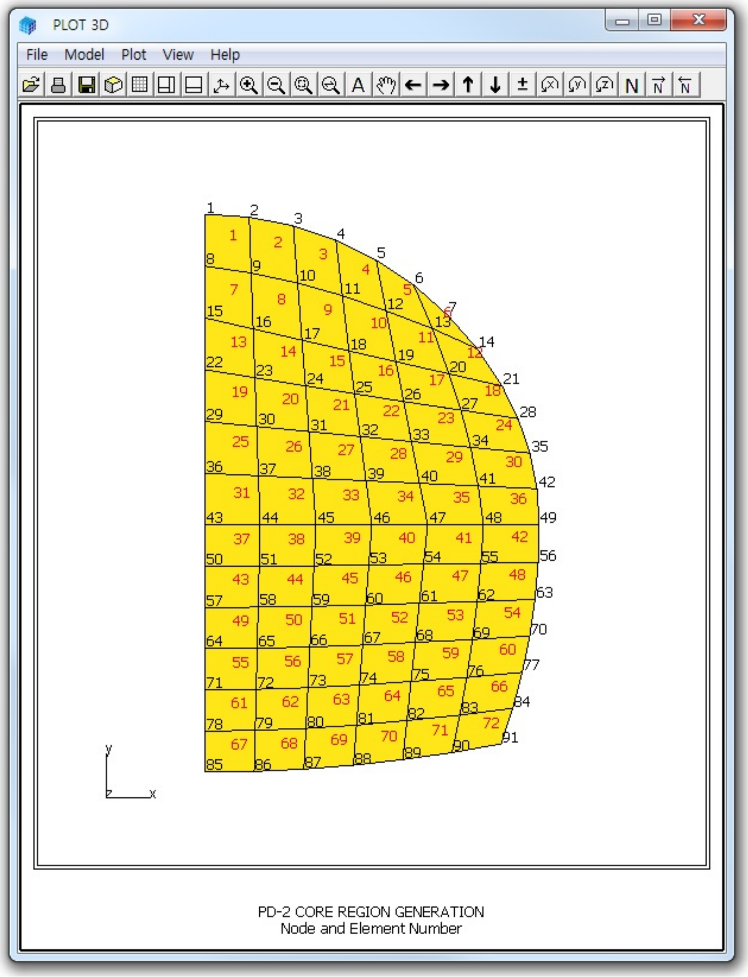


Figure 7.5 Generated element and node numbers for Core region

7.1.1.2 Far-Field Region Mesh Generation

Figure 7.6 shows the block diagram for the Far-field region. Two blocks are used in the horizontal direction (NBX=2) and 6 blocks in the vertical direction (NBY=6). Block numbers 1 and 7 represent weathered soil (MATNO=1). Block numbers 2 and 8 represent weathered rock (MATNO= 2). Block numbers 3 and 9 represent soft rock (MATNO=3). And the rest of blocks represent hard rock (MATNO=4) except Block numbers 4 and 5 (MATNO=0). Note that Block numbers 4 and 5 are void blocks. Elements in this void blocks are not generated in Far-field region, but will be generated in Core and Near-field regions.

You can specify the index of each block as for Core region. Side block nodes are used here to make element sizes bigger as the elements are away from the tunnel core. To simulate plane strain condition at the remote boundary, boundary conditions for the left, right, and bottom are specified as the roller.

Table 7.2 shows the listing of input file, FAR.Rgn, which has been prepared according to the PRESMAP-2D Model 1 in Section 7.2.1 of User's Manual. Generated element and node numbers are shown in Figure 7.7. Note that the Far-field element number starts from 337, considering that there are 336 elements in Core and Near-field regions.

Table 7.2 Listing of input file FAR.Rgn

```
* INPUT DATA FOR PRESMAP-2D MODEL 1
* CARD 1.1
  PD-2 FAR-FIELD REGION GENERATION
* CARD 1.2
* IP
  0
* CARD 1.3
* NBLOCK  NBNODE  NSNEL  CMFAC
   12       31     337    1.0
* CARD 1.4
* NBX  NBY  MIDX  MIDY  NF  NSNODE
   2    6    0     0    1     1
* CARD 2.1
* NODE   X      Y
   1    0.0    21.94
   2    0.0    17.74
   3    0.0    13.44
   4    0.0    9.94
   5    0.0    0.0
   6    0.0   -12.0
   7    0.0   -19.2
   8    0.0   -30.0
   9    14.0   21.94
   10   14.0   17.74
   11   14.0   13.44
   12   14.0   9.94
   13   14.0   0.0
   14   14.0  -12.0
   15   14.0  -19.2
   16   14.0  -30.0
   17   21.2   21.94
   18   21.2   17.74
   19   21.2   13.44
   20   21.2   9.94
   21   21.2   0.0
   22   21.2  -12.0
   23   21.2  -30.0
   24   32.0   21.94
   25   32.0   17.74
   26   32.0   13.44
   27   32.0   9.94
   28   32.0   0.0
   29   32.0  -12.0
   30   32.0  -19.2
   31   32.0  -30.0
```

```
* ====================================================
* CARD 3.1
* BLNAME
  BLOCK 1
* CARD 3.2
* IBLNO
    1
* CARD 3.3
* I1 I2 I3 I4 M5 M6 M7 M8 M9
   9  1  2 10  0  0  0  0  0
* CARD 3.4
* IBASE IB1 IB2 IB3 IB4 IB5 IB6 IB7 IB8
    12   12  13  13  12  12  13  12  12
* CARD 3.5
* MATNO  NDX  NDY  KS   KF
    1     6    1    0    1
* CARD 3.6
* NFSIDE
    0
* ====================================================
  BLOCK 2
  2
  10 2  3  11 0  0  0  0  0
  12 12 13 13 12 12 13 12 12
  2  6  1  0  1
  0
* ====================================================
  BLOCK 3
  3
  11 3  4  12 0  0  0  0  0
  12 12 13 13 12 12 13 12 12
  3  6  2  0  1
  0
* ====================================================
  BLOCK 4
  4
  12 4  5  13 0  0  0  0  0
  12 12 13 13 12 12 13 12 12
  0  6  6  0  1
  0
* ====================================================
  BLOCK 5
  5
  13 5  6  14 0  0  0  0  0
  12 12 13 13 12 12 13 12 12
  0  6  6  0  1
  0
```

```
* =====================================================
  BLOCK 6
  6
  14 6  8  16 0  7  0  15 0
  12 12 13 15 14 12 13 14 12
  4  6  4  0  1
  0
* =====================================================
  BLOCK 7
  7
  24 9  10 25 17 0  18 0  0
  12 13 12 12 13 12 12 12 13
  1  4  1  0  1
  0
* =====================================================
  BLOCK 8
  8
  25 10 11 26 18 0  19 0  0
  12 13 12 12 13 12 12 12 13
  2  4  1  0  1
  0
* =====================================================
  BLOCK 9
  9
  26 11 12 27 19 0  20 0  0
  12 13 12 12 13 12 12 12 13
  3  4  2  0  1
  0
* =====================================================
  BLOCK 10
  10
  27 12 13 28 20 0  21 0  0
  12 13 12 12 13 12 12 12 13
  4  4  6  0  1
  0
* =====================================================
  BLOCK 11
  11
  28 13 14 29 21 0  22 0  0
  12 13 12 12 13 12 12 12 13
  4  4  6  0  1
  0
```

```
* =====================================================
  BLOCK 12
  12
  29 14 16 31 22 15 23 30 0
  12 13 12 14 15 12 12 14 13
  4   4   4   0   1
  0
* =====================================================
* END OF DATA
```

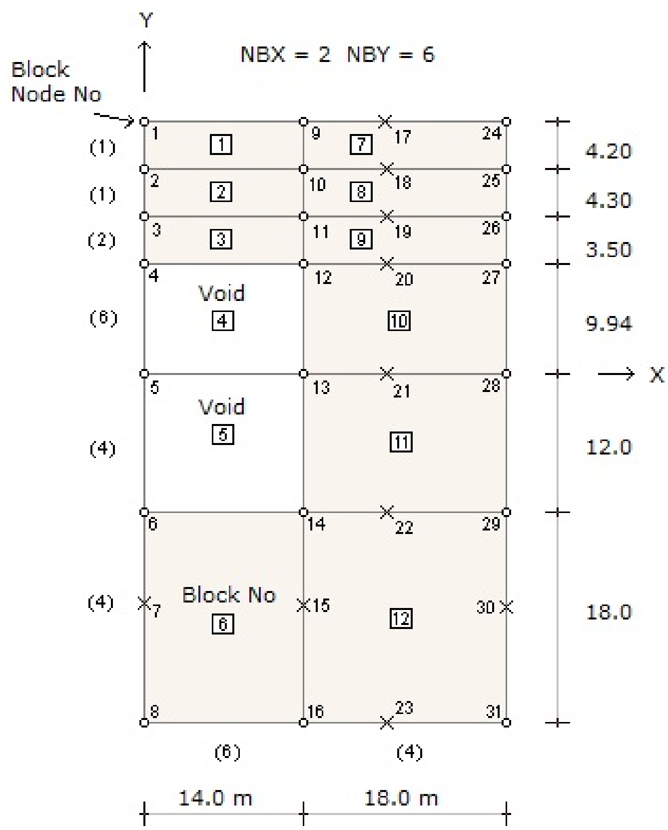


Figure 7.6 Far-field region block diagram

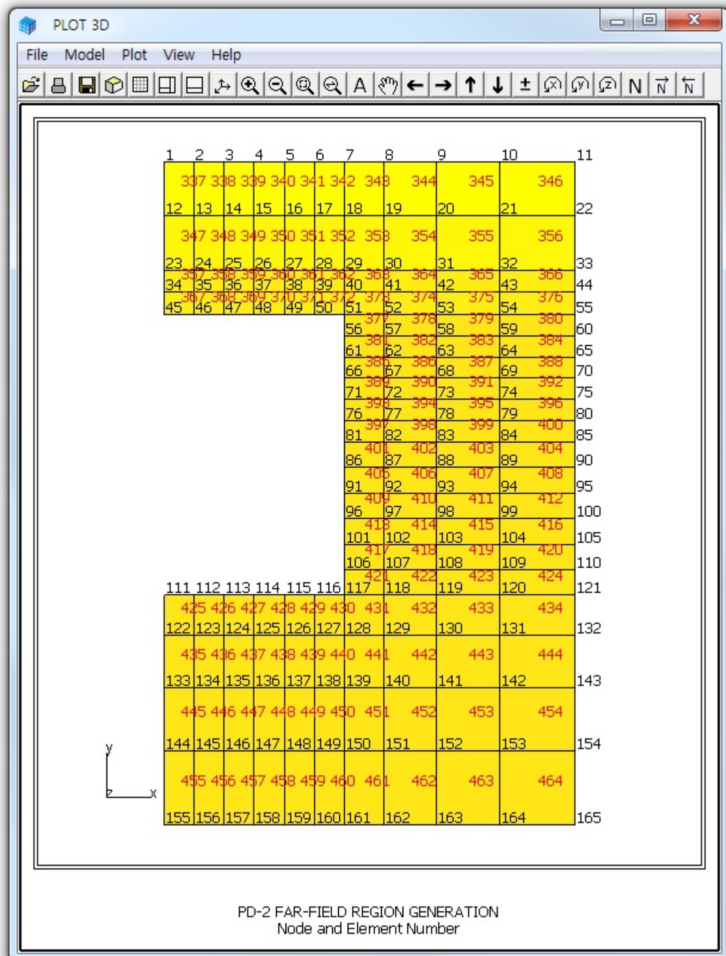


Figure 7.7 Generated element and node numbers for Far-field region

7.1.2 Model 2

Model 2 is the special pre-processor developed to model Near-field region around the underground openings. The Near-field region shown in Figure 7.3 is taken here as an example problem.

As shown in Figure 7.8, eight subregions are used to construct the Near-field region. And each subregion consists of three blocks. Then each block is further divided in radial and tangential directions. For example, Block number 5 in Subregion 2 has 5 elements in radial direction and 6 elements in the tangential direction. Note that element sizes in the third block increase gradually in the radial direction. Parameters specific to each subregion are tabulated in Table 7.3.

Table 7.4 shows the listing of input file, NEAR.Rgn, which has been prepared according to the PRESMAP-2D Model 2 in Section 7.2.2 of User's Manual. Generated element mesh is shown in Figure 7.9.

Table 7.3 Parameters specific in Near-field region

NSUBR = 8 NDRF = 2 NDRS = 5 NDRT = 4
DRF = 0.15 m DRS = 2.85 m

Subregion	ISBTYPE	LSFTYPE	NSEG
1	1	1	6
2	1	1	6
3	0	1	2
4	0	1	2
5	0	1	2
6	0	1	2
7	0	1	2
8	0	1	2

Global block numbers are in order from surface

to outer edge and counterclockwise.

Local block numbers in each subregion are in order
from surface to outer edge.

Example : In Subregion 2,
First block = 4 , Second block = 5, Third block = 6

Table 7.4 Listing of input file NEAR.Rgn

```
* INPUT DATA FOR PRESMAP-2D MODEL 2
* CARD 1.1
  PD-2 NEAR-FIELD MESH GENERATION
* CARD 1.2
* IP
  0
* CARD 1.3
* NSNEL  NSNODE  NF  CMFAC
   73      67    1   1.0
* CARD 1.4
* NSURB  NDRF  NDRS  NDRT  DRF   DRS
    8     2     5     4    0.15  2.85
* =====================================================
* CARD 2.1
* SUBNAME
  SUBREGION 1
* CARD 2.2
* ISUBNO
     1
* CARD 2.3
* ISBTYPE  LSFTYPE  NSEC
     1        1       6
* CARD 2.4.2 (LSFTYPE = 1)
* R       Xo   Yo     TA     TB
  23.86  0.0  20.09  270.   280.93
* (ISBTYPE = 1)
* CARD 2.5.3
* Xc    Yc    Xd    Yd
  0.0   -12.  14.0  -12.
* CARD 2.6
* IBASE1  IBASE2  IBASE3
    12      12      12
* IBb  IBa  IBc  IBd  IBab  IBac  IBcd  Ibbd
   12   13   13   12   12    13    12    12
* CARD 2.7
* MATNO1  KS1   KF1
      4    0     1
* MATNO2  KS2   KF2
      4    0     1
* MATNO3  KS3   KF3
      4    0     1
* CARD
* NFSIDE
      0
```

```
* =====================================================
      SUBREGION 2
      2
      1  1  6
      9.86  -4.754  0.0  340.22  360.
      14.0  -12.  14.0   0.0
      12 12 12
      12 12 12 12 12 12 12 12
      4  0  1
      4  0  1
      4  0  1
      0
* =====================================================
      SUBREGION 3
      3
      0  1  2
      4.24  0.866  0.0  0.0  15.0
      1
      14.0
      0
      14.0  3.31
      12 12 12
      12 12 12 12 12 12 12 12
      4  0  1
      4  0  1
      4  0  1
      0
* =====================================================
      SUBREGION 4
      4
      0  1  2
      4.24  0.866  0.0  15.0  30.0
      0
      14.0  3.31
      0
      14.0  6.63
      12 12 12
      12 12 12 12 12 12 12 12
      4  0  1
      4  0  1
      4  0  1
      0
```

```
* =====================================================
      SUBREGION 5
      5
      0  1  2
      5.24  0.0  -0.5  30.0  45.0
      0
      14.0  6.63
      0
      14.0  9.94
      12 12 12
      12 12 12 12 12 12 12 12
      4  0  1
      4  0  1
      4  0  1
      0
* =====================================================
      SUBREGION 6
      6
      0  1  2
      5.24  0.0  -0.5  45.0  60.0
      0
      14.0  9.94
      0
      9.33  9.94
      12 12 12
      12 12 12 12 12 12 12 12
      4  0  1
      4  0  1
      4  0  1
      0
* =====================================================
      SUBREGION 7
      7
      0  1  2
      5.24  0.0  -0.5  60.  75.0
      0
      9.33  9.94
      0
      4.67  9.94
      12 12 12
      12 12 12 12 12 12 12 12
      4  0  1
      4  0  1
      4  0  1
      0
```

```
* =====================================================
      SUBREGION 8
      8
      0  1  2
      5.24  0.0  -0.5  75.0  90.0
      0
      4.67  9.94
      0
      0.0   9.94
      12 12 12
      13 12 12 13 12 12 12 13
      4  0  1
      4  0  1
      4  0  1
      0
* =====================================================
```

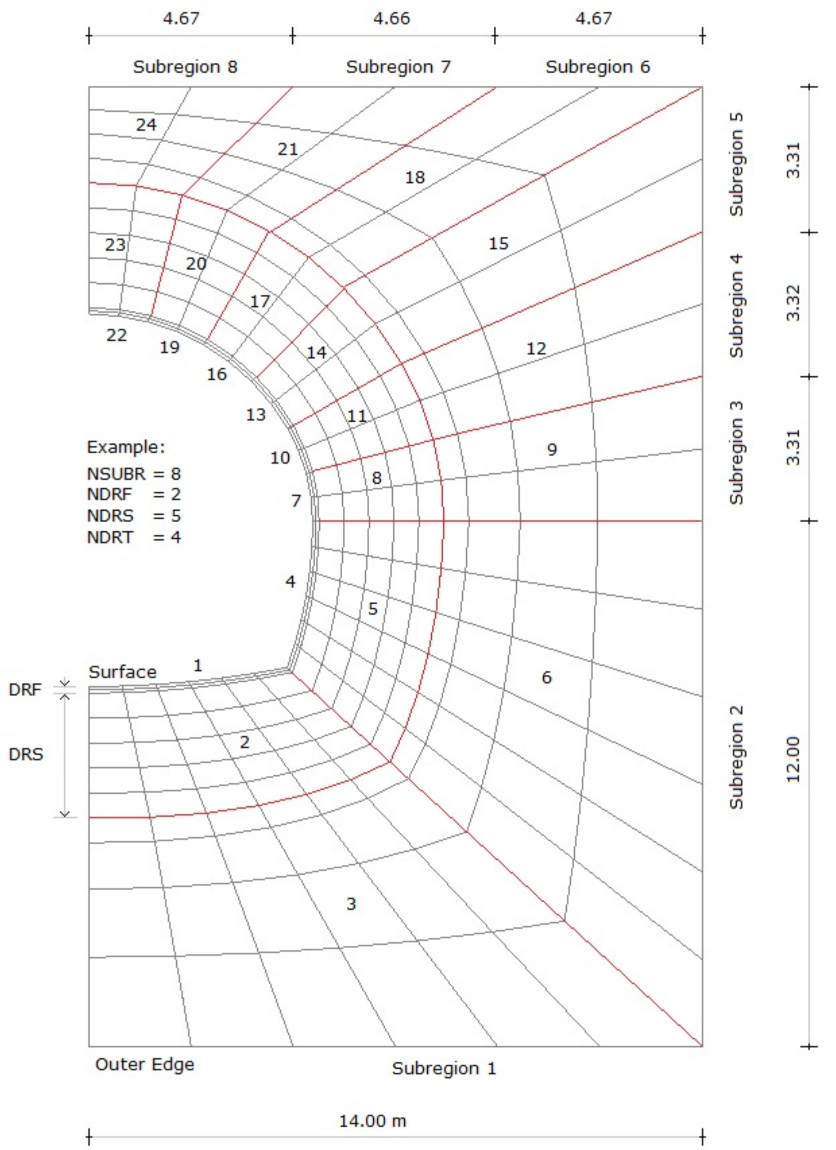


Figure 7.8 Subregions in Near-field region

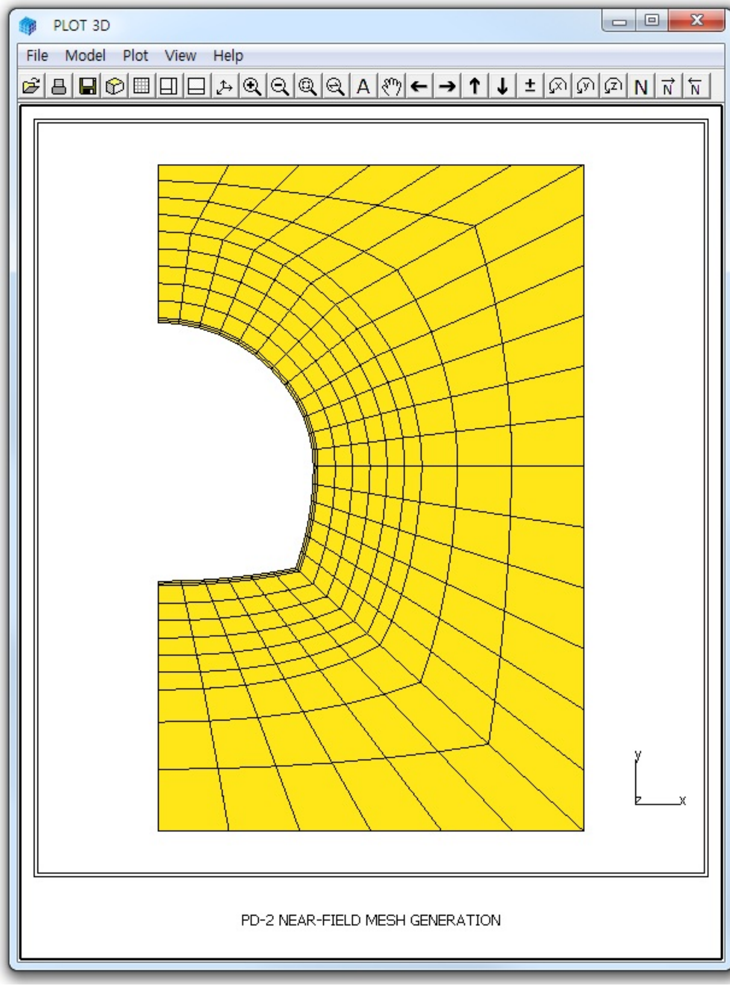


Figure 7.9 Generated mesh for Near-field region

7.1.3 Model 3

Model 3 is a useful pre-processor to generate triangular or rectangular meshes. It is much easier to use compared to Models 1 and 2.
But you have to specify the boundary codes manually.

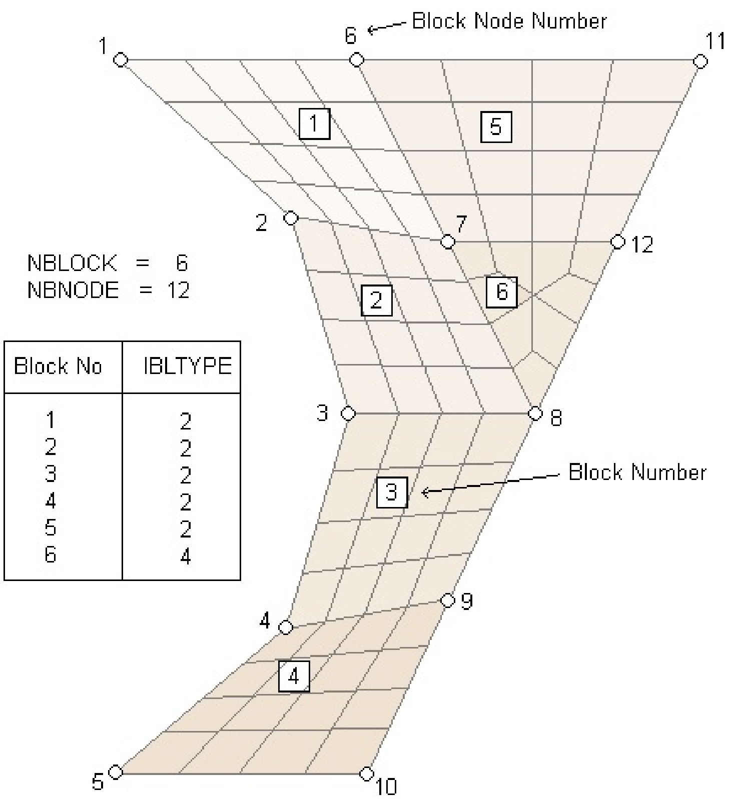
Figure 7.10 shows block diagram for Model 3 example problem.
Block numbers 1 to 5 are 4 x 4 rectangular shape and Block number 6 is the 9-element triangular shape.

Table 7.5 shows the listing of input file, GM3.Rgn, which has been prepared according to the PRESMAP-2D Model 3 in Section 7.2.3 of User's Manual. Generated element and node numbers are shown in Figure 7.11.

Table 7.5 Listing of input file GM3.Rgn

```
* INPUT DATA FOR PRESMAP-2D MODEL 3
* CARD 1.1
  MESH GENERATION SURROUNDING PIPE ( GM3 )
* CARD 1.2
* IP
  0
* CARD 1.3
* NBLOCK  NBNODE  NSNEL  NSNODE  CMFAC
     6       12     171     1       1.0
* CARD 2.1
* NODE      X            Y
   1  .324920E+02  .100000E+03
   2  .809020E+02  .587790E+02
   3  .100000E+03  .000000E+00
   4  .809020E+02 -.587790E+02
   5  .324920E+02 -.100000E+03
   6   100.          100.
   7   125.          50.
   8   150.          0.
   9   125.         -50.
   10  100.         -100.
   11  200.          100.
   12  175.          50.
* =======================================================
* CARD 3.1
* =======================================================
* IBLNO  IBLTYPE  MATNO  KS  KF
    1       2       2     0   1
* FOR IBLTYPE = 2
* I1 I2 I3 I4 M5 M6 M7 M8 M9 M10 M11 M12 M13 M14 M15 M16
   6  1  2  7  0  0  0  0  0   0   0   0   0   0   0   0
* =======================================================
* IBLNO  IBLTYPE  MATNO  KS  KF
    2       2       2     0   1
* FOR IBLTYPE = 2
* I1 I2 I3 I4 M5 M6 M7 M8 M9 M10 M11 M12 M13 M14 M15 M16
   7  2  3  8  0  0  0  0  0   0   0   0   0   0   0   0
* =======================================================
* IBLNO  IBLTYPE  MATNO  KS  KF
    3       2       2     0   1
* FOR IBLTYPE = 2
* I1 I2 I3 I4 M5 M6 M7 M8 M9 M10 M11 M12 M13 M14 M15 M16
   8  3  4  9  0  0  0  0  0   0   0   0   0   0   0   0
```

```
* =======================================================
* IBLNO  IBLTYPE  MATNO  KS  KF
    4       2       2     0   1
* FOR IBLTYPE = 2
* I1  I2  I3  I4  M5  M6  M7  M8  M9  M10  M11  M12  M13  M14  M15  M16
   9   4   5  10   0   0   0   0   0    0    0    0    0    0    0    0
* =======================================================
* IBLNO  IBLTYPE  MATNO  KS  KF
    5       2       2     0   1
* FOR IBLTYPE = 2
* I1  I2  I3  I4  M5  M6  M7  M8  M9  M10  M11  M12  M13  M14  M15  M16
  11   6   7  12   0   0   0   0   0    0    0    0    0    0    0    0
* =======================================================
* IBLNO  IBLTYPE  MATNO  KS  KF
    6       4       2     0   1
* FOR IBLTYPE = 2
* I1  I2  I3  M4  M5  M6  M7  M8  M9  M10  M11  M12
   7   8  12   0   0   0   0   0   0    0    0    0
* =======================================================
```



Block No	IBLTYPE
1	2
2	2
3	2
4	2
5	2
6	4

Figure 7.10 Block diagram for Model 3 example problem

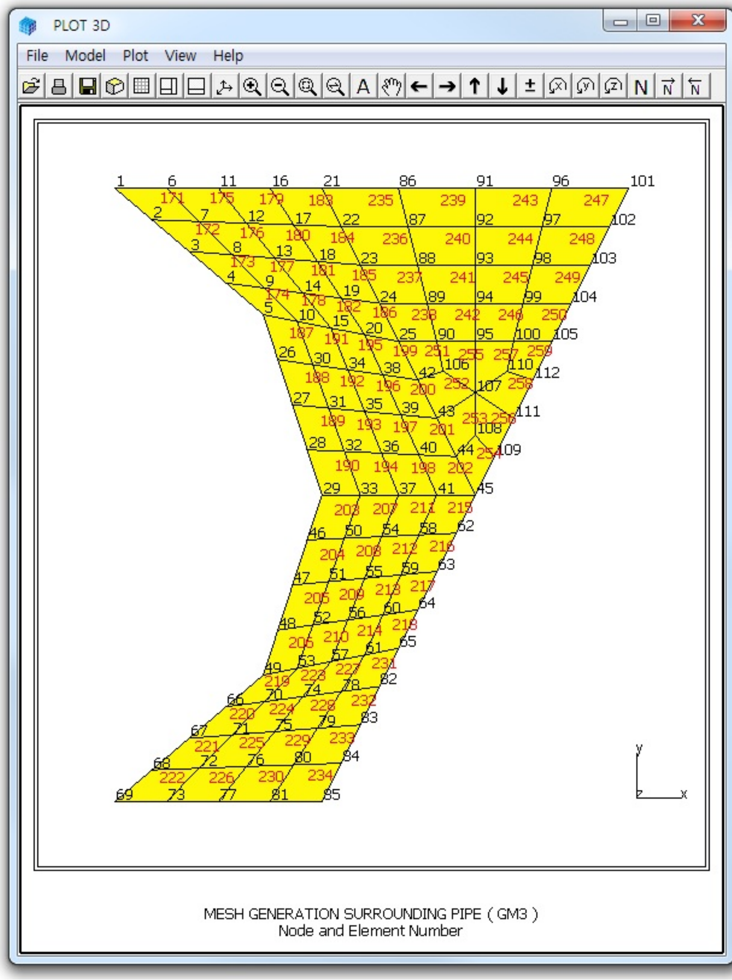


Figure 7.11 Generated element and node numbers for Model 3 example problem

7.1.4 Model 4

Model 4 is a useful pre-processor to generate horizontally layered dams or embankments. It is easy to use but the boundary codes should be specified manually.

As Model 4 example problem, an embankment with 3 layers is considered. Table 7.6 shows the listing of input file, GM4.Rgn, which has been prepared according to the PRESMAP-2D Model 4 in Section 7.2.4 of User's Manual. Generated element and node numbers are shown in Figure 7.12.

Table 7.6 Listing of input file GM4.Rgn

```
* CARD 1.1
* TITLE
  EXAMPLE PROBLEM FOR PRESMAP-2D MODEL 4
* CARD 1.2
* NLAYER  NDIV  ITRANGL
   3       3     1
* CARD 1.3
* NSNEL  NSNODE  CMFAC
   1      1       1.0
* CARD 2.1
* XB1  YB1  YB2  XB2
  0.0  3.0  0.0  12.
* CARD 3.1
* MATNO  KS  KF
   3     0   1
* END OF DATA
```

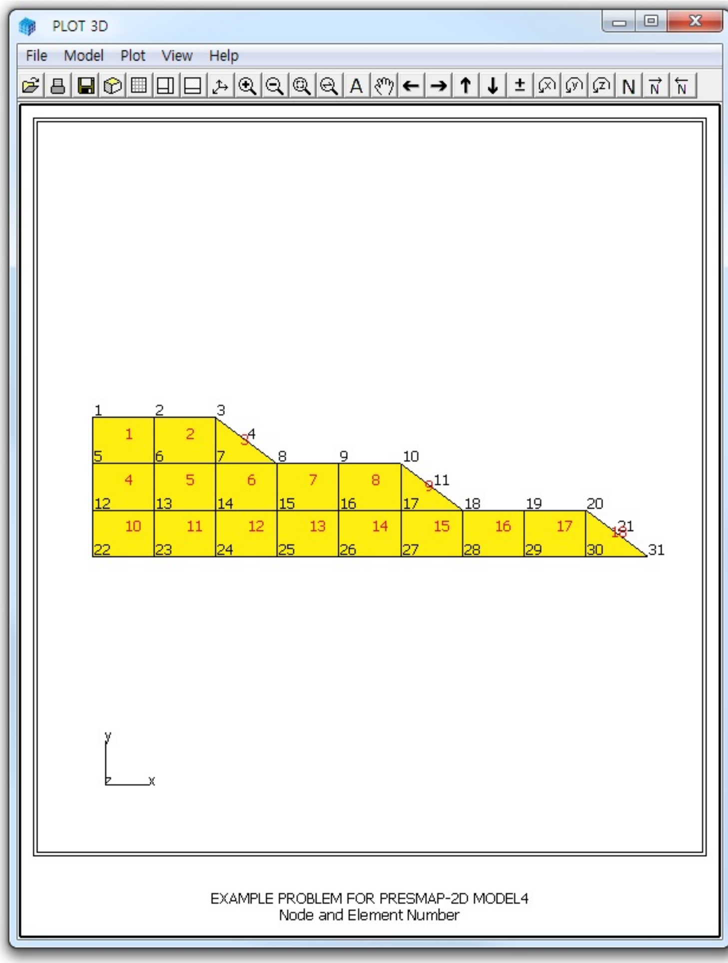


Figure 7.12 Generated element and node numbers for Model 4 example problem

7.2 NATM-2D

NATM-2D is the special pre-processing program to generate automatically two-dimensional finite element meshes and boundary conditions for NATM tunnels. NATM-2D has four different models:

Model 1	Single Tunnel (Half Section)
Model 2	Single Tunnel (Full Section)
Model 3	Two Tunnel (Symmetric Section)
Model 4	Two Tunnel (Unsymmetric Section)

Once you have executed NATM-2D, you will obtain following files:

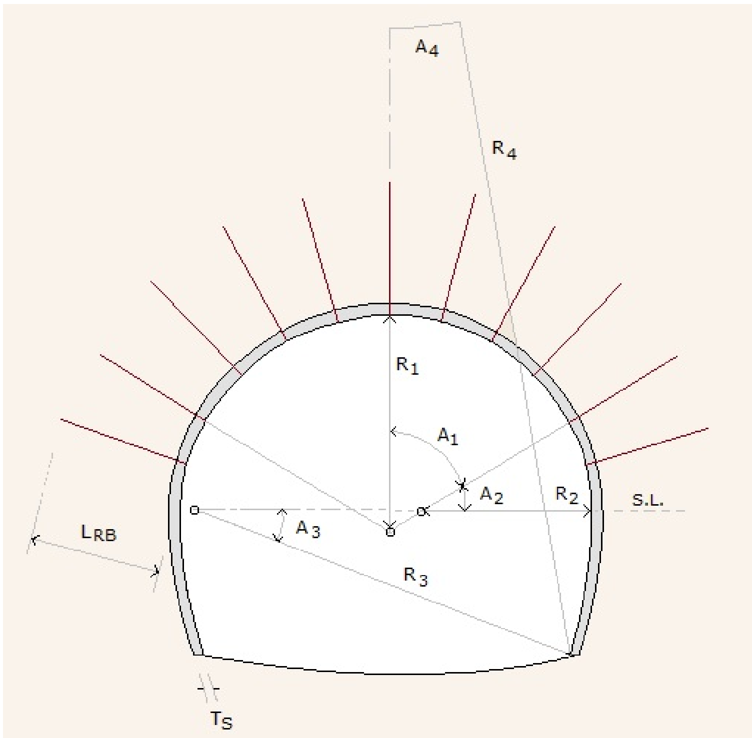
Output File	Mesh File including all elements (Continuum, Beam, and Truss). Output File is the user specified name.
BEAM.Dat	Mesh File including only beam elements.
TRUSS.Dat	Mesh File including only truss elements.
AD.Dat	Card Group 8 in Main File representing default element activities for upper and lower parts of Core, Shotcrete, and Rock Bolt including Joint and Lining elements.
LINING.Dat	Mesh File for Beam-Spring Lining Analysis. This file will be generated only for ILNCOUPL=1.

A typical PD2 tunnel shape is chosen here to illustrate mesh generation using NATM-2D as shown in Figure 7.13. For each model, we will present:

- Listing of input file
- Schematic tunnel section view
- Graphical output of finite element mesh

Table 7.7 Listing of input file PD2-1.Dat

```
* CARD 1.1
* TITLE
  NATM-2D MODEL 1 EXAMPLE PROBLEM
* CARD 1.2
* IUNIT
   2
* CARD 1.3
* MODEL  IGEN  IEXMESH   ILNCOUPL
   1      0     0                0
* CARD 2.1
* HT    HL    W     DELTAX  DELTAX  NDYMAX
  21.94 30.  20.   2.0     2.0     40
* CARD 3.1
* NLAYER
   4
* CARD 3.2
* LAYERNO   H     KF
   1        4.2   1
   2        4.3   1
   3        3.5   1
   4        39.94 1
* CARD 4.1
* R1    A1    R2    A2  R3    A3     R4    GR    GA
  5.24  60.   4.24  30. 9.86  19.781 23.86 1.0   0.5
* CARD 4.2
* INVSHOT  TS
  0        0.3
* CARD 4.3
* NUMRB  LRB    LSPACING  TSPACING  NSRB
  11     3.0    0.8       1.2        2
* CARD 5.1
* LDTYPE  DGW  GAMAW
  1       2.0  1.0
* END OF DATA
```

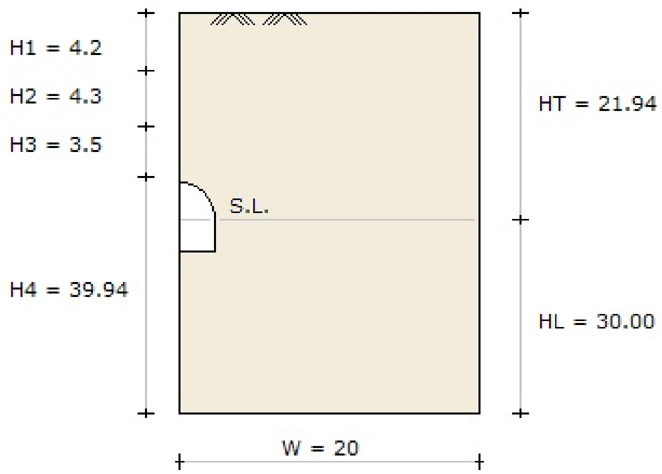


R_1	=	5.24 M	A_1 =	60°
R_2	=	4.24 M	A_2 =	30°
R_3	=	9.86 M	A_3 =	19.781°
R_4	=	23.86 M		

Number of Rock Bolts (NUMRB)	=	11
Length of Rock Bolts (LRB)	=	3.0 M
Spacing of Rock Bolts (TSPACING)	=	1.2 M
Thickness of Shotcrete (TS)	=	15 Cm
Thickness of Liner (TL)	=	30 Cm
Reinforcing Bar Area (ASI)	=	22 Cm^2
Reinforcing Bar Area (ASO)	=	22 Cm^2

Figure 7.13 Tunnel dimensions used for example problem

MODEL=1 Single Tunnel (Half Section)



DELTAX = 2.0 DELTAY = 2.0 NDYMAX = 40

Figure 7.14 Schematic tunnel section view for Model 1 example

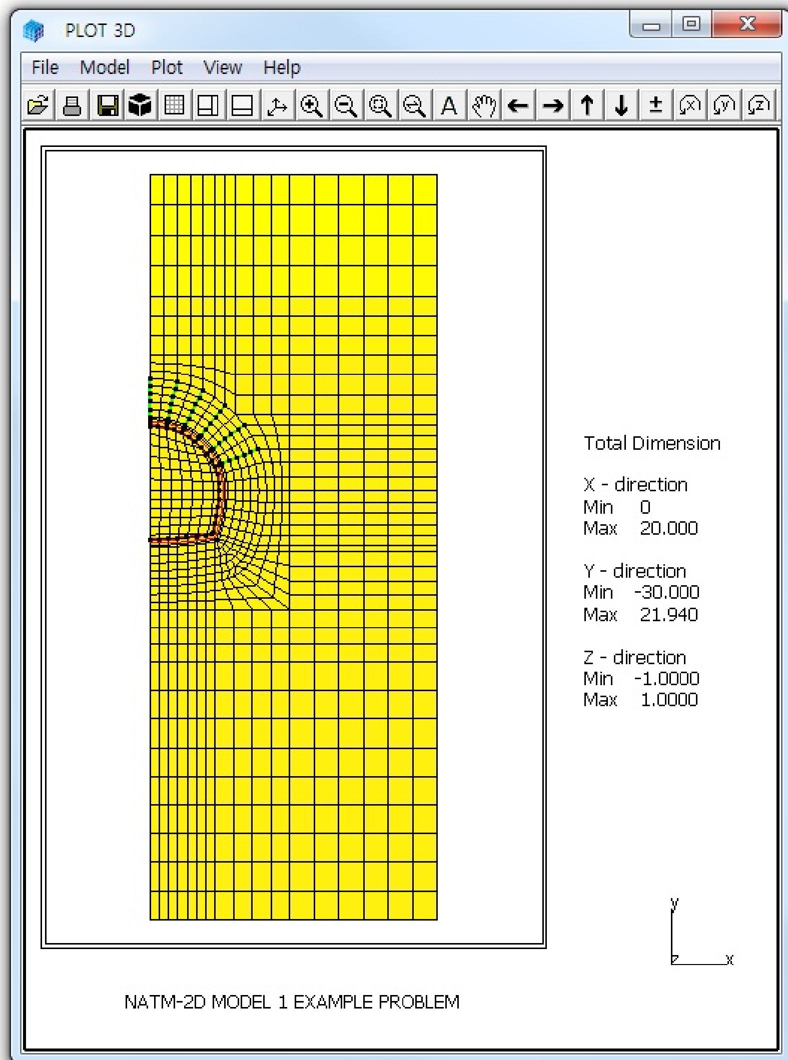


Figure 7.15 Generated finite element mesh for Model 1 example

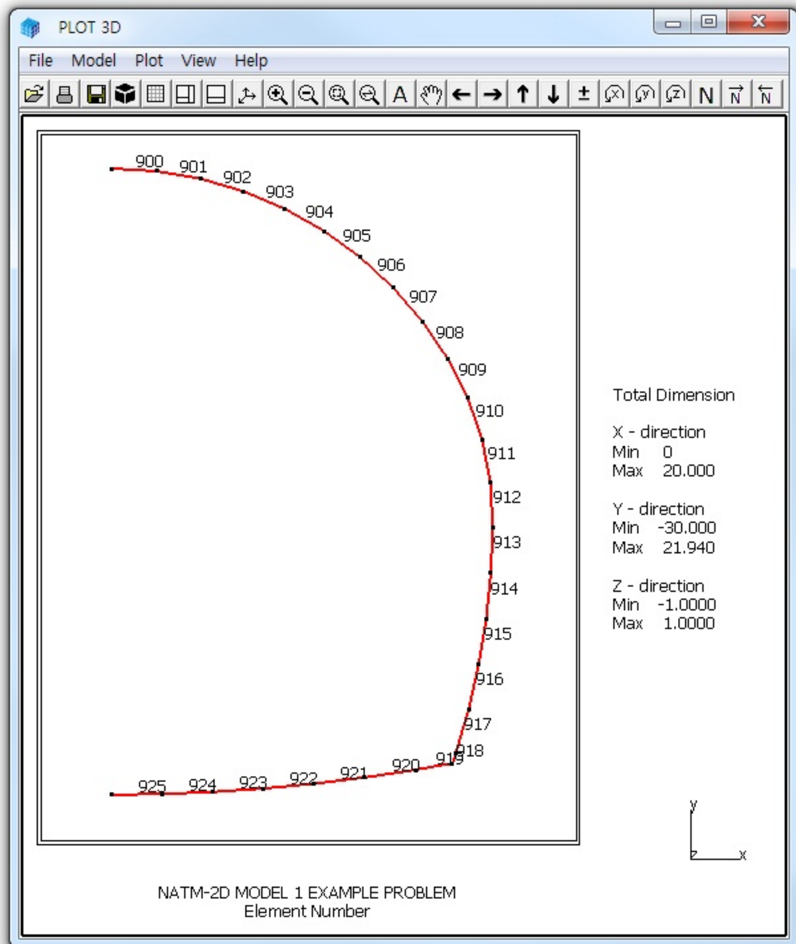


Figure 7.16 Generated beam element number for Model 1 example

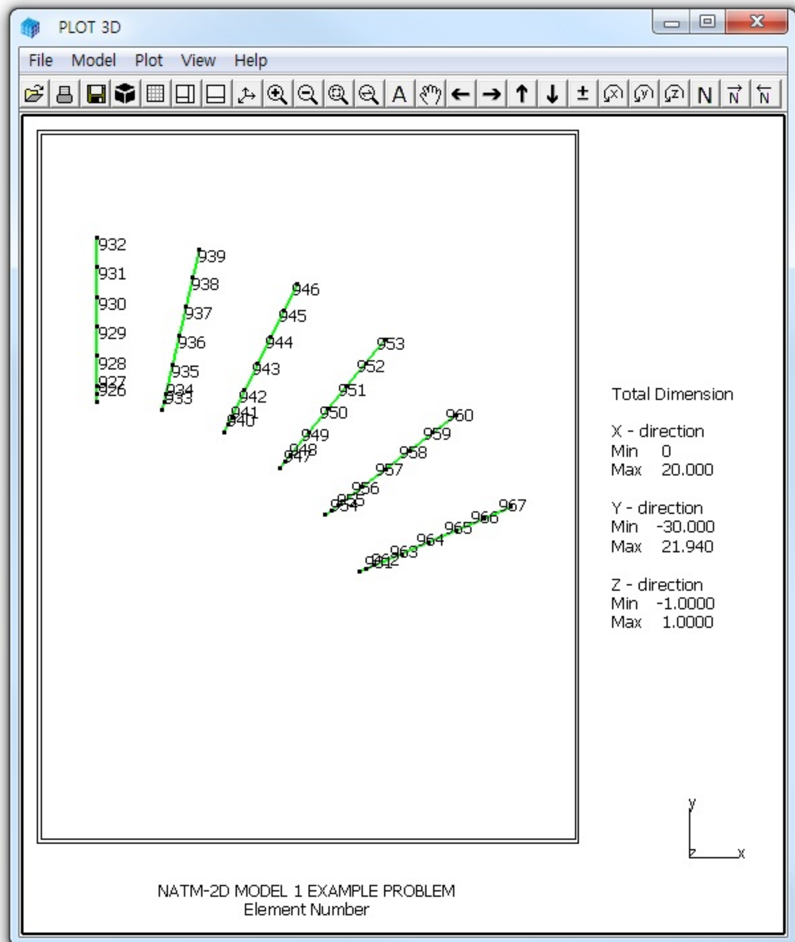
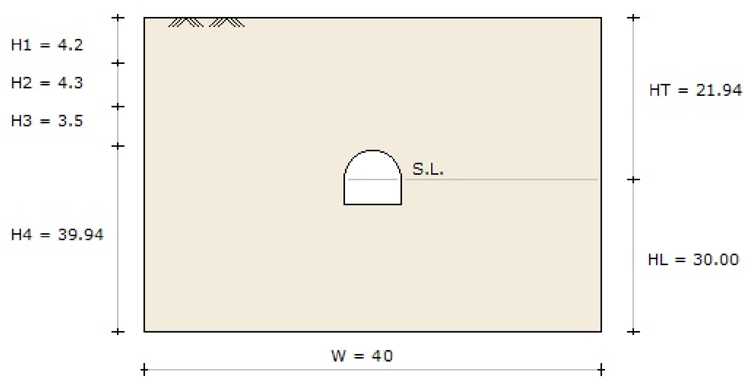


Figure 7.17 Generated truss element number for Model 1 example

Table 7.8 Listing of input file PD2-2.Dat

```
* CARD 1.1
* TITLE
  NATM-2D MODEL 2 EXAMPLE PROBLEM
* CARD 1.2
* IUNIT
   2
* CARD 1.3
* MODEL  IGEN  IEXMESH      ILNCOUPL
   2     0     0            0
* CARD 2.1
* HT    HL   W    DELTAX  DELTAX  NDYMAX
  21.94 30.  40.  2.0     2.0     40
* CARD 3.1
* NLAYER
   4
* CARD 3.2
* LAYERNO   H     KF
   1        4.2   1
   2        4.3   1
   3        3.5   1
   4        39.94 1
* CARD 4.1
* R1    A1    R2    A2  R3    A3     R4    GR    GA
  5.24  60.   4.24  30. 9.86  19.781 23.86 1.0   0.5
* CARD 4.2
* INVSHOT  TS
  0        0.3
* CARD 4.3
* NUMRB  LRB    LSPACING  TSPACING  NSRB
  11     3.0    0.8       1.2        2
* CARD 5.1
* LDTYPE  DGW  GAMAW
  1       2.0  1.0
* END OF DATA
```

MODEL=2 Single Tunnel (Full Section)



DELTAX = 2.0 DELTAY = 2.0 NDYMAX = 40

Figure 7.18 Schematic tunnel section view for Model 2 example

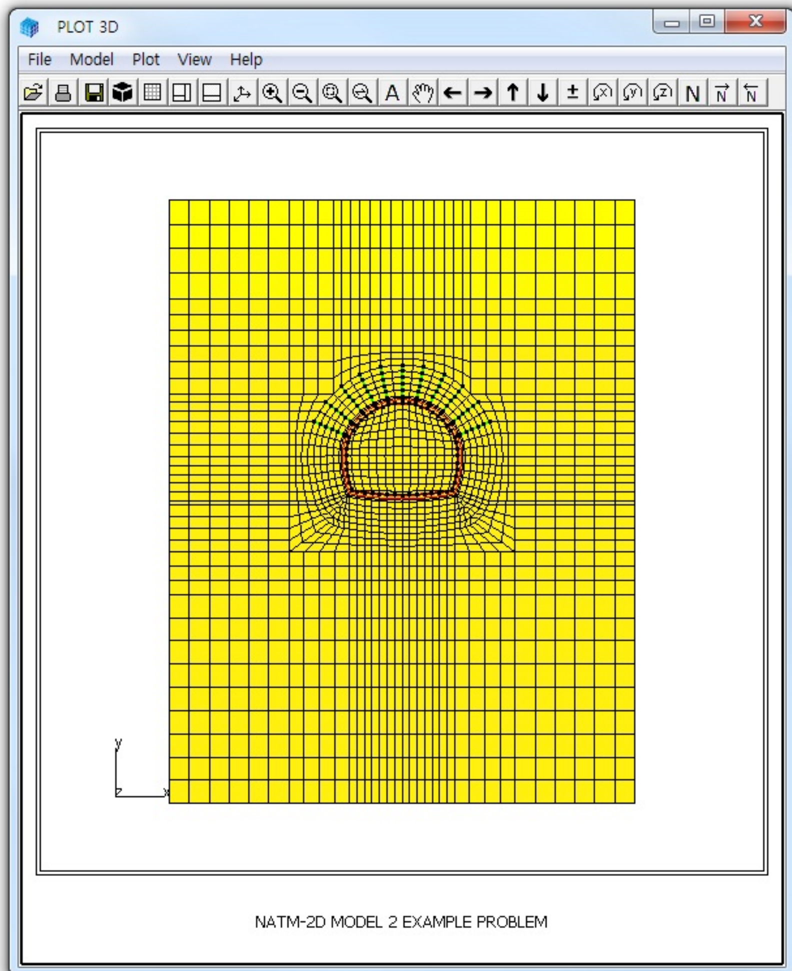
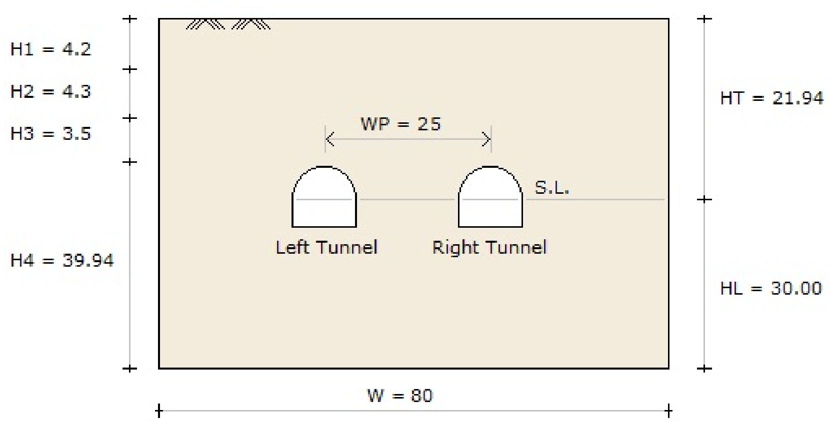


Figure 7.19 Generated finite element mesh for Model 2 example

Table 7.9 Listing of input file PD2-3.Dat

```
* CARD 1.1
* TITLE
  NATM-2D MODEL 3 EXAMPLE PROBLEM
* CARD 1.2
* IUNIT
   2
* CARD 1.3
* MODEL  IGEN  IEXMESH   ILNCOUPL
   3     0     0       0
* CARD 2.1
* HT    HL   W    WP    DELTAX  DELTAY  NDYMAX
  21.94 30.  80.  25.   2.0     2.0     40
* CARD 3.1
* NLAYER
   4
* CARD 3.2
* LAYERNO   H     KF
   1        4.2   1
   2        4.3   1
   3        3.5   1
   4        39.94 1
* CARD 4.1
* R1    A1    R2    A2  R3    A3     R4    GR    GA
  5.24  60.   4.24  30. 9.86  19.781 23.86 1.0   0.5
* CARD 4.2
* INVSHOT  TS
  0        0.3
* CARD 4.3
* NUMRB  LRB    LSPACING  TSPACING  NSRB
  11     3.0    0.8       1.2        2
* CARD 5.1
* LDTYPE  DGW  GAMAW
  1       2.0  1.0
* END OF DATA
```

MODEL=3 Two Tunnel (Symmetric Section)



DELTAX = 2.0   DELTAY = 2.0   NDYMAX = 40

Figure 7.20   Schematic tunnel section view for Model 3 example

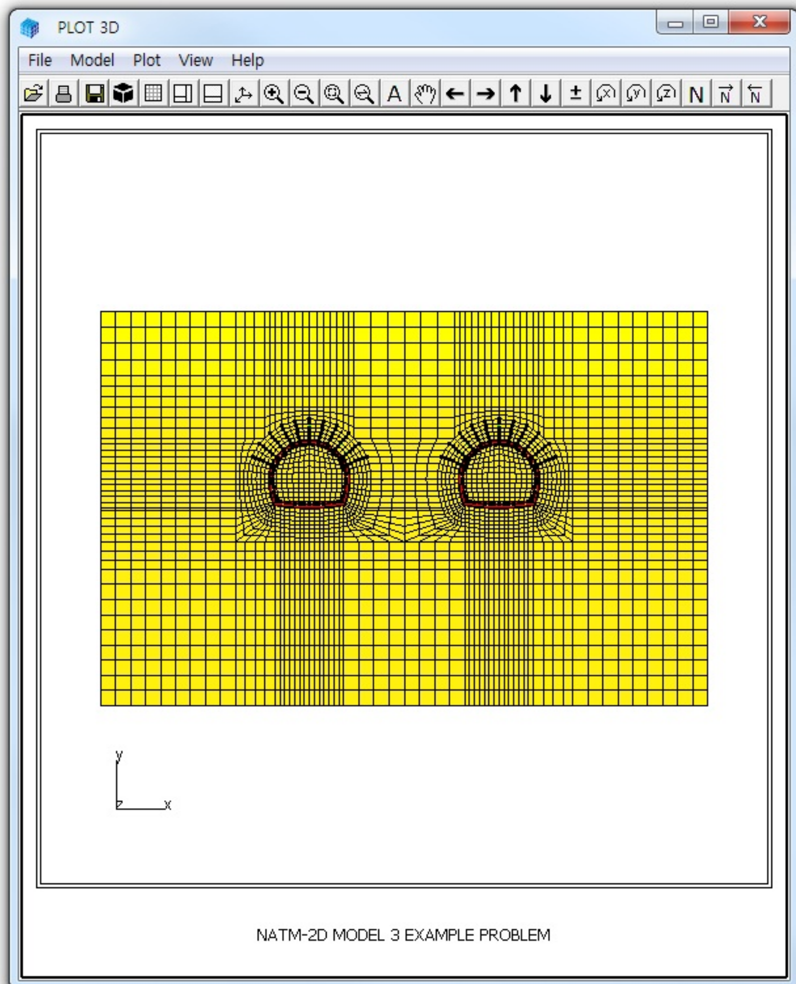
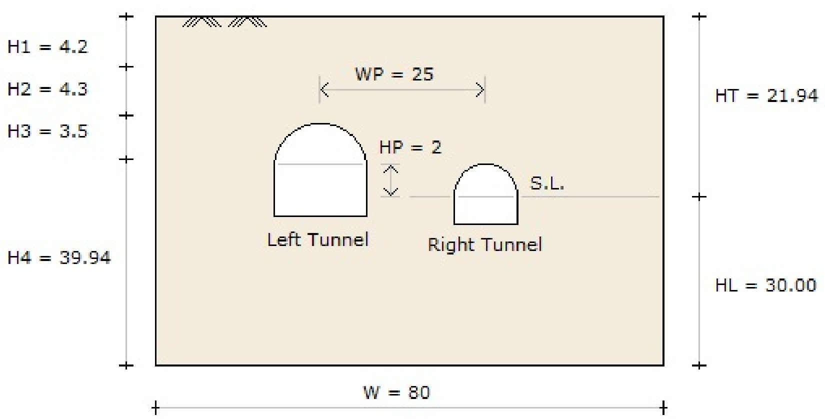


Figure 7.21 Generated finite element mesh for Model 3 example

Table 7.10 Listing of input file PD2-4.Dat

```
* CARD 1.1
* TITLE
  NATM-2D MODEL 4 EXAMPLE PROBLEM
* CARD 1.2
* IUNIT
   2
* CARD 1.3
* MODEL  IGEN  IEXMESH   ILNCOUPL
   4      0     0         0
* CARD 2.1
* HT    HL    W    WP    HP      DELTAX  DELTAY  NDYMAX
  21.94 30.  80.  25.   2.0     2.0     2.0     40
* CARD 3.1
* NLAYER
   4
* CARD 3.2
* LAYERNO   H     KF
   1        4.2   1
   2        4.3   1
   3        3.5   1
   4        39.94 1
* RIGHT TUNNEL
* CARD 4.1
* R1    A1    R2    A2  R3    A3     R4    GR    GA
  5.24  60.   4.24  30. 9.86  19.781 23.86 1.0   0.5
* CARD 4.2
* INVSHOT  TS
  0        0.3
* CARD 4.3
* NUMRB  LRB    LSPACING  TSPACING  NSRB
  11     3.0    0.8       1.2        2
* LEFT TUNNEL
* CARD 4.1
* R1    A1    R2    A2  R3    A3     R4    GR    GA
  7.24  60.   6.24  30. 11.86 21.781 25.86 1.0   0.5
* CARD 4.2
* INVSHOT  TS
  0        0.35
* CARD 4.3
* NUMRB  LRB    LSPACING  TSPACING  NSRB
  15     3.0    0.8       1.2        2
* CARD 5.1
* LDTYPE  DGW  GAMAW
  1       2.0  1.0
* END OF DATA
```

MODEL=4 Two Tunnel (Unsymmetric Section)



DELTAX = 2.0   DELTAY = 2.0
NDYMAX = 40

Right Tunnel   Tunnel dimensions are shown in Figure 7.16

Left Tunnel R_1 = 7.24 M A_1 = 60°
R_2 = 6.24 M A_2 = 30°
R_3 = 11.86 M A_3 = 21.781°
R_4 = 25.86 M

Number of Rock Bolts (NUMRB) = 15
Length of Rock Bolts (LRB) = 3.0 M
Spacing of Rock Bolts (TSPACING) = 1.2 M
Thickness of Shotcrete (TS) = 35 Cm

Figure 7.22   Schematic tunnel section view for Model 4 example

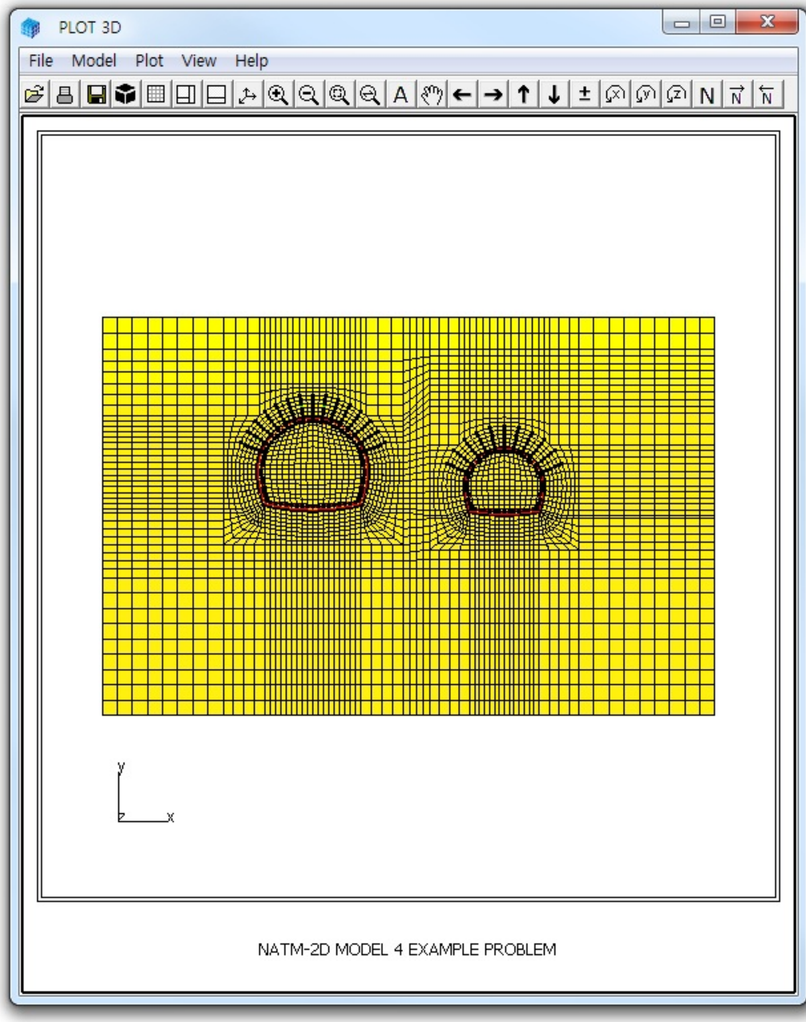


Figure 7.23 Generated finite element mesh for Model 4 example

Table 7.11 Listing of input file Shield.Dat

```
* CARD 1.1
* TITLE
  NATM-2D MODEL 2 FOR SEGMENT LINING
* CARD 1.2
* IUNIT
   2
* CARD 1.3
* MODEL  IGEN  IEXMESH    ILNCOUPL
   2     0     0          1
* CARD 2.1
* HT    HL   W    DELTAX  DELTAX  NDYMAX
  21.94 30.  40.  2.0     2.0     40
* CARD 3.1
* NLAYER
   4
* CARD 3.2
* LAYERNO   H     KF
   1        4.2   1
   2        4.3   1
   3        3.5   1
   4        39.94 1
* CARD 4.1
* R1    A1    R2    A2  R3    A3     R4    GR    GA
  5.3   60.   5.3   60. 5.3   30.    5.3   1.0   0.5
* CARD 4.2
* INVSHOT  TS   TL
  0        0.3  0.3
* NOTE: TUNNEL LINING RADIUS = R1 - TL = 5.3 - 0.3 = 5.0 M
* CARD 4.3
* NUMRB  LRB    LSPACING  TSPACING  NSRB
  11     3.0    0.8       1.2        2
* FOR FINE MESH, USE NSRB = 3
* CARD 5.1
* LDTYPE  DGW  GAMAW  HPRES  VPRES  SUBGK    ITSPR  NUMSJ
  1       2.0  1.0    20.    30.    1.0E+05  1      4
* CARD 5.2
* JOINT LOCATIONS (ANGLES FROM CROWN TOP)
* AJ1   AJ2   AJ3   AJ4
  0     60    120   180
* END OF DATA
```

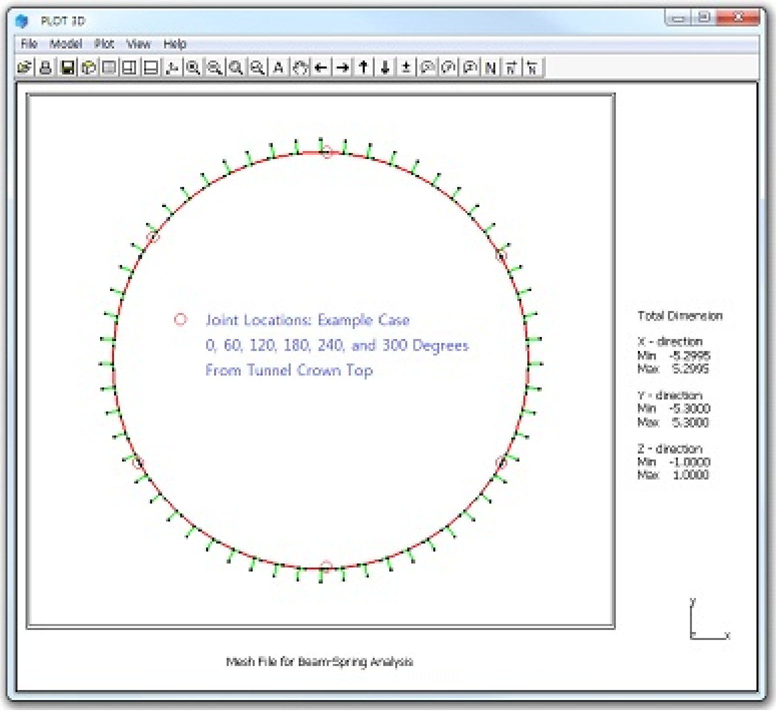


Figure 7.24 Finite element mesh for Model 2-1

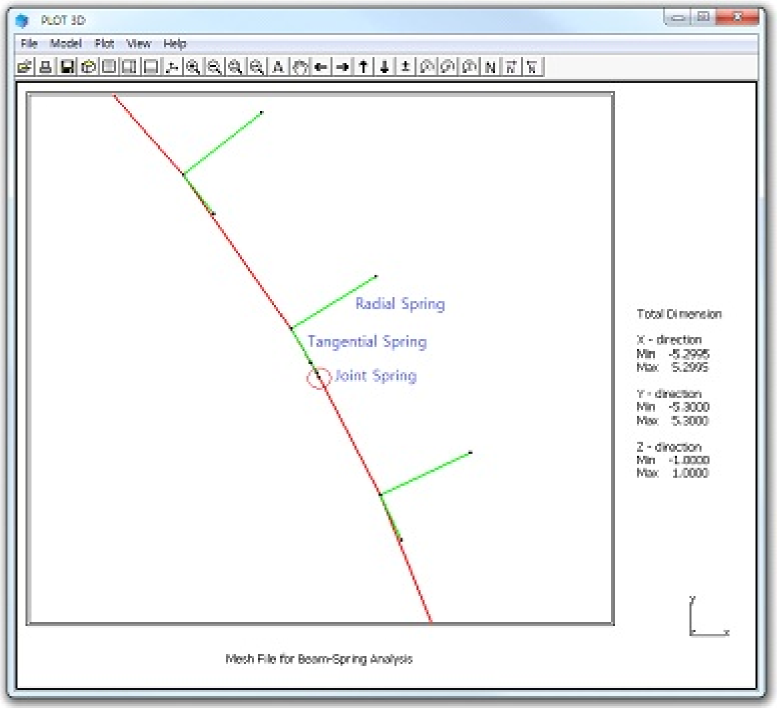


Figure 7.25 Detailed mesh around joint spring element

7.3 CIRCLE-2D

CIRCLE-2D is the special pre-processing program to generate automatically two-dimensional finite element meshes and boundary conditions for circular sections. CIRCLE-2D has three different models:

Model 1	Quarter	Section
Model 2	Half	Section
Model 3	Full	Section

CIRCLE-2D is described in Section 7.4 of User's Manual and can be selected in the following order:

Run → Mesh Generator → PreSmap → Circle 2D

When you finish the execution of CIRCLE-2D, select PLOT-3D to plot the generated finite element mesh.

Three example problems are presented here to show all three types of available models. Figure 7.26 shows schematic section views which are used for example problems.

For each model, we will present:

- Listing of input file
- Graphical output of finite element mesh

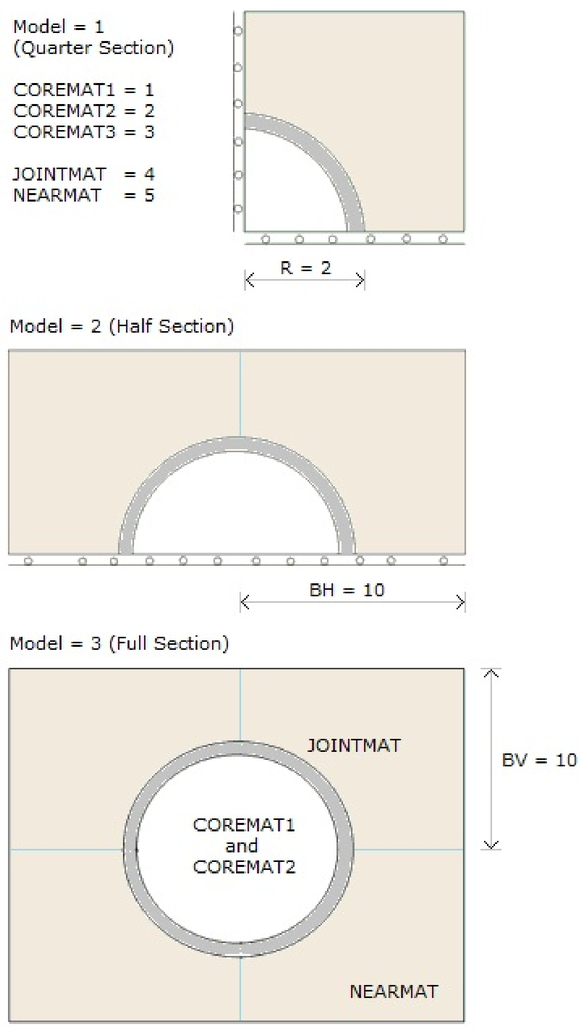


Figure 7.26 Schematic section views for CIRCLE-2D examples

Table 7.12 Listing of input file CIR1C_Q.Dat (MODEL = 1)

```
* CARD 1.1
* TITLE
  MODEL 1 (COARSE, ALL QUAD)
* CARD 1.2
* MODEL     NSNEL      NSNODE
  1         1          1
* CARD 2.1
* R         FINEMESH   NEARMESH    NDIV       BH        BV
  2.0       0          0           5          10.0      10.0
* CARD 3.1
* COREMAT1  COREMAT2   COREMAT2J   JOINTMAT   NEARMAT
  1         2          3           4          5
* END OF DATA
```

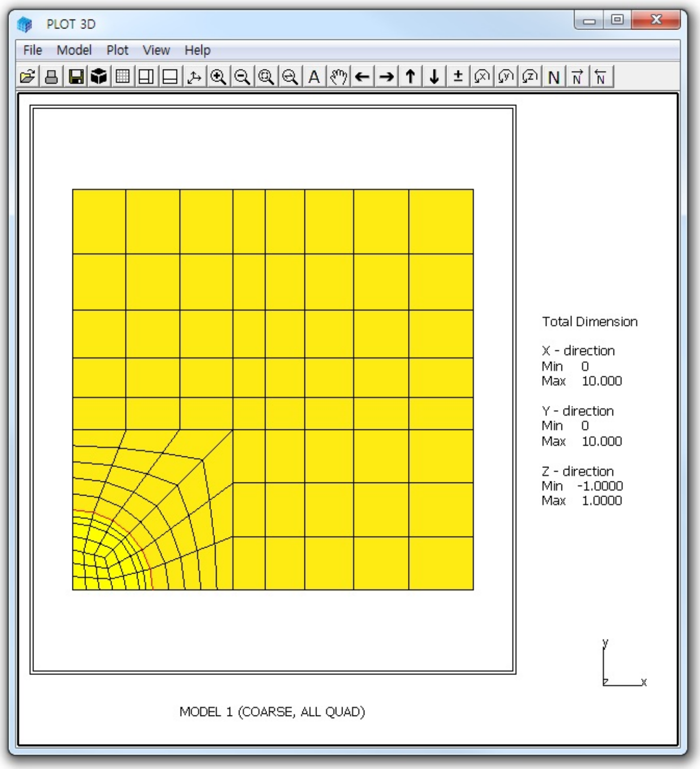


Figure 7.27 Generated finite element mesh for MODEL = 1

Table 7.13 Listing of input file CIR2C_Q.Dat (MODEL = 2)

```
* CARD 1.1
* TITLE
  MODEL 2 (COARSE, ALL QUAD)
* CARD 1.2
* MODEL     NSNEL      NSNODE
  2         1          1
* CARD 2.1
* R         FINEMESH   NEARMESH    NDIV       BH       BV
  2.0       0          0           5          10.0     10.0
* CARD 3.1
* COREMAT1  COREMAT2   COREMAT2J   JOINTMAT   NEARMAT
  1         2          3           4          5
* END OF DATA
```

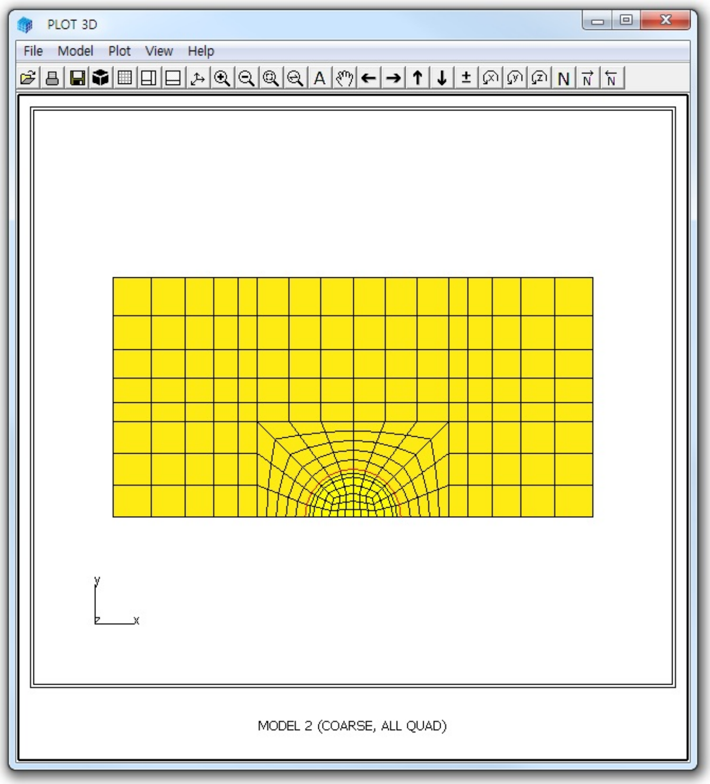


Figure 7.28 Generated finite element mesh for MODEL = 2

Table 7.14 Listing of input file CIR3C_Q.Dat (MODEL = 3)

```
* CARD 1.1
* TITLE
  MODEL 3 (COARSE, ALL QUAD)
* CARD 1.2
* MODEL     NSNEL       NSNODE
  3         1           1
* CARD 2.1
* R         FINEMESH    NEARMESH    NDIV        BH        BV
  2.0       0           0           5           10.0      10.0
* CARD 3.1
* COREMAT1  COREMAT2    COREMAT2J   JOINTMAT    NEARMAT
  1         2           3           4           5
* END OF DATA
```

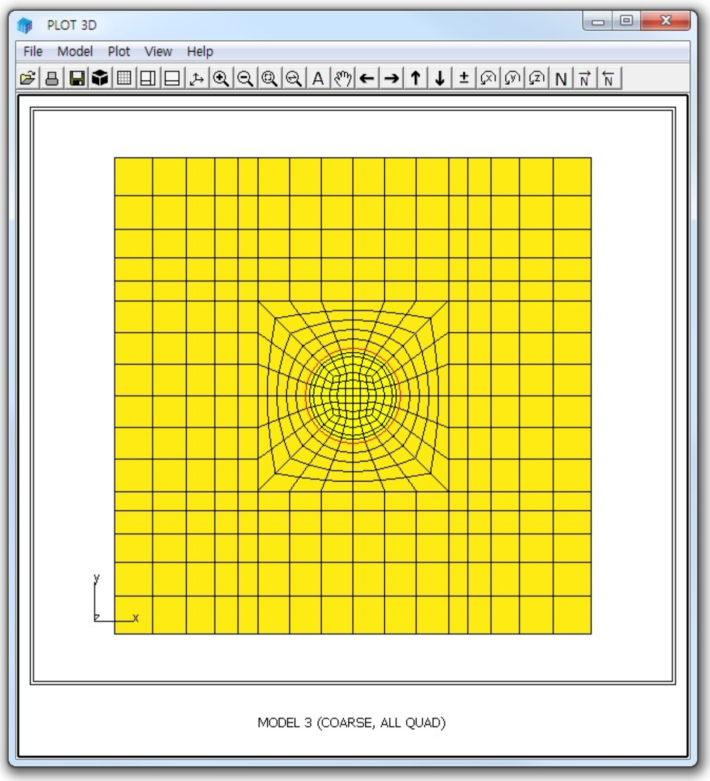


Figure 7.29 Generated finite element mesh for MODEL = 3

7.4 PRESMAP-3D

PRESMAP-3D is the basic pre-processor which can be applied to model various types of 3 dimensional geometries. Input parameters of PRESMAP-3D have been described in detail in Section 7.5 of User's Manual.

PRESMAP-3D can be selected in the following order:

Run → Mesh Generator → PreSmap → Presmap 3D

When you finish the execution of PRESMAP-3D, select PLOT-3D to plot the generated mesh.

7.4.1 Example 1

Figure 7.31 shows block nodes and block numbers for example 1. Detailed block information is listed in Table 7.15. There are 18 block nodes and 3 blocks. Both blocks 1 and 2 have 2 divisions in the x direction and only 1 division in y and z directions. Block 3 has 2 divisions in the z direction and only 1 division in x and y directions. To plot block diagram as shown in Figure 7.31, make the value of NBLOCK negative (example, NBLOCK=-3).

As boundary conditions, roller boundary is assumed along the left surface of blocks 1 and 2, fixed boundary along the right surface of block 3, and free boundary for the rest. Note that PRESMAP-3D generates fixed boundary for all rotational degrees of freedom; i.e., IRX=IRY=IRZ=1.

Graphical outputs are shown for:

- Node numbers in Figure 7.32
- Element numbers in Figure 7.33
- Boundary codes in Figure 7.34

Note that boundary codes in Figure 7.34 are expressed in 3 digits at nodal points. First digit represents ISX, second for ISY and third for ISZ.

Table 7.15 Listing of input file GM3D.Rgn

```
* CARD 1.1
* TITLE
  EXAMPLE 1
* CARD 1.2
* NBLOCK  NBNODE  NSNODE  NSNEL  CMFAC
  3       18      1       1      1.0
* CARD 2.1
* NODE   X      Y      Z
   1     0.0    4.0    5.0
   2     3.0    4.0    5.0
   3     4.0    4.0    5.0
   4     0.0    0.0    5.0
   5     3.0    0.0    5.0
   6     4.0    0.0    5.0
*
   7     0.0    4.0    2.0
   8     3.0    4.0    2.0
   9     4.0    4.0    2.0
  10     0.0    0.0    2.0
  11     3.0    0.0    2.0
  12     4.0    0.0    2.0
*
  13     0.0    4.0    0.0
  14     3.0    4.0    0.0
  15     4.0    4.0    0.0
  16     0.0    0.0    0.0
  17     3.0    0.0    0.0
  18     4.0    0.0    0.0
* -----------------------------------------------------------
* CARD 3.1
  BLOCK 1
* CARD 3.2
* ILAG
   0
* CARD 3.3
*  I1   I2   I3   I4   I5   I6   I7   I8
    2    1    4    5    8    7   10   11
*  M9  M10  M11  M12  M13  M14  M15  M16  M17  M18  M19  M20
    0    0    0    0    0    0    0    0    0    0    0    0
* M21  M22  M23  M24  M25  M26  M27
* CARD 3.4.1
* NBOUND
   2
```

```
* CARD 3.4.2
* IBTYPE  ISX  ISY  ISZ  IFX  IFY  IFZ
   1       0    0    0    0    0    0
   4       1    0    0    1    0    0
* CARD 3.5
* MATNO  NDX  NDY  NDZ  KS  KF
   1      2    1    1    0   0
* -------------------------------------------------------------
* CARD 3.1
  BLOCK 2
* CARD 3.2
* ILAG
   0
* CARD 3.3
*  I1   I2   I3   I4   I5   I6   I7   I8
    8    7   10   11   14   13   16   17
*  M9  M10  M11  M12  M13  M14  M15  M16  M17  M18  M19  M20
    0    0    0    0    0    0    0    0    0    0    0    0
* M21  M22  M23  M24  M25  M26  M27
* CARD 3.4.1
* NBOUND
   2
* CARD 3.4.2
* IBTYPE  ISX  ISY  ISZ  IFX  IFY  IFZ
   1       0    0    0    0    0    0
   4       1    0    0    1    0    0
* CARD 3.5
* MATNO  NDX  NDY  NDZ  KS  KF
   2      2    1    1    0   0
* -------------------------------------------------------------
* CARD 3.1
  BLOCK 3
* CARD 3.2
* ILAG
   0
* CARD 3.3
*  I1   I2   I3   I4   I5   I6   I7   I8
    3    2    5    6   15   14   17   18
*  M9  M10  M11  M12  M13  M14  M15  M16  M17  M18  M19  M20
    9    8   11   12    0    0    0    0    0    0    0    0
* M21  M22  M23  M24  M25  M26  M27
* CARD 3.4.1
* NBOUND
   2
* CARD 3.4.2
* IBTYPE  ISX  ISY  ISZ  IFX  IFY  IFZ
   1       0    0    0    0    0    0
   5       1    1    1    1    1    1
* CARD 3.5
* MATNO  NDX  NDY  NDZ  KS  KF
   3      1    1    2    0   1
```

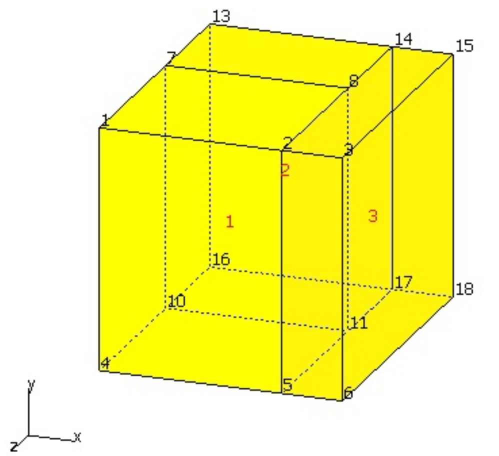


Figure 7.31 Block diagram for example 1

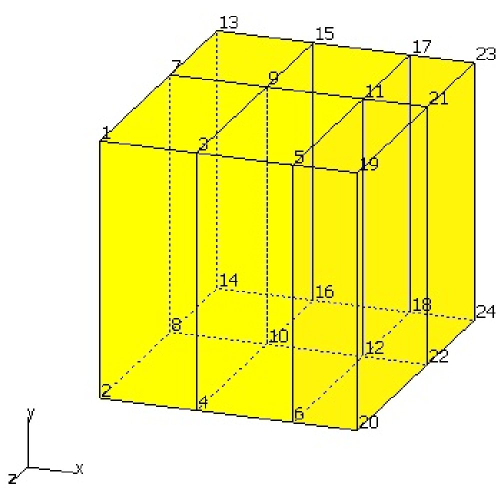


Figure 7.32 Generated node numbers for example 1

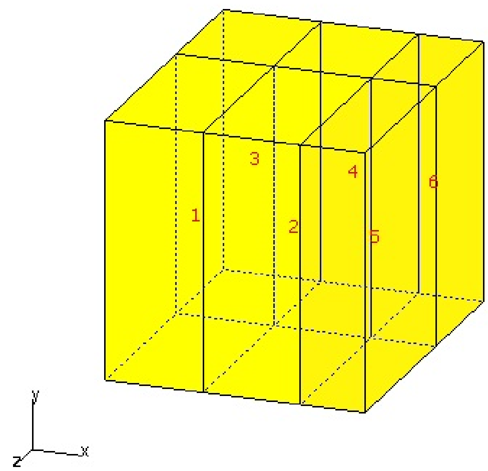


Figure 7.33 Generated element numbers for example 1

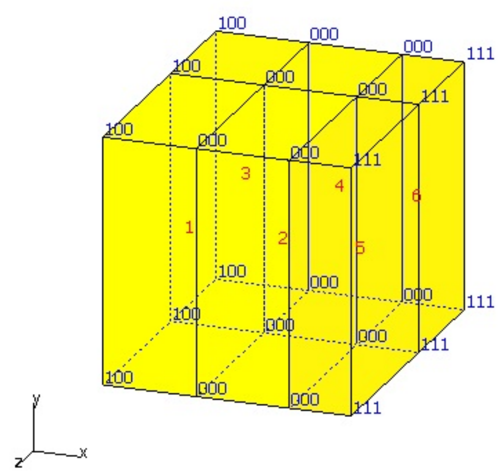


Figure 7.34 Generated boundary codes for example 1 (ISX, ISY, ISZ)

7.5 CROSS-3D

CROSS-3D is the special pre-processing program developed to generate automatically three-dimensional finite element meshes and boundary conditions for crossing tunnels. There are 3 models available for CROSS-3D. Model 1 represents identical size tunnels crossing at right angle at the same level. Model 2 represents large and small tunnels crossing at right angle at the same level. And Model 3 represents lower and upper tunnels crossing at right angle with some clearance. Input parameters of each model have been described in detail in Section 7.6 of User's Manual.

CROSS-3D can be selected in the following order:

Run → Mesh Generator → PreSmap → Cross 3D

When you finish the execution of CROSS-3D, select PLOT-3D to plot the generated mesh.

It should be noted that once you finished running CROSS-3D, you will obtain an intermediate file with file extension .Tmp in working directory. This intermediate file contains useful block information which is essentially the input data to the program PRESMAP-3D.

7.5.1 Model 1

Figure 7.35 shows the schematic view of identical two crossing tunnels for Model 1 example problem. Dimensions defining tunnel location are listed in Figure 7.36. Table 7.16 shows the listing of input file CROSS-M1.Dat.

The output file, CROSS-M1.Tmp in Table 7.17, from CROSS-3D contains block information for the program PRESMAP-3D. Block diagram is shown in Figures 7.37.

Generated finite element mesh is shown in Figure 7.38. Figure 7.39 shows finite element meshes around tunnel core sections.

Table 7.16 Listing of input file CROSS-M1.Dat

```
*
* CARD 1.1
* TITLE
 Identical two crossing tunnels (MODELNO = 1)
* CARD 1.2
* MODELNO  KF  NSNODE  NSNEL  CMFAC
    1       1    1       1     1.0
* CARD 2.1.1
* XL    YB    YT    ZL    t
 100.   50.   100.  100.  3.0
* CARD 2.1.2
* IPART  NDR  NTBND  NTOPN
    0      2   20     20
* CARD 2.1.3
* NTNODE
    9
* NODE  X       Y
    1   0.0     4.0
    2   2.8284  2.8284
    3   4.0     0.0
    4   4.0    -2.0
    5   0.0    -3.0
    6   1.53    3.7
    7   3.7     1.53
    8   4.0    -1.0
    9   2.0    -2.7
* CARD 3.1
* NBOUND
    6
* CARD 3.2
* IBTYPE ISX  ISY  ISZ  IFX  IFY  IFZ
    1     0    0    0    1    1    1
    2     0    0    1    1    1    1
    3     0    0    1    1    1    1
    4     1    0    0    1    1    1
    5     1    0    0    1    1    1
    7     0    1    0    1    1    1
* END OF DATA
```

Table 7.17 Listing of output file CROSS-M1.Tmp

```
* CARD 1.1
* TITLE
 Identical two crossing tunnels (MODELNO = 1)
* CARD 1.2
* NBLOCK NBNODE NSNODE  NSNEL          CMFAC
      25    150      1      1     .10000E+01
* CARD 2.1
* NODE   X-COORDINATE   Y-COORDINATE   Z-COORDINATE
    1     .00000E+00     .10000E+03     .10000E+03
    2     .00000E+00     .29125E+02     .10000E+03
    3     .00000E+00     .70000E+01     .10000E+03
    4     .00000E+00     .40000E+01     .10000E+03
    5     .00000E+00     .00000E+00     .10000E+03
    6     .00000E+00    -.30000E+01     .10000E+03
    7     .00000E+00    -.60000E+01     .10000E+03
    8     .00000E+00    -.18938E+02     .10000E+03
    9     .00000E+00    -.50000E+02     .10000E+03
   10     .26775E+01     .64750E+01     .10000E+03
   11     .15300E+01     .37000E+01     .10000E+03

    -

  139     .40000E+01    -.50000E+01     .26688E+02
  140     .40000E+01    -.50000E+02     .26688E+02
  141     .70000E+01     .00000E+00     .29125E+02
  142     .70000E+01    -.20000E+01     .29125E+02
  143     .70000E+01    -.50000E+01     .29125E+02
  144     .70000E+01    -.50000E+02     .29125E+02
  145     .10000E+03     .10000E+03     .27459E+02
  146     .10000E+03     .49497E+01     .27459E+02
  147     .10000E+03     .00000E+00     .29125E+02
  148     .10000E+03    -.20000E+01     .29125E+02
  149     .10000E+03    -.50000E+01     .29125E+02
  150     .10000E+03    -.50000E+02     .29125E+02
* ===========================================================
* CARD 3.1
  BLOCK  1
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1   I2   I3   I4   I5   I6   I7   I8
   12    4    5   14   58   50   51   60
*  M9  M10  M11  M12  M13  M14  M15  M16  M17  M18  M19  M20
  136  129  130  137   11    0    0   13   57    0    0   59
```

```
* CARD 3.4.1
* NBOUND
    3
* CARD 3.4.2
* IBTYPE ISX   ISY   ISZ   IFX   IFY   IFZ
      1     0     0     0     1     1     1
      2     0     0     1     1     1     1
      4     1     0     0     1     1     1
* CARD 3.5
* MATNO  NDX   NDY  NDZ    KS    KF
      1     4     4     5     0     1
* ===========================================================
* CARD 3.1
  BLOCK  2
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1    I2    I3    I4    I5    I6    I7    I8
   25     3     4    12    68    49    50    58
*  M9   M10   M11   M12   M13   M14   M15   M16   M17   M18   M19   M20
  135   128   129   136    10     0    11     0    56     0    57     0
* CARD 3.4.1
* NBOUND
    3
* CARD 3.4.2
* IBTYPE ISX   ISY   ISZ   IFX   IFY   IFZ
      1     0     0     0     1     1     1
      2     0     0     1     1     1     1
      4     1     0     0     1     1     1
* CARD 3.5
* MATNO  NDX   NDY  NDZ    KS    KF
      2     4     2     5     0     1

    -
* ===========================================================
* CARD 3.1
  BLOCK           24
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1    I2    I3    I4    I5    I6    I7    I8
   43    29    30    44   123    72    73   124
*  M9   M10   M11   M12   M13   M14   M15   M16   M17   M18   M19   M20
  148   142   143   149    36     0    37     0    81     0    82     0
```

```
* CARD 3.4.1
* NBOUND
    3
* CARD 3.4.2
* IBTYPE ISX   ISY   ISZ   IFX   IFY   IFZ
      1    0     0     0     1     1     1
      2    0     0     1     1     1     1
      5    1     0     0     1     1     1
* CARD 3.5
* MATNO   NDX   NDY   NDZ    KS    KF
     10     5     2     5     0     1
* ============================================================
* CARD 3.1
  BLOCK          25
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1    I2    I3    I4    I5    I6    I7    I8
   44    30    32    46   124    73    75   126
*  M9   M10   M11   M12   M13   M14   M15   M16   M17   M18   M19   M20
  149   143   144   150    37    31    38    45    82    74    83   125
* CARD 3.4.1
* NBOUND
    4
* CARD 3.4.2
* IBTYPE ISX   ISY   ISZ   IFX   IFY   IFZ
      1    0     0     0     1     1     1
      2    0     0     1     1     1     1
      5    1     0     0     1     1     1
      7    0     1     0     1     1     1
* CARD 3.5
* MATNO   NDX   NDY   NDZ    KS    KF
     10     5     5     5     0     1
* ============================================================
```

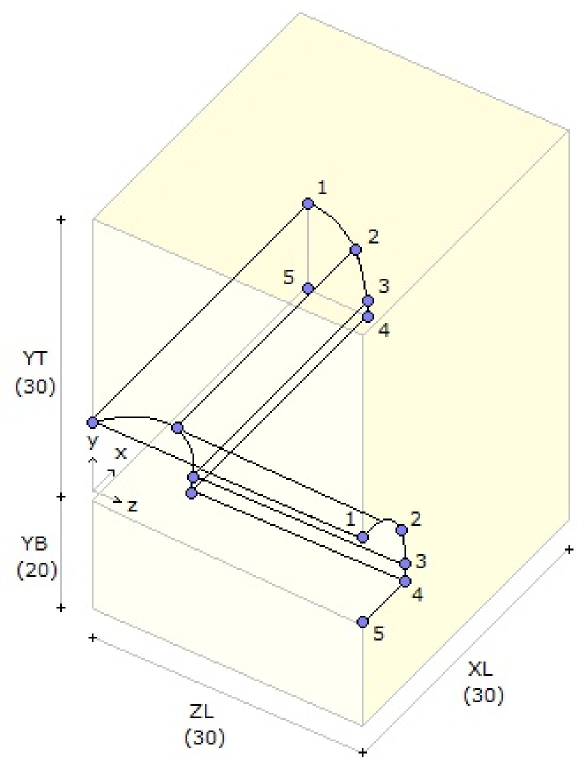


Figure 7.35 Schematic view of crossing tunnels for Model 1

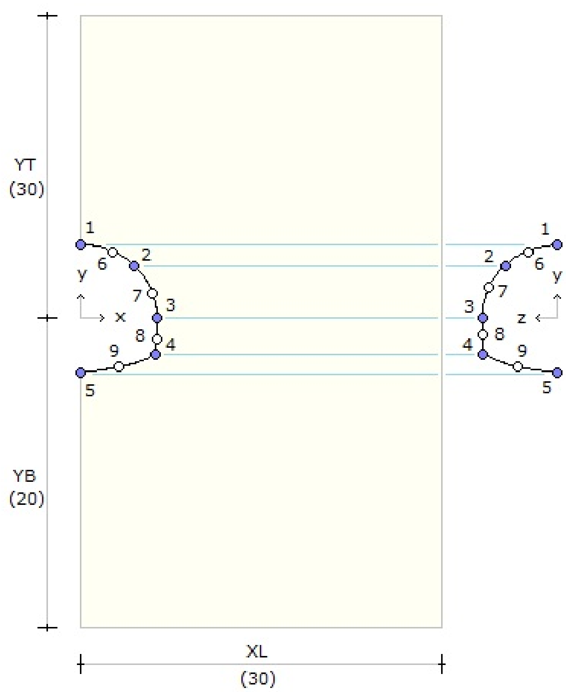


Figure 7.36 Tunnel shapes for Model 1

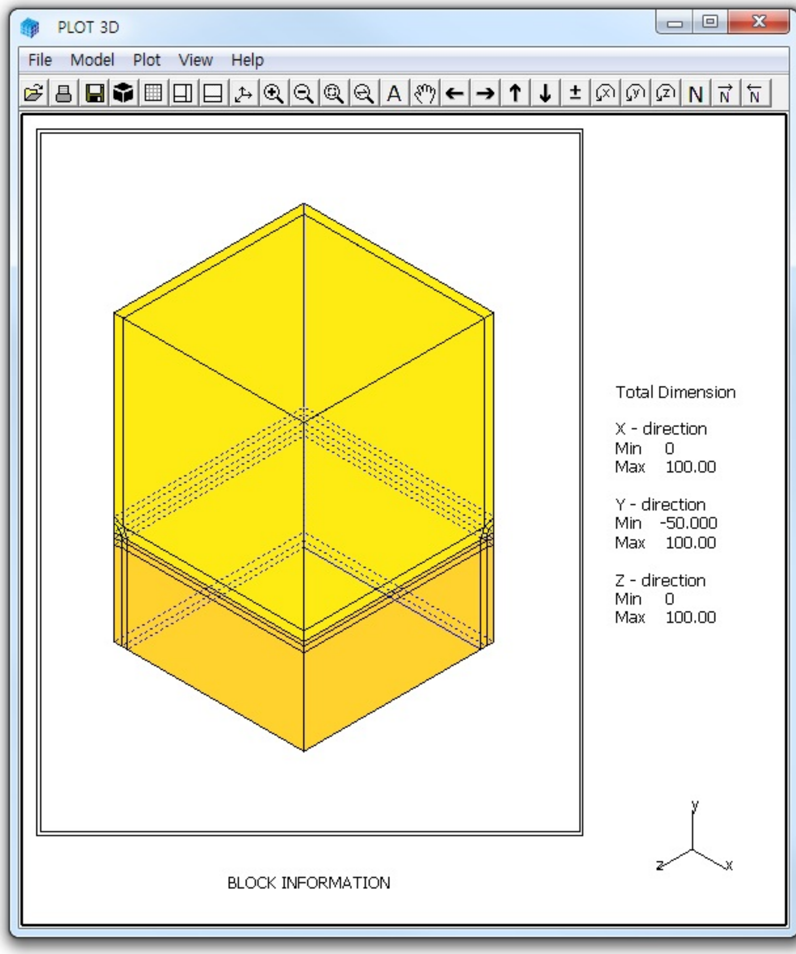


Figure 7.37 Block diagram for Model 1

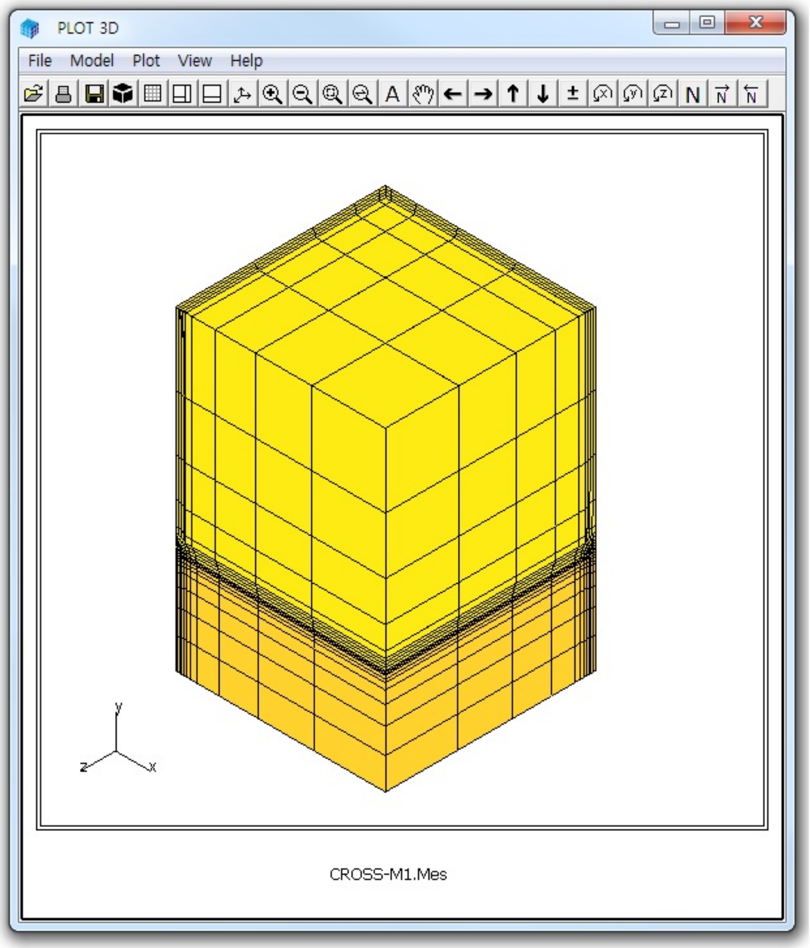


Figure 7.38 Generated finite element mesh for Model 1

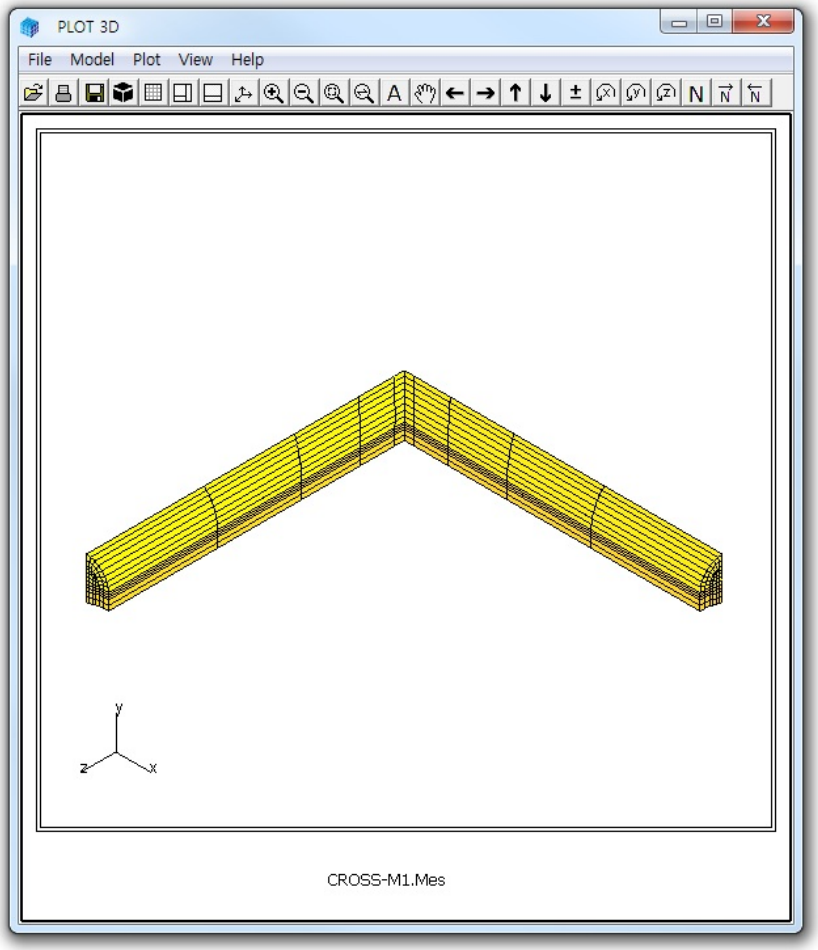


Figure 7.39 Generated mesh around tunnel core sections for Model 1

7.5.2 Model 2

Figure 7.40 shows the schematic view of large and small crossing tunnels for Model 2 example problem. Dimensions defining tunnel location are listed in Figure 7.41. Table 7.18 shows the listing of input file CROSS-M2.Dat.

The output file, CROSS-M2.Tmp in Table 7.19, from CROSS-3D contains block information for the program PRESMAP-3D. Block diagram is shown in Figures 7.42.

Generated finite element mesh is shown in Figure 7.43. Figure 7.44 shows the finite element meshes around tunnel core sections.

Table 7.18 Listing of input file CROSS-M2.Dat

```
* CARD 1.1
* TITLE
 Large and small crossing tunnels (MODELNO = 2)
* CARD 1.2
* MODELNO  KF  NSNODE  NSNEL  CMFAC
    2       1    1       1      1.0
* CARD 2.2.1
* XL     YB     YT     ZL     tl     ts
  30.    20.    30.    30.    3.0    3.0
* CARD 2.2.2
* IPART  NDR  NTBND  NTOPNL  NTOPNS
    0      2   20     20      14
* CARD 2.2.3
* NTLNODE
    9
* NODE  X       Y
    1   0.0     9.0
    2   4.3     7.0
    3   6.6     4.0
    4   7.2     2.0
    5   7.3     0.0
    6   7.3    -2.0
    7   0.0    -3.0
    8   2.3     8.3
    9   5.7     5.5
```

```
* CARD 2.3.3
* NTSNODE
    8
* NODE   Z        Y
    1   0.0      4.0
    2   3.5      2.0
    3   4.0      0.0
    4   4.0     -2.0
    5   0.0     -2.0
    6   2.6      3.0
    7   3.9      1.0
    8   4.0     -1.0
* CARD 3.1
* NBOUND
    6
* CARD 3.2
* IBTYPE ISX   ISY   ISZ   IFX   IFY   IFZ
    1     0     0     0     1     1     1
    2     0     0     1     1     1     1
    3     0     0     1     1     1     1
    4     1     0     0     1     1     1
    5     1     0     0     1     1     1
    7     0     1     0     1     1     1
* END OF DATA
```

Table 7.19 Listing of output file CROSS-M2.Tmp

```
* CARD 1.1
* TITLE
 Large and small crossing tunnels (MODELNO = 2)
* CARD 1.2
* NBLOCK NBNODE NSNODE  NSNEL          CMFAC
      34    201      1      1     .10000E+01
* CARD 2.1
* NODE   X-COORDINATE   Y-COORDINATE   Z-COORDINATE
    1      .00000E+00     .30000E+02     .30000E+02
    2      .49793E+01     .30000E+02     .30000E+02
    3      .81520E+01     .30000E+02     .30000E+02
    4      .30000E+02     .30000E+02     .30000E+02
    5      .00000E+00     .12000E+02     .30000E+02
    6      .49793E+01     .99021E+01     .30000E+02
    7      .81520E+01     .70000E+01     .30000E+02
    8      .30000E+02     .70000E+01     .30000E+02
    9      .00000E+00     .90000E+01     .30000E+02
   10      .43000E+01     .70000E+01     .30000E+02
   11      .66000E+01     .40000E+01     .30000E+02
    -
  193      .10300E+02    -.12500E+02     .70000E+01
  194      .30000E+02    -.12500E+02     .70000E+01
```

```
  199     .00000E+00     .00000E+00     .00000E+00
  200     .10212E+02     .17500E+01     .68250E+01
  201     .10300E+02    -.10000E+01     .70000E+01
* ===========================================================
* CARD 3.1
  BLOCK  1
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1    I2    I3    I4    I5    I6    I7    I8
   10     9    12    11    41    40    42    43
*  M9   M10   M11   M12   M13   M14   M15   M16   M17   M18   M19   M20
  190   166   167   177   112     0     0   113   124     0     0   125
* CARD 3.4.1
* NBOUND
    3
* CARD 3.4.2
* IBTYPE ISX   ISY   ISZ   IFX   IFY   IFZ
      1     0     0     0     1     1     1
      2     0     0     1     1     1     1
      4     1     0     0     1     1     1
* CARD 3.5
* MATNO  NDX  NDY  NDZ   KS   KF
      1    4    3    6    0    1
* ===========================================================
* CARD 3.1
  BLOCK  2
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1    I2    I3    I4    I5    I6    I7    I8
   11    12    13    14    43    42    22    23
*  M9   M10   M11   M12   M13   M14   M15   M16   M17   M18   M19   M20
  177   167   168   178     0     0     0   114     0   159     0   147
* CARD 3.4.1
* NBOUND
    3
* CARD 3.4.2
* IBTYPE ISX   ISY   ISZ   IFX   IFY   IFZ
      1     0     0     0     1     1     1
      2     0     0     1     1     1     1
    -
* CARD 3.5
* MATNO  NDX  NDY  NDZ   KS   KF
      1    4    4    6    0    1
```

```
* ============================================================
* CARD 3.1
  BLOCK          33
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1   I2   I3   I4   I5   I6   I7   I8
   51   50   54   55   63   62   66   67
*  M9  M10  M11  M12  M13  M14  M15  M16  M17  M18  M19  M20
  144  185  186  145   91    0   92    0  156    0  157    0
* CARD 3.4.1
* NBOUND
    3
* CARD 3.4.2
* IBTYPE ISX  ISY  ISZ  IFX  IFY  IFZ
      1    0    0    0    1    1    1
      2    0    0    1    1    1    1
      5    1    0    0    1    1    1
* CARD 3.5
* MATNO  NDX  NDY  NDZ   KS   KF
     10    6    2    6    0    1
* ============================================================
* CARD 3.1
  BLOCK          34
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1   I2   I3   I4   I5   I6   I7   I8
   55   54   58   59   67   66   72   73
*  M9  M10  M11  M12  M13  M14  M15  M16  M17  M18  M19  M20
  145  186  187  146   92   95   97   96  157  193  158  194
* CARD 3.4.1
* NBOUND
    4
* CARD 3.4.2
* IBTYPE ISX  ISY  ISZ  IFX  IFY  IFZ
      1    0    0    0    1    1    1
      2    0    0    1    1    1    1
      5    1    0    0    1    1    1
      7    0    1    0    1    1    1
* CARD 3.5
* MATNO  NDX  NDY  NDZ   KS   KF
     10    6    5    6    0    1
```

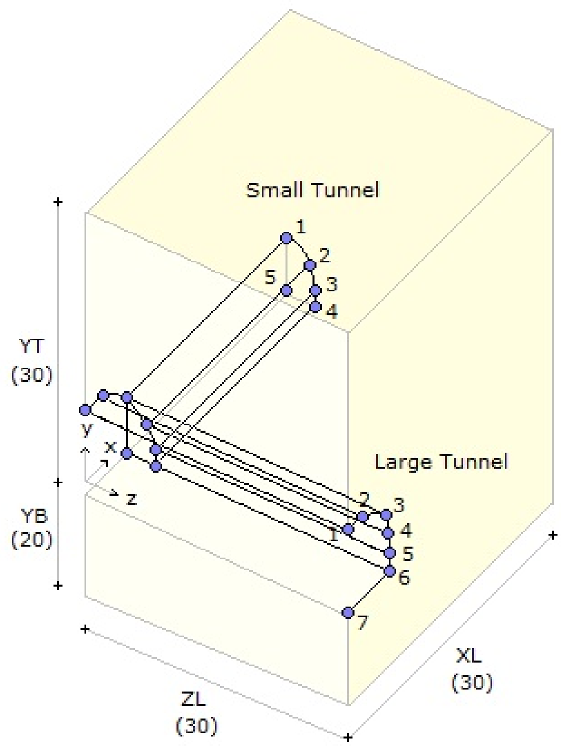


Figure 7.40 Schematic view of crossing tunnels for Model 2

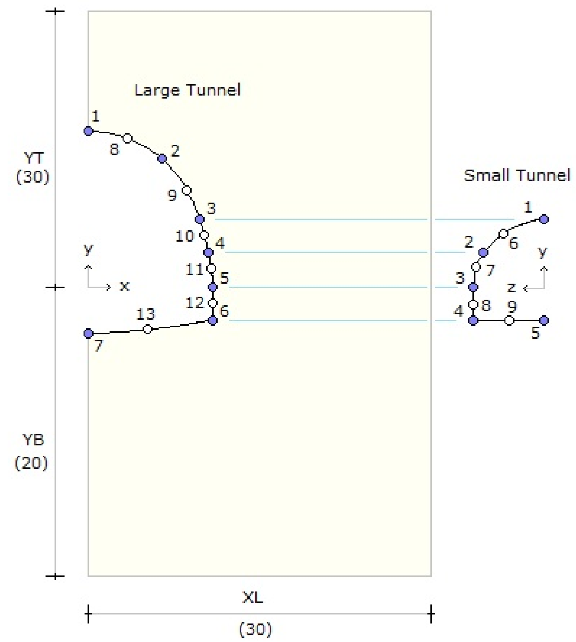


Figure 7.41 Tunnel shapes for Model 2

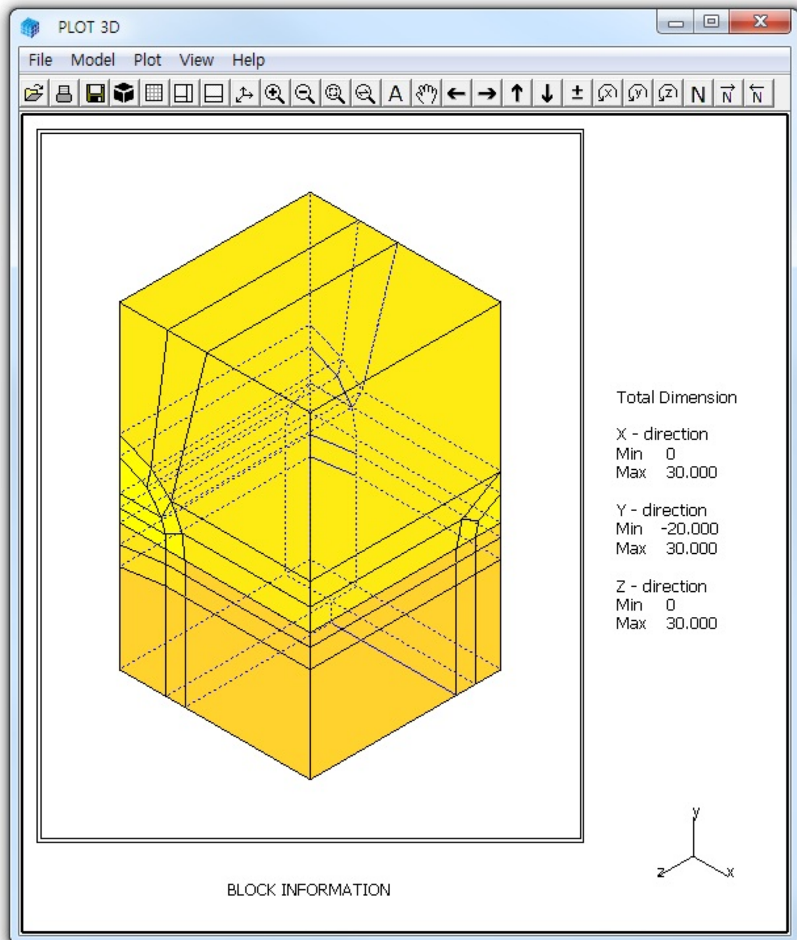


Figure 7.42 Block diagram for Model 2

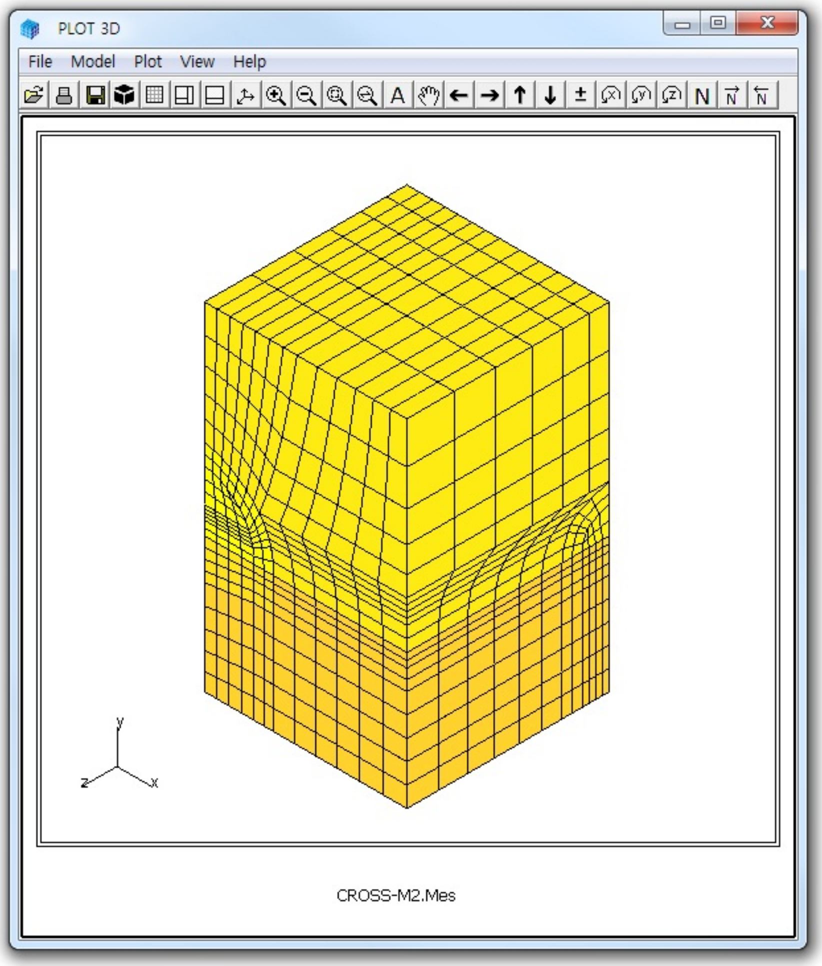


Figure 7.43 Generated finite element mesh for Model 2

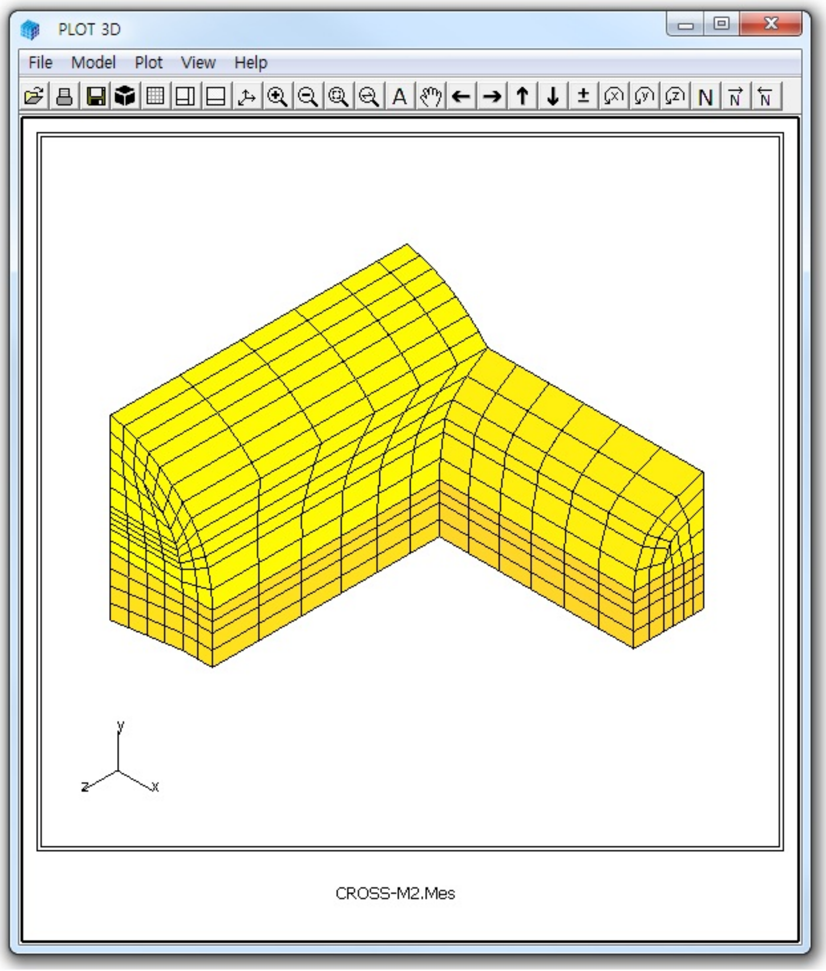


Figure 7.44 Generated mesh around tunnel core sections for Model 2

7.5.3 Model 3

Figure 7.45 shows the schematic view of crossing tunnels with clearance for Model 3 example problem. Dimensions defining tunnel location are listed in Figure 7.46. Table 7.20 shows the listing of input file CROSS-M3.Dat.

The output file, CROSS-M3.Tmp in Table 7.21, from CROSS-3D contains block information for the program PRESMAP-3D. Block diagram is shown in Figures 7.47.

Generated finite element mesh is shown in Figure 7.48. Figure 7.49 shows the finite element meshes around tunnel core sections.

Table 7.20 Listing of input file CROSS-M3.Dat

```
* CARD 1.1
* TITLE
  Crossing tunnels with clearance (MODELNO = 3)
* CARD 1.2
* MODELNO  KF  NSNODE  NSNEL  CMFAC
    3       1    1       1     1.0
* CARD 2.3.1
* XL    YB    YC    YT    ZL    tl    tu
  30.   20.   16.   20.   30.   3.0   3.0
* CARD 2.3.2
* NDRL   NDRU  NTBND  NTOPNL  NTOPNS
    2      2    20     14      14
* CARD 2.3.3
* NTLNODE
    9
* NODE  X       Y
    1   0.0     4.0
    2   2.828   2.828
    3   4.0     0.0
    4   2.828  -2.828
    5   0.0    -4.0
    6   1.531   3.7
    7   3.7     1.531
    8   3.7    -1.531
    9   1.531  -3.7
* CARD 2.3.3
* NTUNODE
    9
```

```
* NODE  Z       Y
    1   0.0     19.
    2   2.12    18.12
    3   3.0     16.
    4   2.12    13.88
    5   0.0     13.
    6   1.148   18.77
    7   2.77    17.148
    8   2.77    14.852
    9   1.148   13.23
* CARD 3.1
* NBOUND
    6
* CARD 3.2
* IBTYPE ISX  ISY  ISZ  IFX  IFY  IFZ
    1     0    0    0    1    1    1
    2     0    0    1    1    1    1
    3     0    0    1    1    1    1
    4     1    0    0    1    1    1
    5     1    0    0    1    1    1
    7     0    1    0    1    1    1
* END OF DATA
```

Table 7.21 Listing of output file CROSS-M3.Tmp

```
* CARD 1.1
* TITLE
  Crossing tunnels with clearance (MODELNO = 3)
* CARD 1.2
* NBLOCK NBNODE NSNODE  NSNEL          CMFAC
      44    226      1      1     .10000E+01
* CARD 2.1
* NODE   X-COORDINATE   Y-COORDINATE   Z-COORDINATE
    1     .30000E+02     .36000E+02     .00000E+00
    2     .30000E+02     .29313E+02     .00000E+00
    3     .30000E+02     .22000E+02     .00000E+00
    4     .30000E+02     .19000E+02     .00000E+00
    5     .30000E+02     .16000E+02     .00000E+00
    6     .30000E+02     .13000E+02     .00000E+00
    7     .30000E+02     .10000E+02     .00000E+00
    8     .30000E+02     .49490E+01     .00000E+00
    9     .30000E+02     .00000E+00     .00000E+00
   10     .30000E+02    -.49490E+01     .00000E+00
   11     .30000E+02    -.12459E+02     .00000E+00
    -
  218     .49490E+01    -.20000E+02     .14792E+02
```

```
  222     .30000E+02     .11760E+02     .14792E+02
  223     .30000E+02     .49490E+01     .14792E+02
  224     .30000E+02     .00000E+00     .14792E+02
  225     .30000E+02    -.49490E+01     .14792E+02
  226     .30000E+02    -.20000E+02     .14792E+02
* ===========================================================
* CARD 3.1
  BLOCK  1
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1   I2   I3   I4   I5   I6   I7   I8
  171  151  152  173  120  113  114  122
*  M9  M10  M11  M12  M13  M14  M15  M16  M17  M18  M19  M20
  213  164  165  215  170    0    0  172  119    0    0  121
* CARD 3.4.1
* NBOUND
    3
* CARD 3.4.2
* IBTYPE ISX  ISY  ISZ  IFX  IFY  IFZ
      1    0    0    0    1    1    1
      2    0    0    1    1    1    1
      4    1    0    0    1    1    1
* CARD 3.5
* MATNO  NDX  NDY  NDZ   KS   KF
      1    3    3    6    0    1
* ===========================================================
* CARD 3.1
  BLOCK  2
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1   I2   I3   I4   I5   I6   I7   I8
  120  113  114  122   39   54   55   41
*  M9  M10  M11  M12  M13  M14  M15  M16  M17  M18  M19  M20
    0    0    0    0  119    0    0  121   38    0    0   40
* CARD 3.4.1
* NBOUND
    3
* CARD 3.4.2
* IBTYPE ISX  ISY  ISZ  IFX  IFY  IFZ
      1    0    0    0    1    1    1
 -
```

```
* ============================================================
* CARD 3.1
  BLOCK 43
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1   I2   I3   I4   I5   I6   I7   I8
  205  187  189  207   77  131  133   79
*  M9  M10  M11  M12  M13  M14  M15  M16  M17  M18  M19  M20
  225  217  218  226  196  188  197  206  143  132  144   78
* CARD 3.4.1
* NBOUND
    4
* CARD 3.4.2
* IBTYPE ISX  ISY  ISZ  IFX  IFY  IFZ
      1    0    0    0    1    1    1
      2    0    0    1    1    1    1
      5    1    0    0    1    1    1
      7    0    1    0    1    1    1
* CARD 3.5
* MATNO  NDX  NDY  NDZ   KS   KF
     11    6    5    6    0    1
* ============================================================
* CARD 3.1
  BLOCK 44
* CARD 3.2
* ILAG
    0
* CARD 3.3
*  I1   I2   I3   I4   I5   I6   I7   I8
   77  131  133   79   10   34   36   12
*  M9  M10  M11  M12  M13  M14  M15  M16  M17  M18  M19  M20
    0    0    0    0  143  132  144   78   21   35   22   11
* CARD 3.4.1
* NBOUND
    4
* CARD 3.4.2
* IBTYPE ISX  ISY  ISZ  IFX  IFY  IFZ
      1    0    0    0    1    1    1
      3    0    0    1    1    1    1
      5    1    0    0    1    1    1
      7    0    1    0    1    1    1
* CARD 3.5
* MATNO  NDX  NDY  NDZ   KS   KF
     11    6    5    3    0    1
```

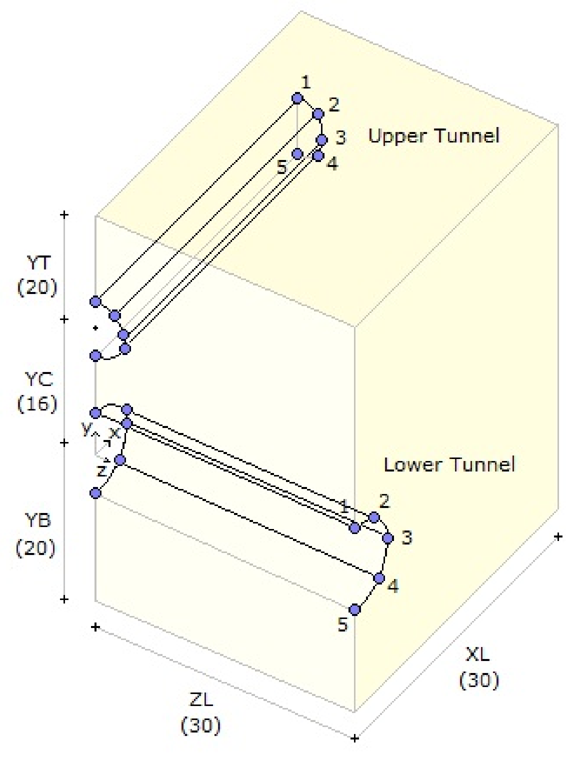


Figure 7.45 Schematic view of crossing tunnels for Model 3

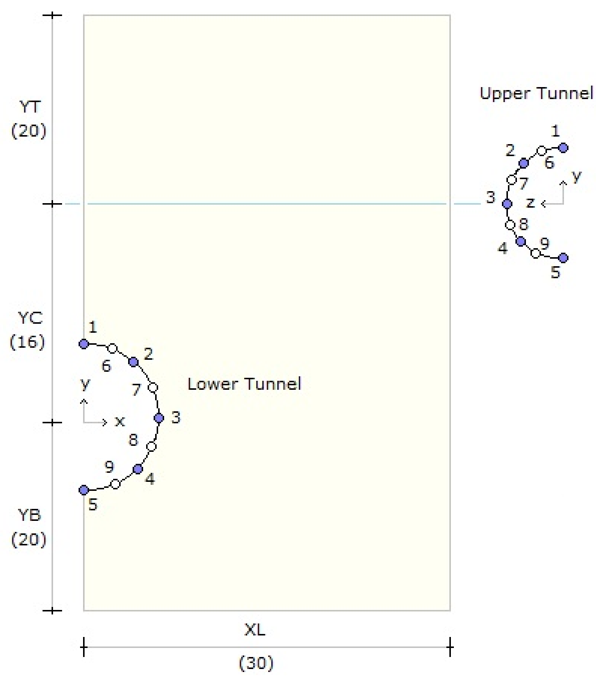


Figure 7.46 Tunnel shapes for Model 3

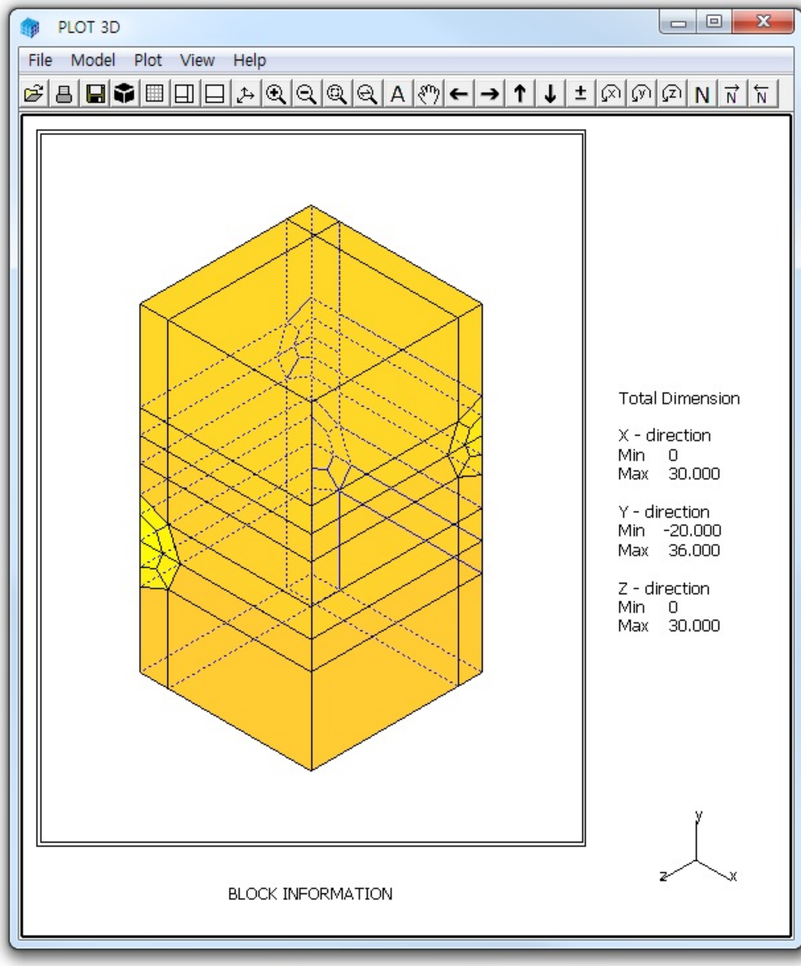


Figure 7.47 Block diagram for Model 3

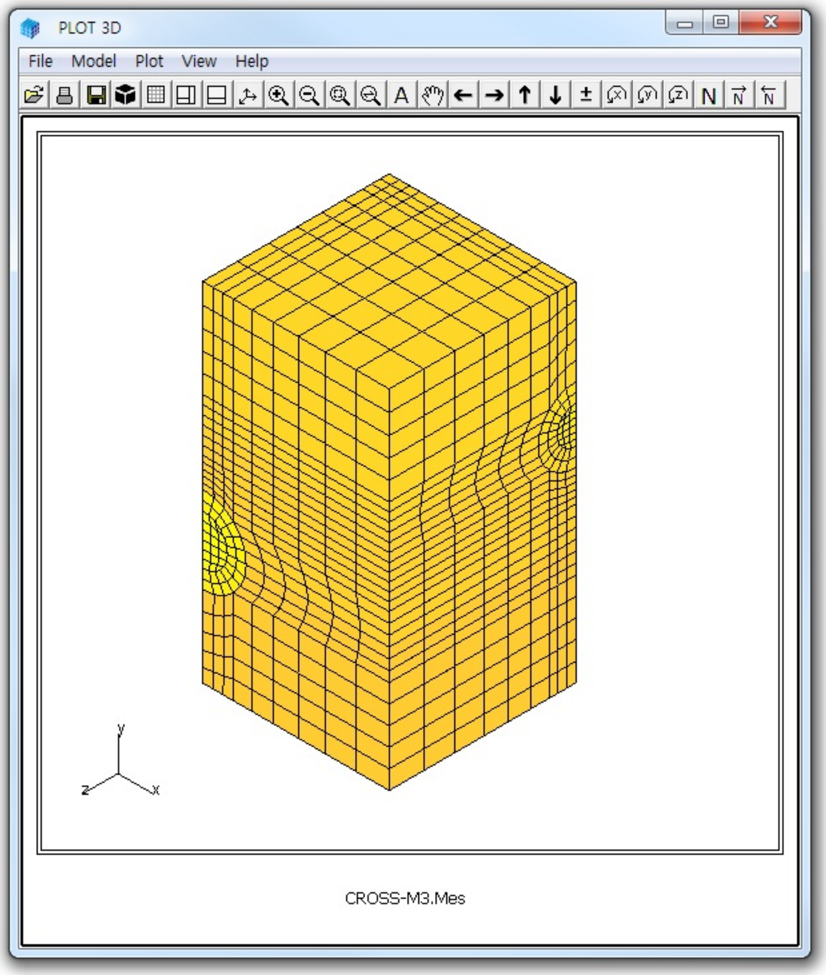


Figure 7.48 Generated finite element mesh for Model 3

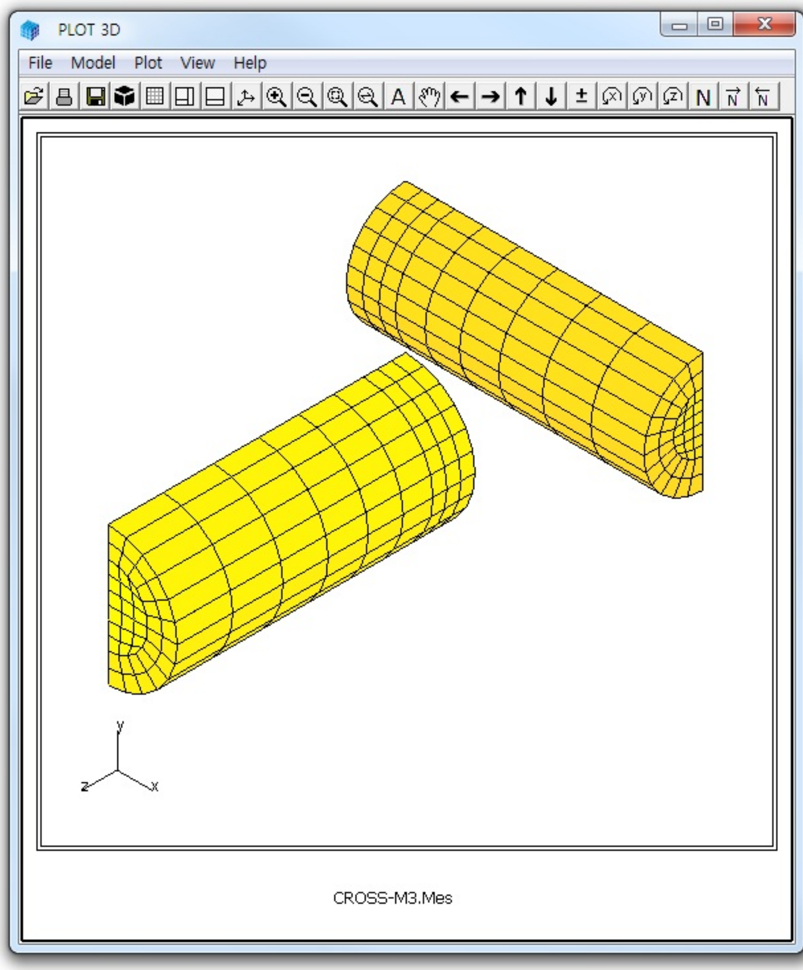


Figure 7.49 Generated mesh around tunnel core sections for Model 3

7.6 GEN-3D

GEN-3D is used to generate nodal coordinates, element indexes, boundary codes, external loads and transmitting boundaries in 3-dimensional coordinate system by extending typical 2-dimensional output from PRESMAP-2D, NATM-2D, CIRCLE-2D, or PRESMAP-GP. Input parameters of GEN-3D have been described in detail in Section 7.7 of User's Manual.

GEN-3D can be selected in the following order:

Run → Mesh Generator → PreSmap → Gen 3D

When you finish the execution of GEN-3D, select PLOT-3D to plot the generated mesh.

7.6.1 Example 1: 3-D Tunnel Mesh Generation

In Sections 7.1 and 8.1, a typical tunnel section having Core, Near-field, and Far-field regions has been constructed using PRESMAP-2D and ADDRGN-2D. Table 7.22 shows the listing of the file, Ex1-2D.Mes, containing this typical 2D section. Graphical output for this typical 2D section is presented in Figure 7.50.

In this example, we want to extend this typical 2D section in XY coordinate into 5 sections in Z coordinate using GEN-3D as schematically illustrated in Figure 7.51. The input file, Ex1.Dat in Table 7.23, has been prepared according to Section 7.7 of User's Manual.

Generated 3-dimensional finite element mesh is shown in Figures 7.52. The output file from GEN-3D contains nodal coordinates, element indexes, and boundary codes which are compatible to format of SMAP-3D Mesh File.

Table 7.22 Listing of typical 2D section Ex1-2D.Mes for Example 1

```
COMBINED REGION : Ex1-2D.Mes
NUMNP   NCONT   NBEAM   NTROSS
 506     464      0      0
NODAL COORDINATES
NODE  ISX  ISY  IFX  IFY  IRZ      XC           YC
  1    1    0    1    1    1  .000000E+00  .474000E+01
  2    0    0    1    1    1  .684000E+00  .469500E+01
  3    0    0    1    1    1  .135600E+01  .456200E+01
  4    0    0    1    1    1  .200500E+01  .434100E+01
  5    0    0    1    1    1  .262000E+01  .403800E+01
  6    0    0    1    1    1  .319000E+01  .366000E+01
  7    0    0    1    1    1  .370500E+01  .320500E+01
  8    1    0    1    1    1  .000000E+00  .395000E+01
  9    0    0    1    1    1  .714000E+00  .384225E+01
 10    0    0    1    1    1  .142200E+01  .369050E+01
 11    0    0    1    1    1  .210460E+01  .349792E+01
  -
  -
494    0    0    1    1    1  .261500E+02 -.241500E+02
495    1    0    1    1    1  .320000E+02 -.241500E+02
496    1    1    1    1    1  .000000E+00 -.300000E+02
497    0    1    1    1    1  .233333E+01 -.300000E+02
498    0    1    1    1    1  .466667E+01 -.300000E+02
499    0    1    1    1    1  .700000E+01 -.300000E+02
500    0    1    1    1    1  .933333E+01 -.300000E+02
501    0    1    1    1    1  .116667E+02 -.300000E+02
502    0    1    1    1    1  .140000E+02 -.300000E+02
503    0    1    1    1    1  .171500E+02 -.300000E+02
504    0    1    1    1    1  .212000E+02 -.300000E+02
505    0    1    1    1    1  .261500E+02 -.300000E+02
506    1    1    1    1    1  .320000E+02 -.300000E+02
ELEMENT INDEX
NEL   I1   I2   I3   I4   M5   M6   M7   M8 MATC KS KF INTR INTS   TBJWL
  1    2    1    8    9    0    0    0    0    4  0  1    2    2  .0000E+00
  2    3    2    9   10    0    0    0    0    4  0  1    2    2  .0000E+00
  3    4    3   10   11    0    0    0    0    4  0  1    2    2  .0000E+00
  4    5    4   11   12    0    0    0    0    4  0  1    2    2  .0000E+00
  5    6    5   12   13    0    0    0    0    4  0  1    2    2  .0000E+00
  6    7    6   13   14    0    0    0    0    4  0  1    2    2  .0000E+00
  -
  -
458  489  488  499  500    0    0    0    0    4  0  1    2    2  .0000E+00
459  490  489  500  501    0    0    0    0    4  0  1    2    2  .0000E+00
460  491  490  501  502    0    0    0    0    4  0  1    2    2  .0000E+00
461  492  491  502  503    0    0    0    0    4  0  1    2    2  .0000E+00
462  493  492  503  504    0    0    0    0    4  0  1    2    2  .0000E+00
463  494  493  504  505    0    0    0    0    4  0  1    2    2  .0000E+00
464  495  494  505  506    0    0    0    0    4  0  1    2    2  .0000E+00
```

Table 7.23 Listing of input file Ex1.Dat for Example 1

```
* CARD 1.1
* TITLE
  3-D TUNNEL MESH GENERATION
* CARD 1.2
* NBZ  NBNODE
   2     3
* CARD 1.3
* IBZ_base IBZ_front IBZ_back
   1        3         3
* CARD 2.1
* NODE   ZP     XP
   1     60.    0
   2     41.    0
   3      0.    0
* ===============================
* CARD 3.1
* BLNAME
  BLOCK1
* IBLNO
  1
* CARD 3.3
* I   J   LTYPE
  1   2   0
* CARD 3.4
* NDZ     ALPA
  2       0.4
* ===============================
* CARD 3.1
* BLNAME
  BLOCK2
* IBLNO
  2
* CARD 3.3
* I   J   LTYPE
  2   3   0
* CARD 3.4
* NDZ     ALPA
  3       0.4
* ===============================
* CARD 4.1
* ITRANB
  0
* END OF DATA
```

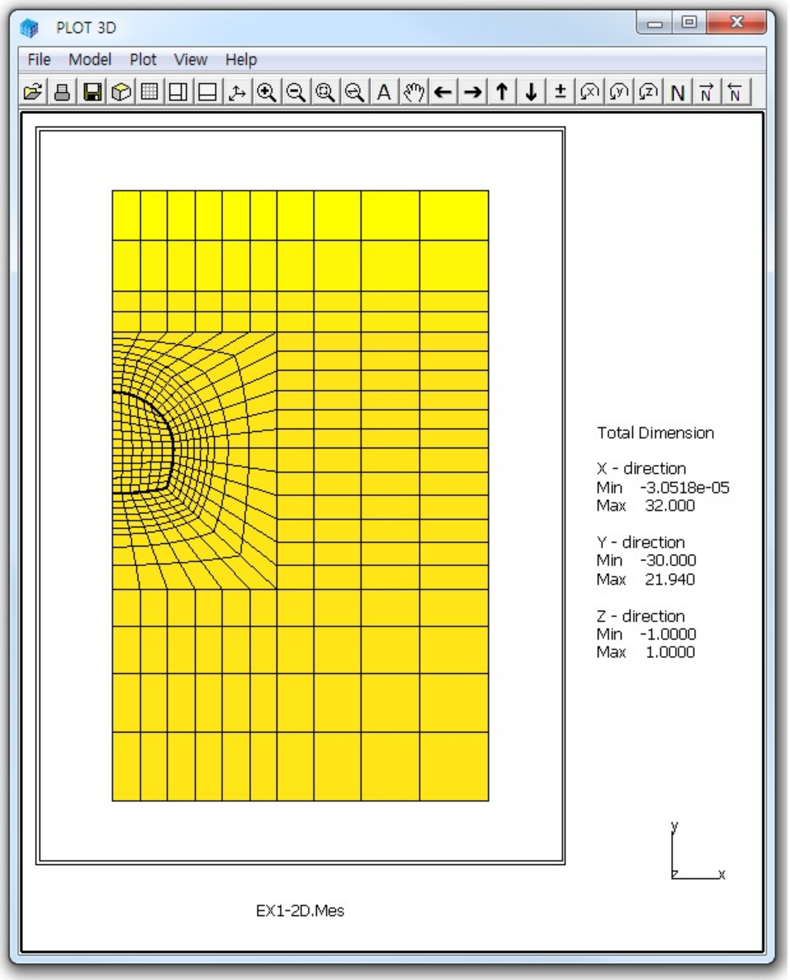
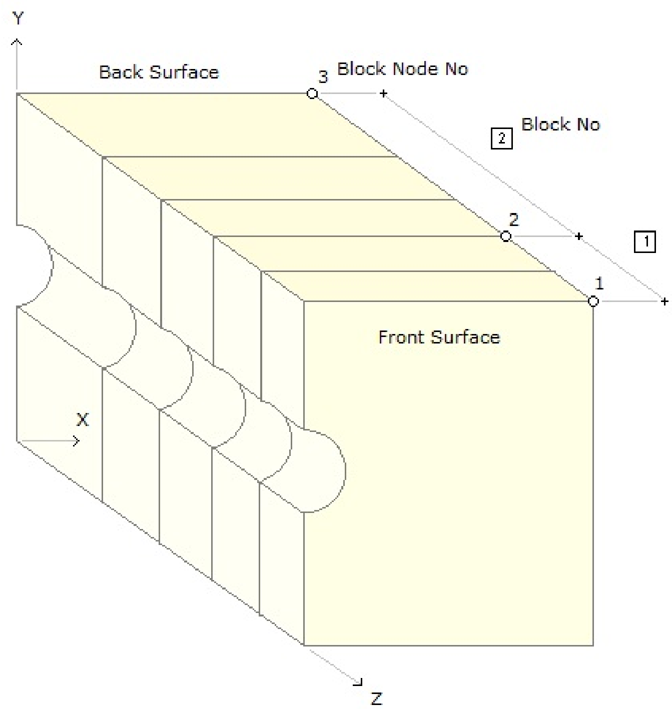


Figure 7.50 Finite element meshes representing typical 2D section



IPLANE = 0 (Input 2D section in X-Y plane)

For Block No 1, I = 1 J = 2 NDZ = 2 α = 0.4
For Block No 2, I = 2 J = 3 NDZ = 3 α = 0.4

Total Number of Blocks, NBZ = 2
Total Number of Block Nodes, NBNODE = 3

Figure 7.51 Schematic section view of 3D extension

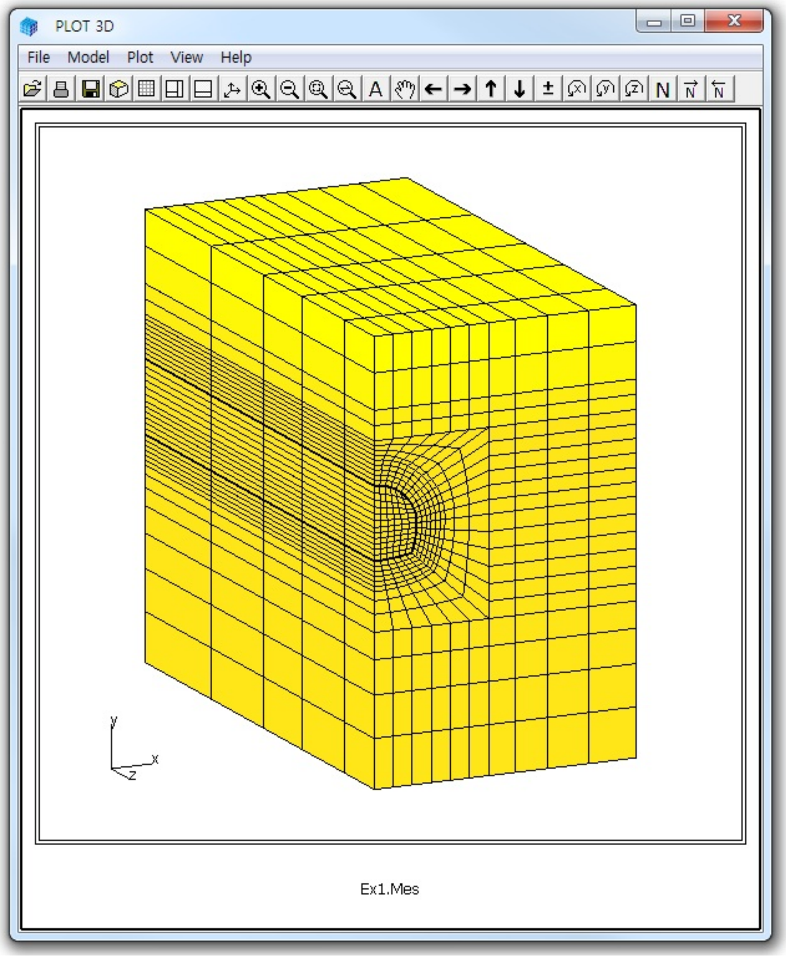


Figure 7.52 Generated 3D finite element mesh

7.6.2 Example 2: 3-D Curved Tunnel

Table 7.24 Listing of input file Ex2.Dat for Example 2

```
* CARD 1.1
* TITLE
  3-D CURVED TUNNEL
* CARD 1.2
* NBZ  NBNODE
   2     3
* CARD 1.3
* IBZ_base IBZ_front IBZ_back
   1        3         3
* CARD 2.1
* NODE   Zp      Xp
   1      0.0    16.30
   2     -6.238  15.06
   3     -42.60  0.00
*================================
* CARD 3.1
* BLNAME
  BLOCK1
* IBLNO
  1
* I   J   LTYPE
  1   2   1
* CARD 3.4
* NDZ,    ALPA
  4       0.5
* CARD 3.5
* Zo      Xo     R     Tb    Te
  0.0     0.0   16.3  0.0   22.5
*================================
* BLNAME
  BLOCK2
* IBLNO
  2
* I   J   LTYPE
  2   3   0
* NDZ     ALPA
  8       0.3
*================================
* CARD 4.1
* ITRANB
  0
* END OF DATA
```

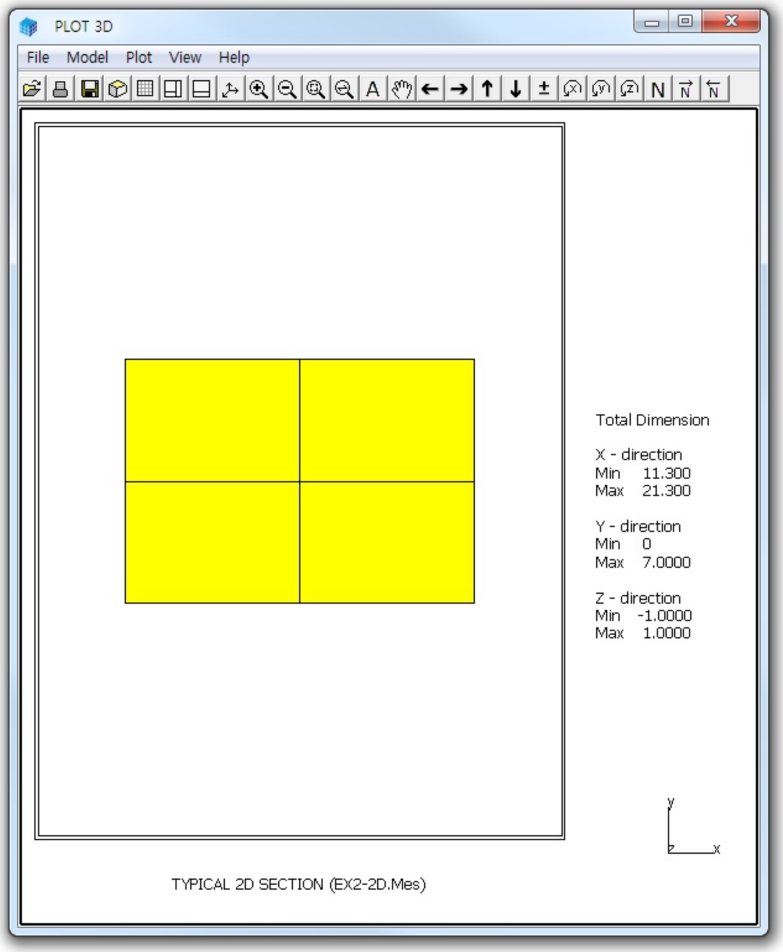


Figure 7.53 Typical 2D section for Example 2

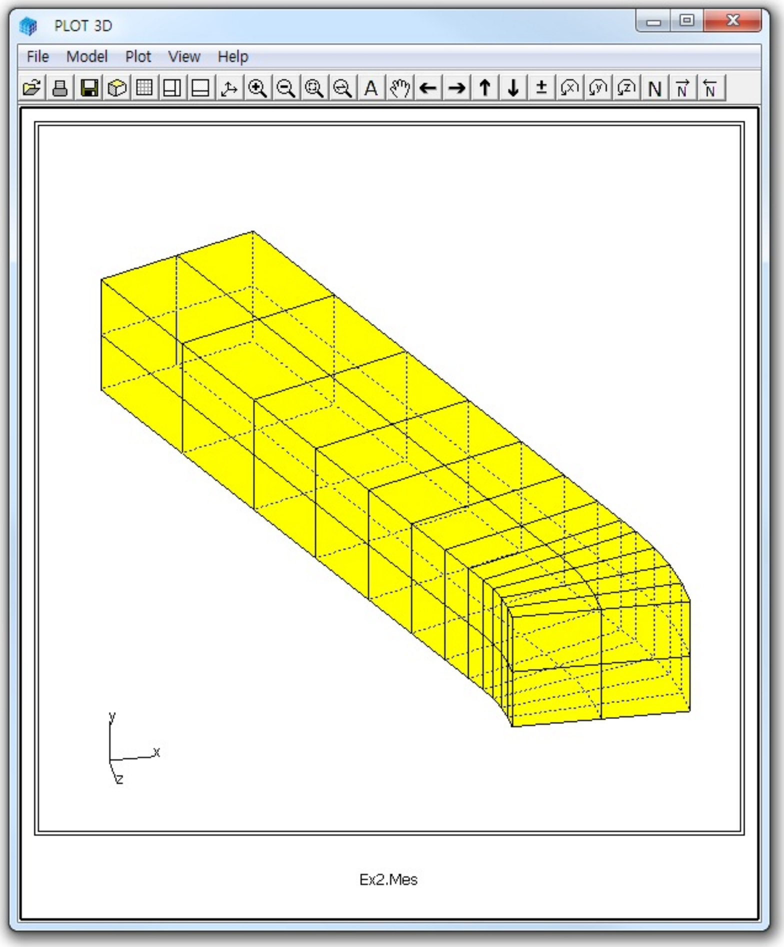


Figure 7.54 Generated 3D mesh for Example 2

7.6.3 Example 3: 3-D Tunnel with Prism Elements

Table 7.25 Listing of input file Ex3.Dat for Example 3

```
* CARD 1.1
* TITLE
  3-D TUNNEL WITH PRISM ELEMENTS
* CARD 1.2
* NBZ  NBNODE
   2     3
* CARD 1.3
* IBZ_base IBZ_front IBZ_back
   1        3         3
* CARD 2.1
* NODE   Zp     Xp
   1      0.0    16.30
   2    -6.238  15.06
   3    -42.60  0.00
*================================
* CARD 3.1
* BLNAME
  BLOCK1
* IBLNO
  1
* I   J   LTYPE
  1   2   1
* CARD 3.4
* NDZ,    ALPA
  4       0.5
* CARD 3.5
* Zo      Xo     R     Tb     Te
  0.0     0.0   16.3  0.0    22.5
*================================
* BLNAME
  BLOCK2
* IBLNO
  2
* I   J   LTYPE
  2   3   0
* NDZ     ALPA
  8       0.3
*================================
* CARD 4.1
* ITRANB
  0
* END OF DATA
```

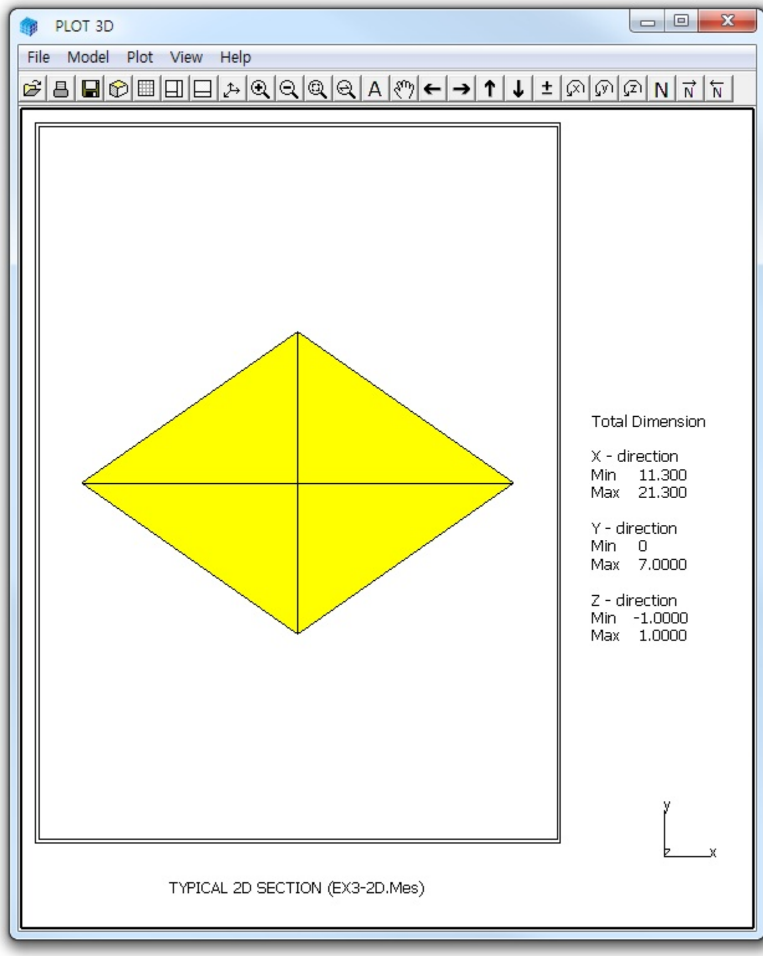


Figure 7.55 Typical 2D section for Example 3

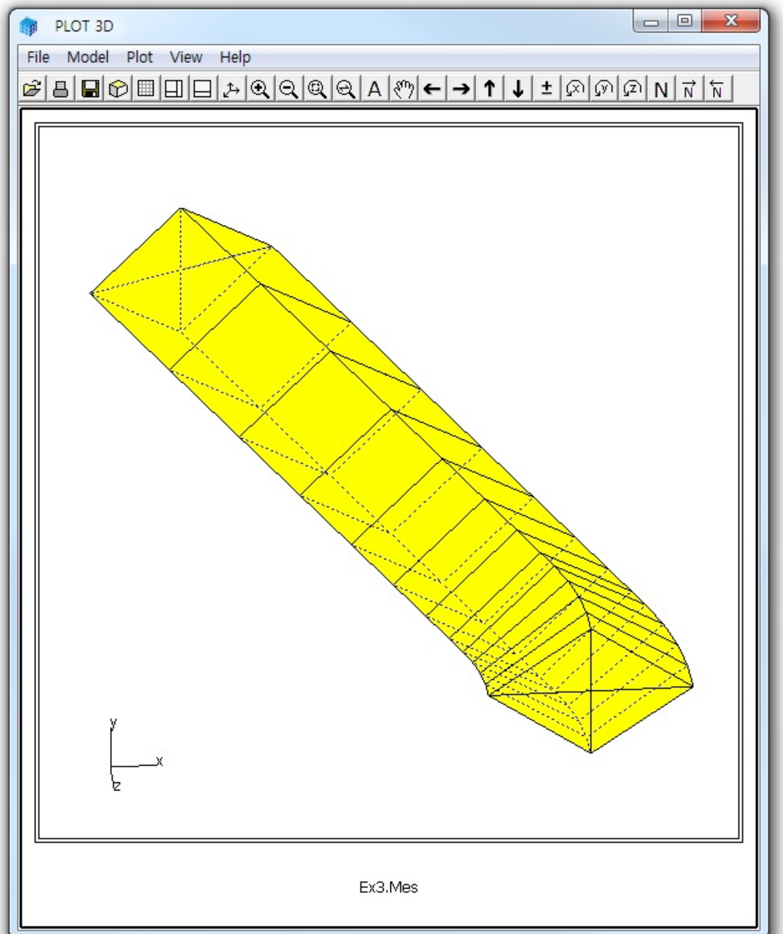


Figure 7.56 Generated 3D mesh for Example 3

7.6.4 Example 4: 3-D Shell Generation

Table 7.26 Listing of input file Ex4.Dat for Example 4

```
* CARD 1.1
* TITLE
  3-D SHELL GENERATION
* CARD 1.2
* NBZ     NBNODE  NSNODE  NSNEL  IBOUND  IPLANE  ICLOSE  CMFAC
  1       2       1       1      3       3       0       1.0
* CARD 1.2.1
* Xleft  Xright  Ybot    Ytop   Zback   Zfront
 -10     10     -10      10    -20      25
* CARD 1.2.2
* Xo      Yo      Zo
  0.0     0.0     0.0
* Xa      Ya      Za
  5.0     0.0    -2.0
* Xb      Yb      Zb
  0.0     10.0    0.0
* CARD 1.3
* IBZ_base IBZ_front IBZ_back
   1         3         3
* CARD 2.1
* NODE    Z       X
   1      30.     0
   2     -30.     0
*==================================
* CARD 3.1
* BLNAME
  BLOCK1
* IBLNO
  1
* CARD 3.3
* I   J   LTYPE
  1   2   0
* CARD 3.4
* NDZ     ALPA
  10      0.3
*==================================
* CARD 4.1
* ITRANB
  0
* END OF DATA
```

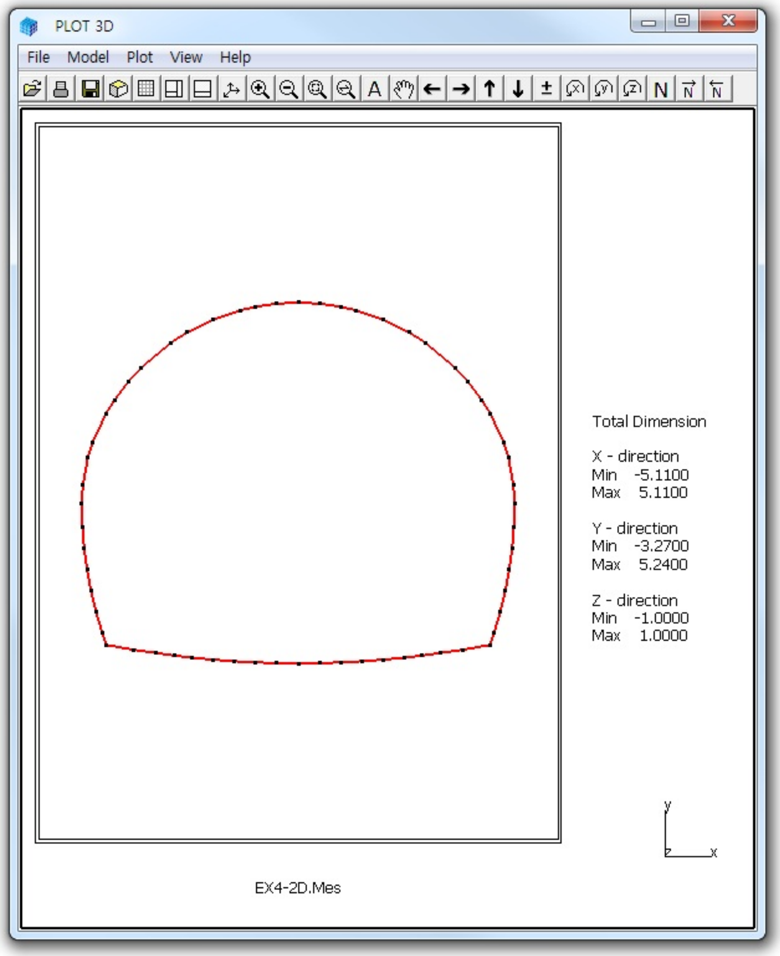


Figure 7.57 Typical 2D section for Example 4

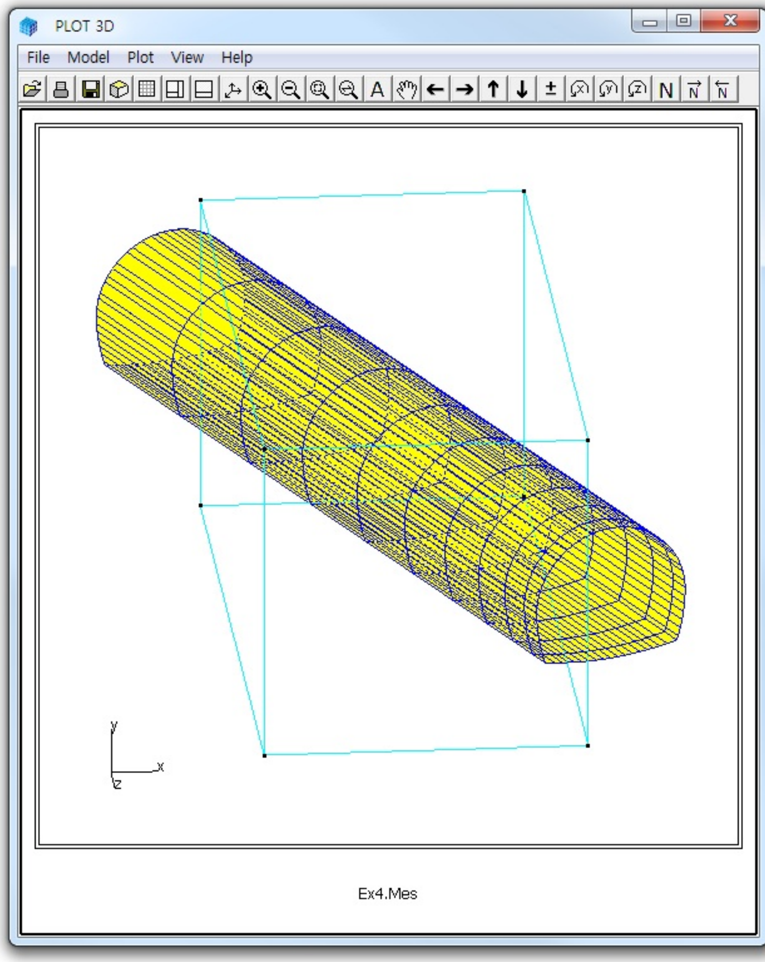


Figure 7.58 Generated 3D mesh for Example 4

7.6.5 Example 5: 3-D Pile Foundation

Table 7.27 Listing of input file Ex5.Dat for Example 5

```
* CARD 1.1
* TITLE
  3-D PILE FOUNDATION
* CARD 1.2
* NBZ  NBNODE  NSNODE  NSNEL  IBOUND  IPLANE  ICLOSE  CMFAC
   5     6       1       1       0       2      0       1.0
* IBZ_base IBZ_front IBZ_back
   1        1         3
* CARD 2.1
* NODE    Zp      Xp
   1     20.00   0
   2     19.50   0
   3     12.50   0
   4     12.25   0
   5     12.00   0
   6      0.00   0
*=======================================
* CARD 3.1
* BLNAME
  BLOCK1
* IBLNO
  1
* CARD 3.3
* I   J   LTYPE  IMATC  IMATB  IMATT
  1   2   0        0      0       0
* CARD 3.4
* NDZ     ALPA  MC1   MC2  MC3  MB   MT
   1      0.5   -1    -4   -5    0    0
*=======================================
* CARD 3.1
* BLNAME
  BLOCK2
* IBLNO
  2
* CARD 3.3
* I   J   LTYPE  IMATC  IMATB  IMATT
  2   3   0        0      0       0
* CARD 3.4
* NDZ     ALPA  MC1   MC2  MC3  MB   MT
   14     0.5    0     0    0    0    0
*=======================================
```

```
* CARD 3.1
* BLNAME
  BLOCK3
* IBLNO
  3
* CARD 3.3
* I   J   LTYPE  IMATC  IMATB  IMATT
  3   4   0       1      0       0
* CARD 3.4
* NDZ     ALPA  MC1  MC2  MC3  MB   MT
   1      0.5    3    4    5    0    0
*========================================
* CARD 3.1
* BLNAME
  BLOCK4
* IBLNO
  4
* CARD 3.3
* I   J   LTYPE  IMATC  IMATB  IMATT
  4   5   0       1      0       0
* CARD 3.4
* NDZ     ALPA  MC1  MC2  MC3  MB   MT
   1      0.5    3    4    0    0    0
*========================================
* CARD 3.1
* BLNAME
  BLOCK5
* IBLNO
  5
* CARD 3.3
* I   J   LTYPE  IMATC  IMATB  IMATT
  5   6   0       6      0       0
* CARD 3.4
* NDZ     ALPA  MC1  MC2  MC3  MB   MT
   8      0.3   -3   -5    0    0    0
*========================================
* CARD 4.1
* ITRANB
  0
* END OF DATA
```

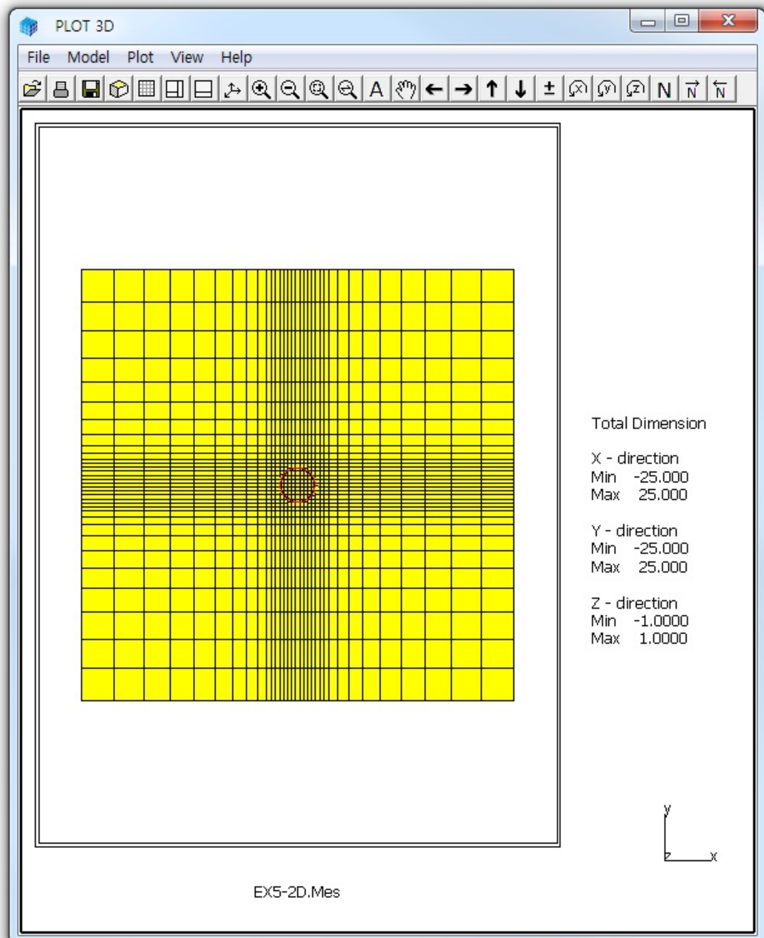


Figure 7.59 Typical 2D section for Example 5

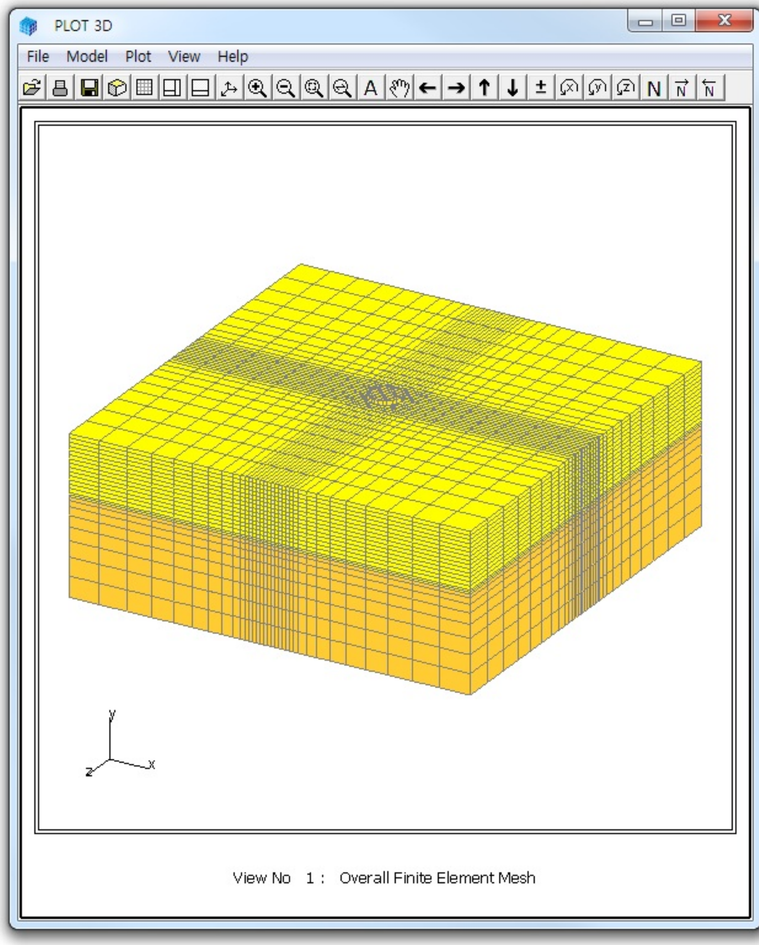


Figure 7.60 Generated 3D mesh for Example 5

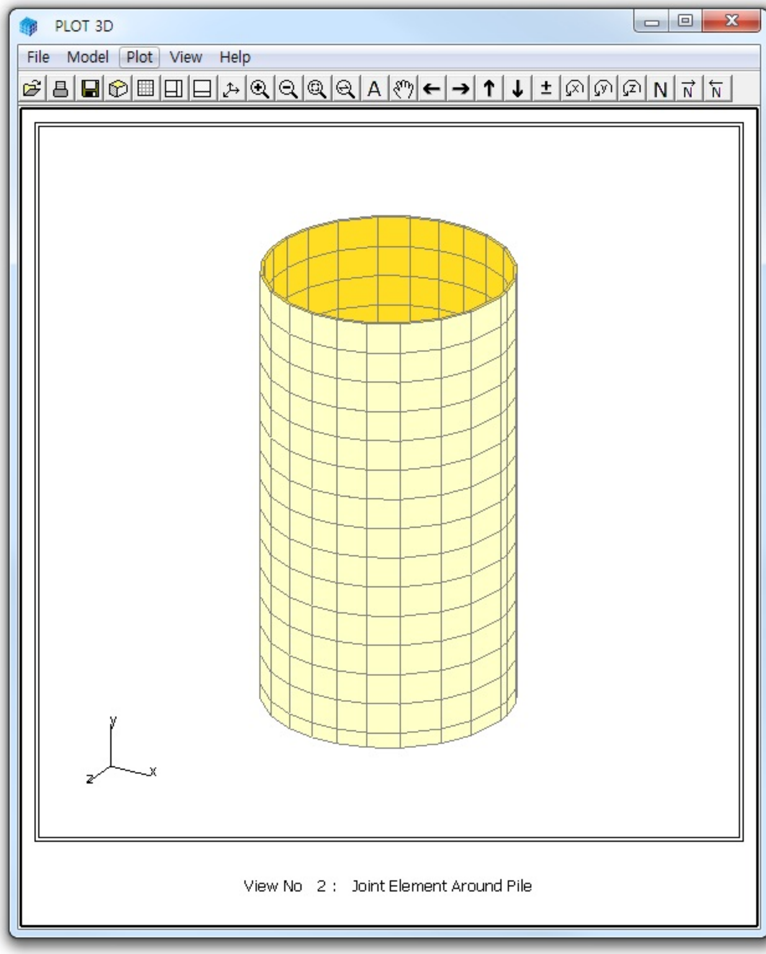


Figure 7.61 Generated joint element for Example 5

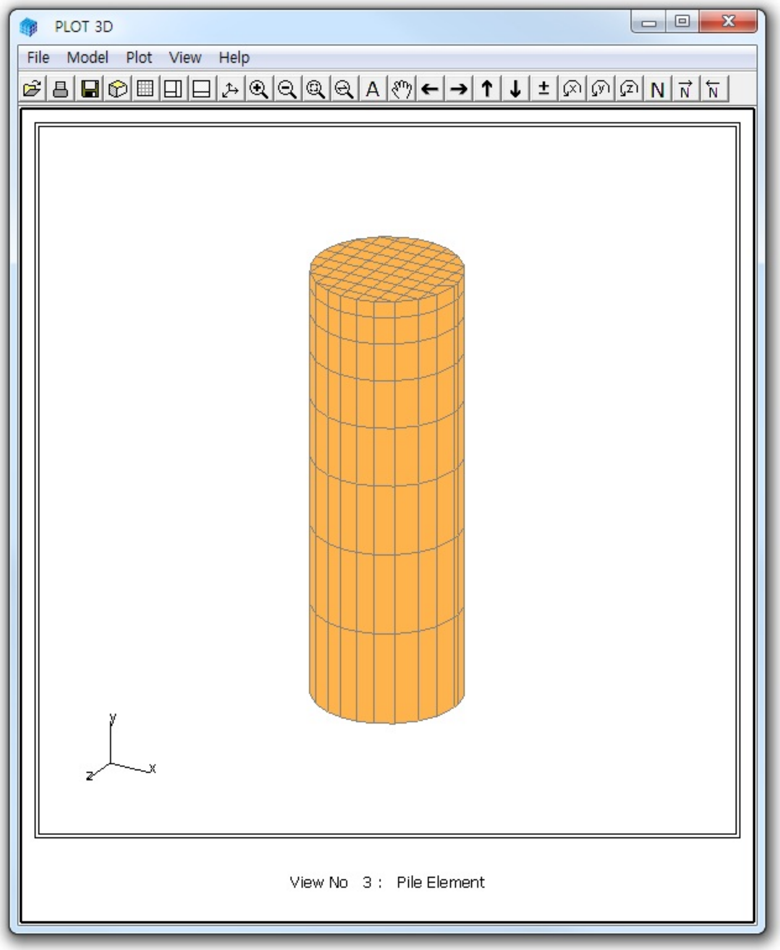


Figure 7.62 Generated pile element for Example 5

7.6.6 Example 6: 3-D Embedded Truss

Table 7.28 Listing of input file Ex6.Dat for Example 6

```
* CARD 1.1
* TITLE
  3-D EMBEDDED TRUSS
* CARD 1.2
* NBZ  NBNODE  NSNODE  NSNEL  IBOUND  IPLANE  ICLOSE  CMFAC
   1     2      29385  27982   0       0      1       1.0
* CARD 1.3
* IBZ_base IBZ_front IBZ_back
   1        3         3
* CARD 2.1
* NODE   Zp     Xp
   1     0.0    1.75
   2     0.0    1.75
*==============================
* CARD 3.1
* BLNAME
  BLOCK1
* IBLNO
  1
* CARD 3.3
* I   J   LTYPE
  1   2   1
* CARD 3.4
* NDZ, ALPA
  16   0.5
* CARD 3.5
* Zo    Xo    R     Tb    Te
  0.0   0.0   1.75  0.0   360.
*==============================
* END
  0
* END OF DATA
```

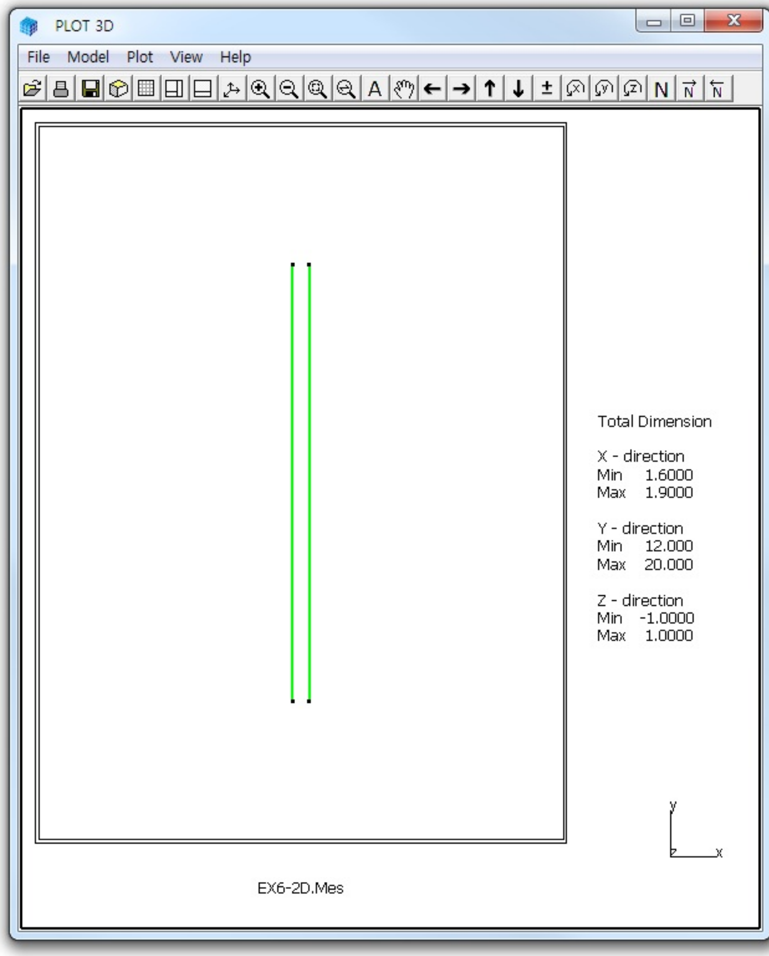


Figure 7.63 Typical 2D section for Example 6

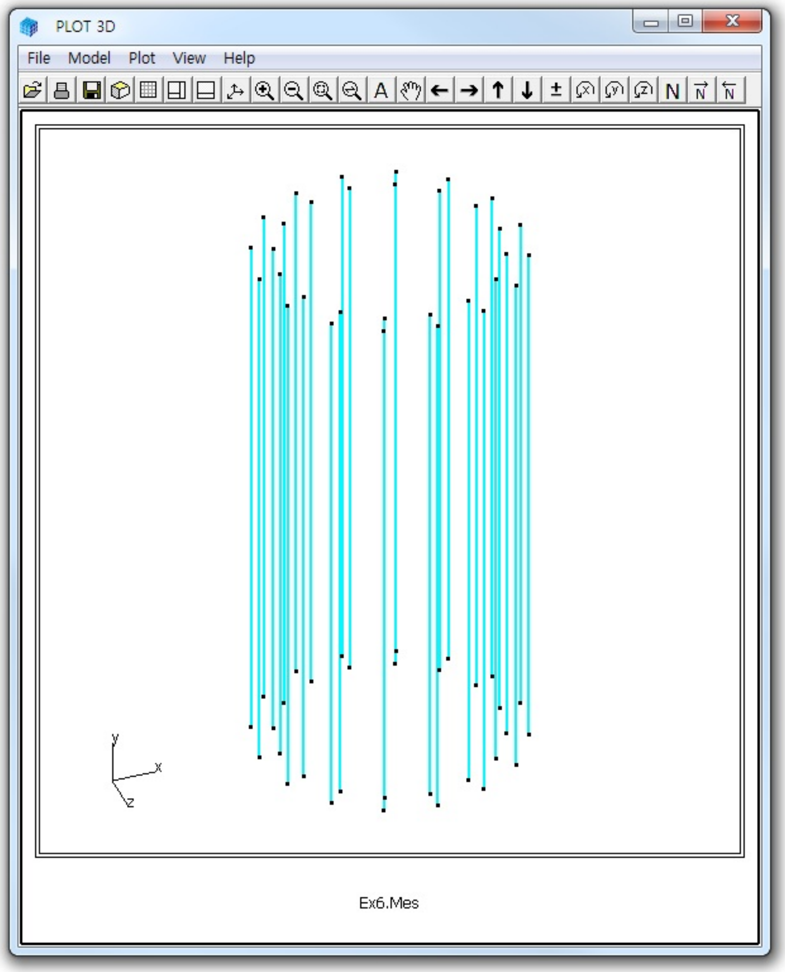


Figure 7.64 Generated 3D mesh for Example 6

7.6.7 Example 7: Pile Foundation Using CIRCLE-2D

Table 7.29 Listing of input file Ex7.Dat for Example 7

```
* CARD 1.1
* TITLE
  PILE FOUNDATION USING CIRCLE-2D (CIR2F_QT.MES)
* CARD 1.2
* NBZ  NBNODE  NSNODE  NSNEL  IBOUND  IPLANE  ICLOSE  CMFAC
   5     6      1       1       0       2      0       1.0
* IBZ_base IBZ_front IBZ_back
   1        1         3
* CARD 2.1
* NODE   Zp      Xp
   1     20.00   0
   2     19.50   0
   3     12.50   0
   4     12.25   0
   5     12.00   0
   6      0.00   0
*==============================================================
* CARD 3.1
* BLNAME
  BLOCK1
* IBLNO
  1
* CARD 3.3
* I   J   LTYPE  IMATC  IMATB  IMATT  NIXCH
  1   2   0       0      0       0      2
* CARD 3.4
* NDZ     ALPA  MC1  MC2  MC3  MB   MT
   1      0.5   -1   -5    0    0    0
* CARD 3.6
* MATNO   NEWNO  NI1  NI2  NI3  NI4  NI5   NI6   NI7   NI8
   3      2
   4      3
*==============================================================
```

```
* CARD 3.1
* BLNAME
  BLOCK2
* IBLNO
  2
* CARD 3.3
* I   J   LTYPE  IMATC  IMATB  IMATT  NIXCH
  2   3   0       0      0       0      3
* CARD 3.4
* NDZ     ALPA  MC1   MC2   MC3   MB    MT
   14     0.5    0     0     0     0     0
* CARD 3.6
* MATNO   NEWNO  NI1  NI2  NI3  NI4  NI5   NI6   NI7   NI8
   1       8
   3       2
   5       5
*==============================================================
* CARD 3.1
* BLNAME
  BLOCK3
* IBLNO
  3
* CARD 3.3
* I   J   LTYPE  IMATC  IMATB  IMATT  NIXCH
  3   4   0       0      0       0      4
* CARD 3.4
* NDZ     ALPA  MC1   MC2   MC3   MB    MT
   1      0.5    0     0     0     0     0
* CARD 3.6
* MATNO   NEWNO  NI1  NI2  NI3  NI4  NI5   NI6   NI7   NI8
   1       9      0    0    0    0    1010  1010  1010  1010
   3       2      0    0    0    0    0     0     0     0
   4       4      0    0    0    0    1010  1010  0     0
   5       6      0    0    0    0    1010  1010  1010  1010
*==============================================================
```

```
* CARD 3.1
* BLNAME
  BLOCK4
* IBLNO
  4
* CARD 3.3
* I   J   LTYPE  IMATC  IMATB  IMATT  NIXCH
  4   5   0        0      0       0      2
* CARD 3.4
* NDZ     ALPA  MC1   MC2   MC3   MB    MT
   1      0.5   -1    -4    -5     0     0
* CARD 3.6
* MATNO   NEWNO  NI1  NI2  NI3  NI4  NI5   NI6   NI7   NI8
   2      -1
   3      -1     0    0    0    0    25    25    0     0
*==============================================================
* CARD 3.1
* BLNAME
  BLOCK5
* IBLNO
  5
* CARD 3.3
* I   J   LTYPE  IMATC  IMATB  IMATT  NIXCH
  5   6   0       0       0       0      2
* CARD 3.4
* NDZ     ALPA  MC1   MC2   MC3   MB    MT
   8      0.3   -2    -3    -4     0     0
* CARD 3.6
* MATNO   NEWNO  NI1  NI2  NI3  NI4  NI5   NI6   NI7   NI8
   1      7
   5      7
*==============================================================
* CARD 4.1
* ITRANB
  0
* END OF DATA
```

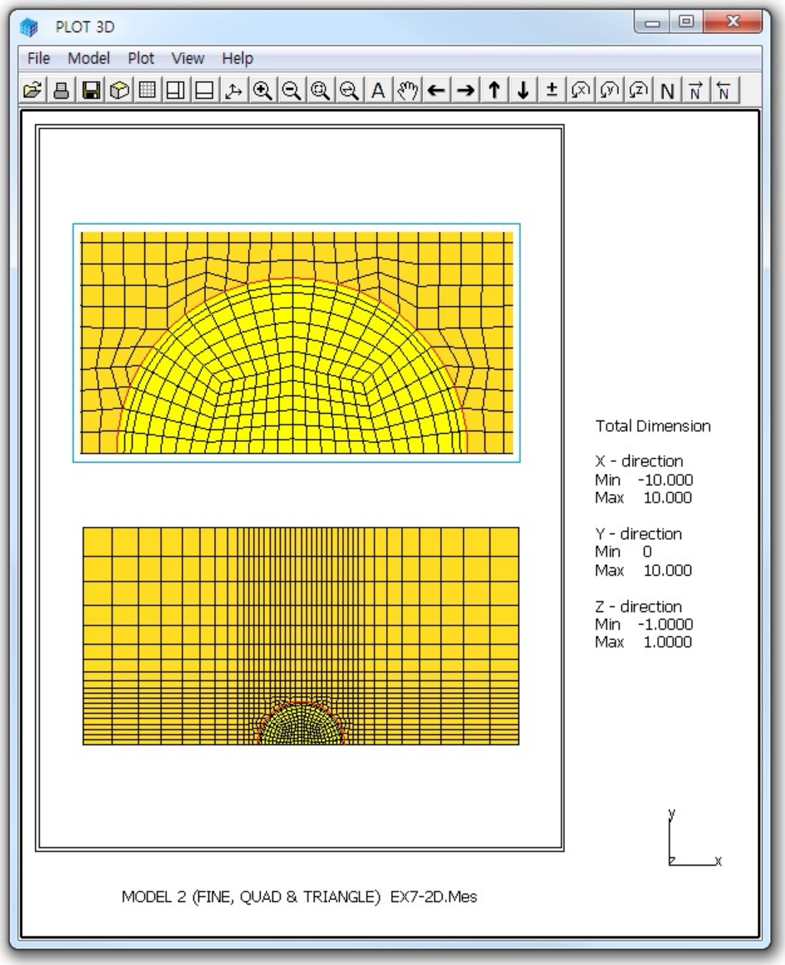


Figure 7.65 Typical 2D section for Example 7

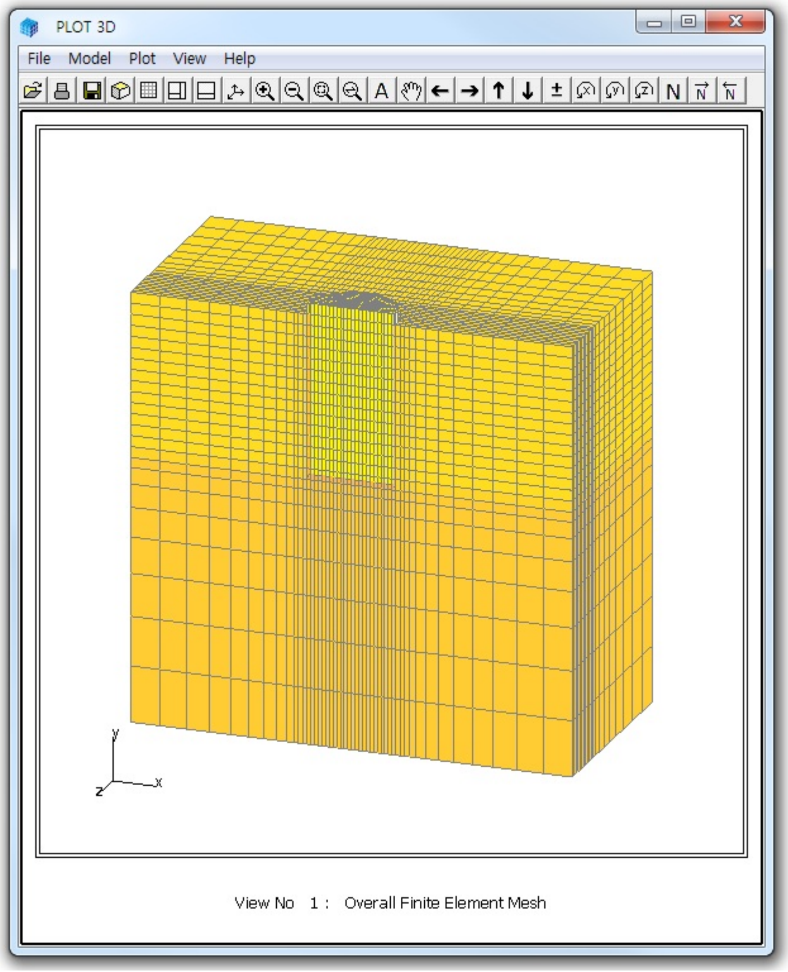


Figure 7.66 Generated 3D mesh for Example 7

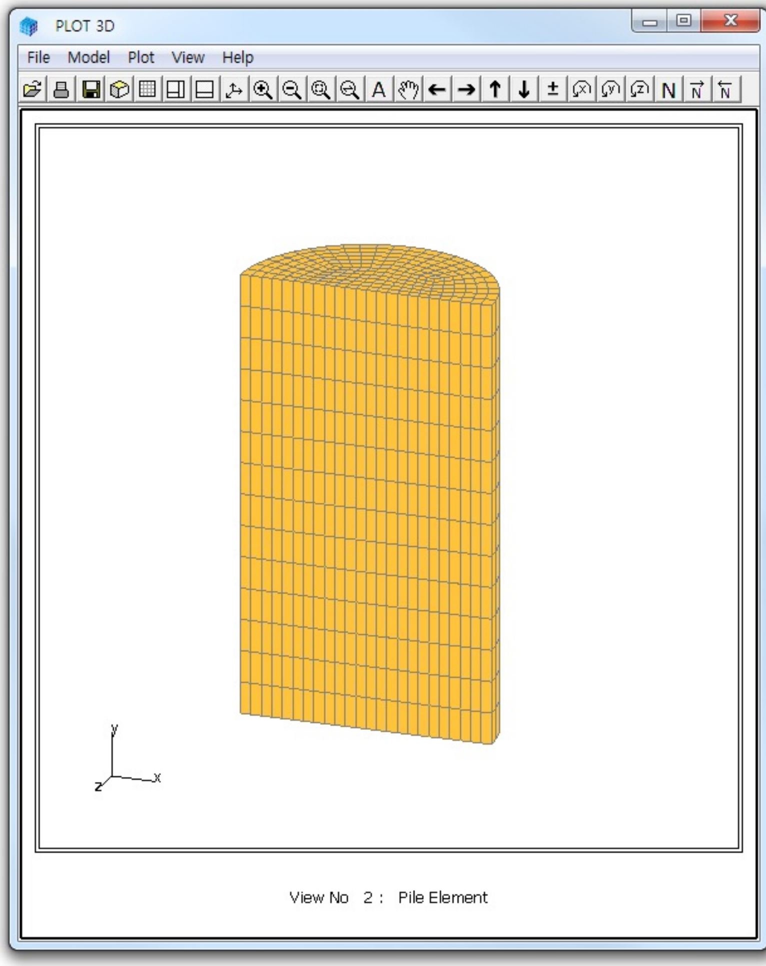


Figure 7.67 Generated pile element for Example 7

7.7 PILE-3D

PILE-3D is the special pre-processor which can be used to generate all input files required for pile foundations analysis. It can generate Concrete Pile with Anchor Bolts or Steel Pipe with Concrete Cap. Input parameters of PILE-3D have been described in detail in Section 7.8 of User's Manual.

Output files from PILE-3D include Pile3D.Dat, Pile3D.Mes, Pile3D.Man, and Pile3D.Pos. You can modify such generated files as you want.

PILE-3D can be selected in the following order.

Run → Mesh Generator → PreSmap → Pile 3D

When you finish the execution of PILE-3D, select PLOT-3D to plot the generated mesh.

7.7.1 Example 1: Concrete Pile with Anchor Bolts

Example 1 is to generate Concrete Pile with Anchor Bolts.
Detailed input data is listed in Table 7.30. Figure 7.68 shows schematic section view of concrete pile and soil profile around the pile foundation subjected to vertical and horizontal forces along with overturning moment.

Figure 7.69 shows generated finite element meshes around the pile foundation. Anchor bolts are modeled by truss elements. Interfaces between concrete pile and surrounding soils are modeled by joint elements which allows slippage and debonding.

Refer to other output files from PILE-3D:
Pile.Dat (Project), Pile.Mes (Mesh), Pile.Man (Main) and Pile.Pos (Post)

7.7.2 Example 2: Steel Pipe with Concrete Cap

Example 2 is to generate Steel Pile with Concrete Cap.
Input file is very similar to Example 1 except that steel pipe is used instead of concrete block. Figure 7.70 shows generated finite element meshes around the steel pipe foundation. Steel pipe is modeled by shell elements.

Table 7.30 Listing of input file EX1.dat

```
* Title
* Card 1.1
  Example 1
*
* Stitle
* Card 1.2
  Concrete Pile with Anchor Bolt
*
* Pile Dimension
* Card 2.1
* D          Ht         Hs         Hw          Nt
  1.5,       8,         0.2,       10,         20
*
* Steel Pipe
* Card 2.2
* Ep         Vp         tp
  2E+07,     0.3,       0.
*
* Reinforcing Bars
* Card 2.3
* Nr         dtop       dbot
  3,         10,        10
*
* Card 2.4-1
* Db         db         Nb
  32,        100,       43
* Card 2.4-2
* Db         db         Nb
  32,        300,       32
* Card 2.4-3
* Db         db         Nb
  32,        400,       26
*
* Concrete Property
* Card 2.5
* Ec         Vc         Phi        C           T          Gama
  2856759,   0.2,       30,        500,        300,       2.4
*
* Rebar Property
* Card 2.6
* Er         Sigy
  2E+07,     40000
*
```

```
* Pile Base Interface Property
* Card 2.7
* Eb          Gb         Phi        C           T          tb
  100000,     1000,      10,        0,          0.001,     0.1
*
* Soil/Rock Layers
*
* Card 3.1
* NLAYER
  4
*
* Card 3.2
* LayerNo     ModelNo    H          Gama        Ko
  1,          3,         2,         2,          0.46
* Pile Side Interface
* Card 3.3
* Ej          Gj         Phij       Cj          Tj         tj
  100000,     1000,      10,        0,          0.001,     0.1
* Card 3.4.3
* E           V          Phi        C           T
  1000,       0.3,       33,        0,          0.1
*
* Card 3.2
* LayerNo     ModelNo    H          Gama        Ko
  2,          3,         4,         2.2,        0.43
* Pile Side Interface
* Card 3.3
* Ej          Gj         Phij       Cj          Tj         tj
  100000,     1000,      10,        0,          0.001,     0.1
* Card 3.4.3
* E           V          Phi        C           T
  3000,       0.3,       35,        0,          0.1
*
* Card 3.2
* LayerNo     ModelNo    H          Gama        Ko
  3,          3,         3,         2.2,        0.34
* Pile Side Interface
* Card 3.3
* Ej          Gj         Phij       Cj          Tj         tj
  100000,     1000,      10,        0,          0.001,     0.1
* Card 3.4.3
* E           V          Phi        C           T
  7000,       0.25,      41,        0,          0.1
*
* Card 3.2
* LayerNo     ModelNo    H          Gama        Ko
  4,          3,         5,         2.2,        0.34
```

```
* Pile Side Interface
* Card 3.3
* Ej          Gj         Phij       Cj          Tj         tj
  100000,     1000,      10,        0,          0.001,     0.1
* Card 3.4.3
* E           V          Phi        C           T
  8000,       0.25,      41,        0,          0.1
*
* Card 4.1
* Fv          Fh         M          NumStep
  31,         54,        812,       5
*
* Anchor Bolt
* Card 5.1
* Da          da         La         Nbolt       Ea         Sigya
  50,         200,       4,         32,         2E+07,     40000
*
* Finite Element Mesh on Plan View
* Card 6.1
* FineMesh    NearMesh   Ndiv       BH          BV
  0,          1,         10,        15.,        15.
*
* End of Data
```

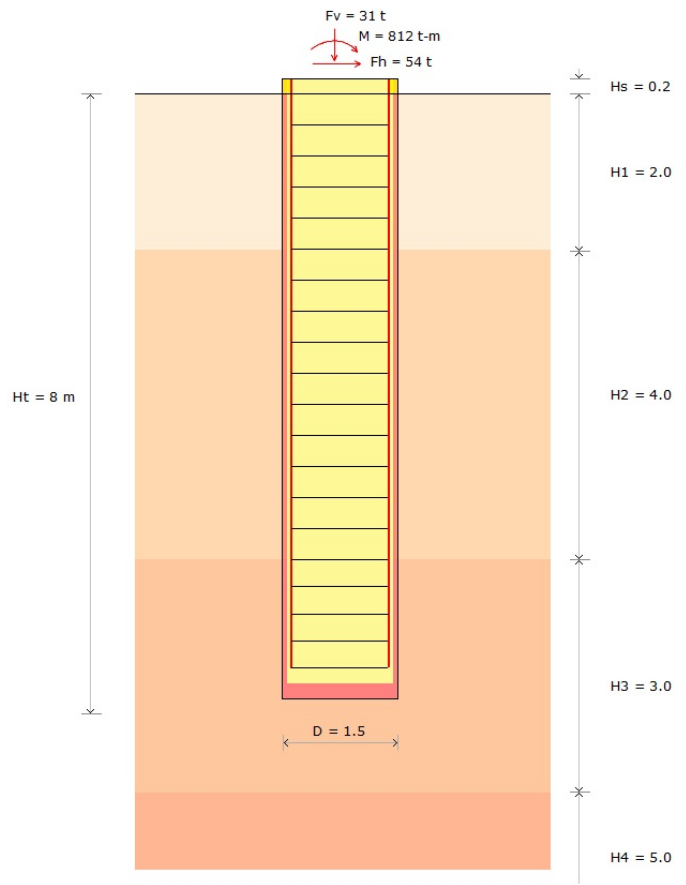


Figure 7.68 Schematic section view of concrete pile for Example 1

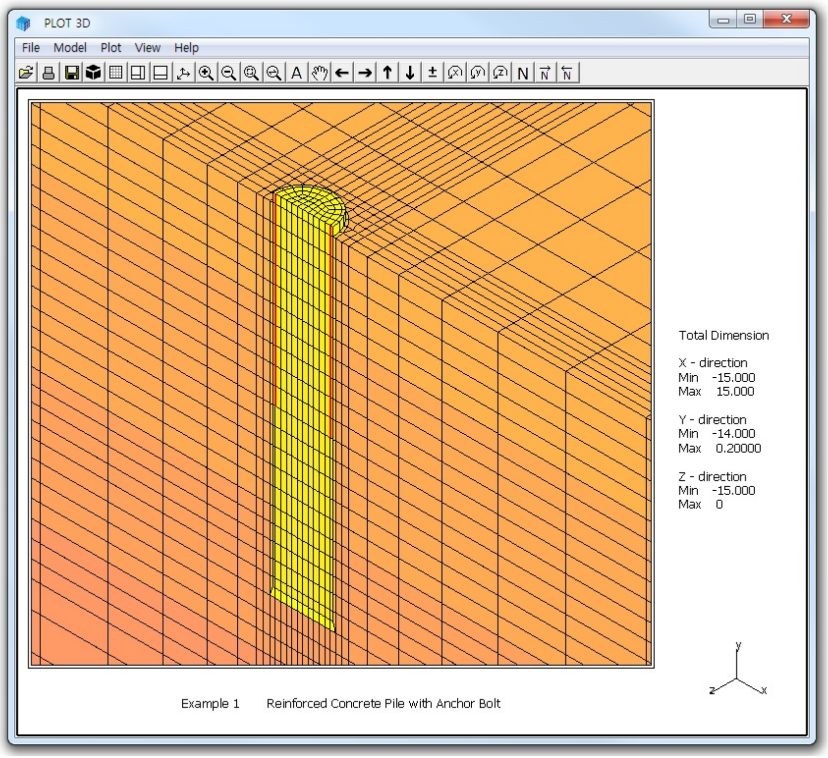


Figure 7.69 Generated finite element meshes for concrete pile

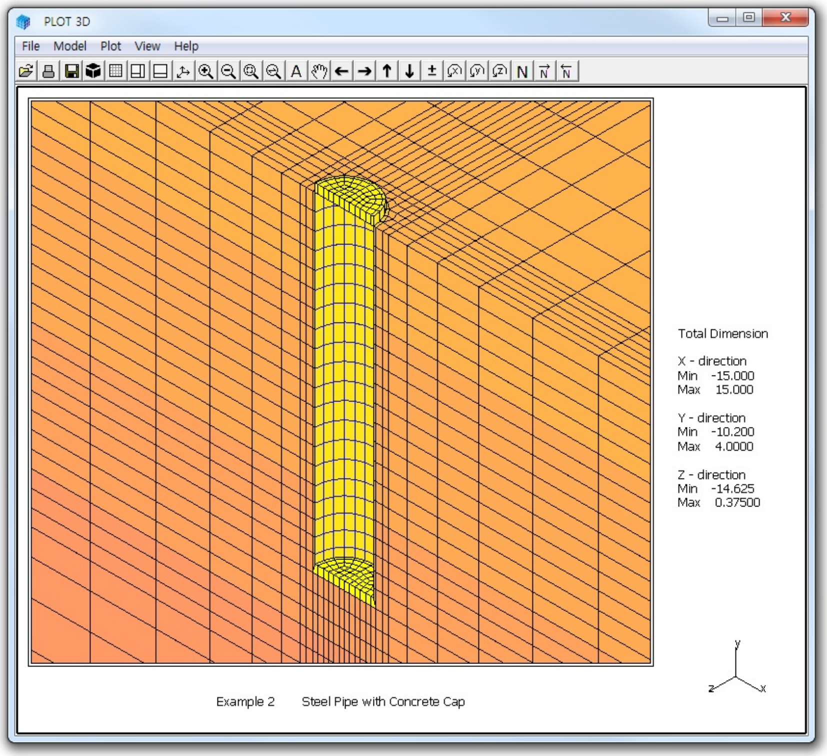


Figure 7.70 Generated finite element meshes for steel pipe

7.8 PRESMAP-GP

PRESMAP-GP is the general purpose pre-processor which can be used to generate coordinates, element indexes, and boundary codes of various geometries modeled by truss, beam, shell or continuum elements. Input parameters of PRESMAP-GP have been described in detail in Section 7.9 of User's Manual.

Input file for PRESMAP-GP is also called block mesh file which can be generated or modified by Block Mesh Generator described in Section 6 of User's Manual.

PRESMAP-GP can be selected in the following order.

Run → Mesh Generator → PreSmap → Presmap GP

When you finish the execution of PRESMAP-GP, select PLOT-3D to plot the generated mesh.

7.8.1 Example 1: 3-D Line/Surface/Volume Blocks

Example 1 shows you how Beam, Shell and Continuum elements are generated using various types of blocks. There are a total of 5 blocks consisting of a line block, a triangle surface block, and a quad surface block, a prism volume block, and a hexahedron volume block. Detailed block information is listed in Table 7.31.

Input block meshes and generated finite element meshes are presented in the following order:

Input Block Meshes
Figure 7.71 Node and block numbers
Figure 7.72 Block numbers for line and surface blocks
Figure 7.73 Material numbers for line and surface blocks
Figure 7.74 Block numbers for volume blocks
Figure 7.75 Material numbers for volume blocks
Figure 7.76 Skeleton boundary codes
Figure 7.77 Fluid boundary codes
Figure 7.78 Rotation boundary codes

Generated Finite Element Meshes

Table 7.31 Listing of input file EX1.Meb

```
StartPresmap
VersionNo = 7.000
* CARD 1.1
* TITLE
  3-D LINE/SURFACE/VOLUME ELEMENT GENERATION
* CARD 1.2
* NBLOCK    NBNODE    NSNODE    NSNEL    IGBND    ISMAP    CMFAC    ICOMP
  5         12        1         1        0        3        1.000    1
*======================================================================
* CARD 1.3
* Global Outer Surface Boundary
* X - Right Boundary
* ISG  ISX  ISY  ISZ  IFG  IFX  IFY  IFZ  IRG  IRX  IRY  IRZ
  3    0    0    0    0    0    0    0    0    0    0    0
* X - Left Boundary
* ISG  ISX  ISY  ISZ  IFG  IFX  IFY  IFZ  IRG  IRX  IRY  IRZ
  3    0    0    0    0    0    0    0    0    0    0    0
* Y - Top Boundary
* ISG  ISX  ISY  ISZ  IFG  IFX  IFY  IFZ  IRG  IRX  IRY  IRZ
  4    1    1    0    4    1    1    1    0    0    0    0
* Y - Bottom Boundary
* ISG  ISX  ISY  ISZ  IFG  IFX  IFY  IFZ  IRG  IRX  IRY  IRZ
  3    0    0    0    4    1    0    1    0    0    0    0
* Z - Front Boundary
* ISG  ISX  ISY  ISZ  IFG  IFX  IFY  IFZ  IRG  IRX  IRY  IRZ
  3    0    0    0    0    0    0    0    4    0    1    0
* Z - Back Boundary
* ISG  ISX  ISY  ISZ  IFG  IFX  IFY  IFZ  IRG  IRX  IRY  IRZ
  3    0    0    0    0    0    0    0    4    1    0    1
*======================================================================
```

```
* CARD 1.4
* Automatic Finite Element Generation Control Parameters
* Min Length    Max Element
  1.000         10000
*======================================================================
* CARD 2.1
* NODE  X        Y        Z
  1     4.0      6.5      0.0
  2     0.0      2.0      0.0
  3     5.9      0.8      0.0
  4     7.0      7.0      0.0
  5     7.0      1.0      0.0
  6     5.72     3.87     0.0
  7     4.0      6.5     -1.0
  8     0.0      2.0     -1.0
  9     5.9      0.8     -1.0
 10     7.0      7.0     -1.0
 11     7.0      1.0     -1.0
 12     5.72     3.87    -1.0
*======================================================================
StartBlock
* CARD 3.0
* IBETYPE
  1
* CARD 3.1
* BLNAME
  BLOCK 1
* CARD 3.2
* ICOORD IMODE  ILAG
  1      0      0
* CARD 3.3
* I1     I2
  1      3
* M3
  0
* M4
  0
* M5     M6     M7
  0      0      0
* CARD 3.4.1
* NBOUND
  2
* CARD 3.4.2
* IBTYPE ISX    ISY    ISZ    IFX    IFY    IFZ    IRX    IRY    IRZ
  3      0      0      0      1      1      1      1      1      1
  4      0      0      1      1      1      1      1      0      0
```

```
* CARD 3.5
* MATNO  NDX
  1      4
EndBlock
*======================================================================
StartBlock
* CARD 3.0
* IBETYPE
  -2
* CARD 3.1
* BLNAME
  BLOCK 2
* CARD 3.2
* ICOORD IMODE  ILAG
  1      0      1
* CARD 3.3
* I1     I2     I3
  1      2      3
* M4     M5     M6
  0      0      0
* M7
  0
* M8     M9     M10
  0      0      0
* CARD 3.4.1
* NBOUND
  4
* CARD 3.4.2
* IBTYPE ISX    ISY    ISZ    IFX    IFY    IFZ    IRX    IRY    IRZ
  1      0      0      0      0      0      0      1      1      1
  2      1      1      1      0      0      0      1      1      1
  3      0      1      1      1      1      1      0      0      0
  4      1      1      1      1      1      1      1      1      1
* CARD 3.5
* MATNO  NDXY
  4      4
EndBlock
*======================================================================
StartBlock
* CARD 3.0
* IBETYPE
  2
* CARD 3.1
* BLNAME
  BLOCK 3
* CARD 3.2
* ICOORD IMODE  ILAG
  1      0      1
```

```
* CARD 3.3
* I1      I2      I3      I4
  4       1       3       5
* M5      M6      M7      M8
  0       0       0       0
* M9
  0
* M10     M11     M12
  0       0       0
* CARD 3.4.1
* NBOUND
  1
* CARD 3.4.2
* IBTYPE ISX     ISY     ISZ     IFX     IFY     IFZ     IRX     IRY     IRZ
  5       1       0       1       0       1       0       1       0       1
* CARD 3.5
* MATNO  NDX     NDY
  2       1       4
* NT1     NT2     NT3     NT4
  0       0       0       0
* MAT1    MAT2    MAT3    MAT4
  0       0       0       0
EndBlock
*========================================================================
StartBlock
* CARD 3.0
* IBETYPE
  -3
* CARD 3.1
* BLNAME
  BLOCK 4
* CARD 3.2
* ICOORD IMODE  ILAG
  1       0       1
* CARD 3.3
* I1    I2    I3    I4    I5    I6
  1     2     3     7     8     9
* M7    M8    M9    M10   M11   M12   M13   M14   M15   M16   M17
  0     0     0     0     0     0     0     0     0     0     0
* M18   M19   M20   M21
  0     0     0     0
* M22   M23   M24
  0     0     0
* CARD 3.4.1
* NBOUND
  3
```

```
* CARD 3.4.2
* IBTYPE ISX     ISY     ISZ     IFX     IFY     IFZ     IRX     IRY     IRZ
  1      1       1       1       0       0       0       1       1       1
  3      0       0       0       1       1       1       0       0       0
  4      1       1       0       0       1       1       1       0       0
* CARD 3.5
* MATNO  NDXY    NDZ     KS      KF
  1      4       1       0       1
EndBlock
*======================================================================
StartBlock
* CARD 3.0
* IBETYPE
  3
* CARD 3.1
* BLNAME
  BLOCK 5
* CARD 3.2
* ICOORD IMODE  ILAG
  1      0       1
* CARD 3.3
* I1   I2   I3   I4   I5   I6   I7   I8
  4    1    3    5    10   7    9    11
* M9   M10  M11  M12  M13  M14  M15  M16  M17  M18  M19  M20
  0    0    0    0    0    0    0    0    0    0    0    0
* M21  M22  M23  M24  M25  M26  M27
  0    0    0    0    0    0    0
* M28  M29  M30
  0    0    0
* CARD 3.4.1
* NBOUND
  3
* CARD 3.4.2
* IBTYPE ISX     ISY     ISZ     IFX     IFY     IFZ     IRX     IRY     IRZ
  1      0       0       0       0       0       0       0       0       0
  2      0       0       0       1       1       1       0       0       0
  3      1       1       0       0       1       1       1       0       0
* CARD 3.5
* MATNO  NDX     NDY     NDZ     KS      KF
  3      1       4       1       0       1
* NT1    NT2     NT3     NT4
  0      0       0       0
* MAT1   MAT2    MAT3    MAT4
  0      0       0       0
EndBlock
*======================================================================
EndOfLastBlock
```

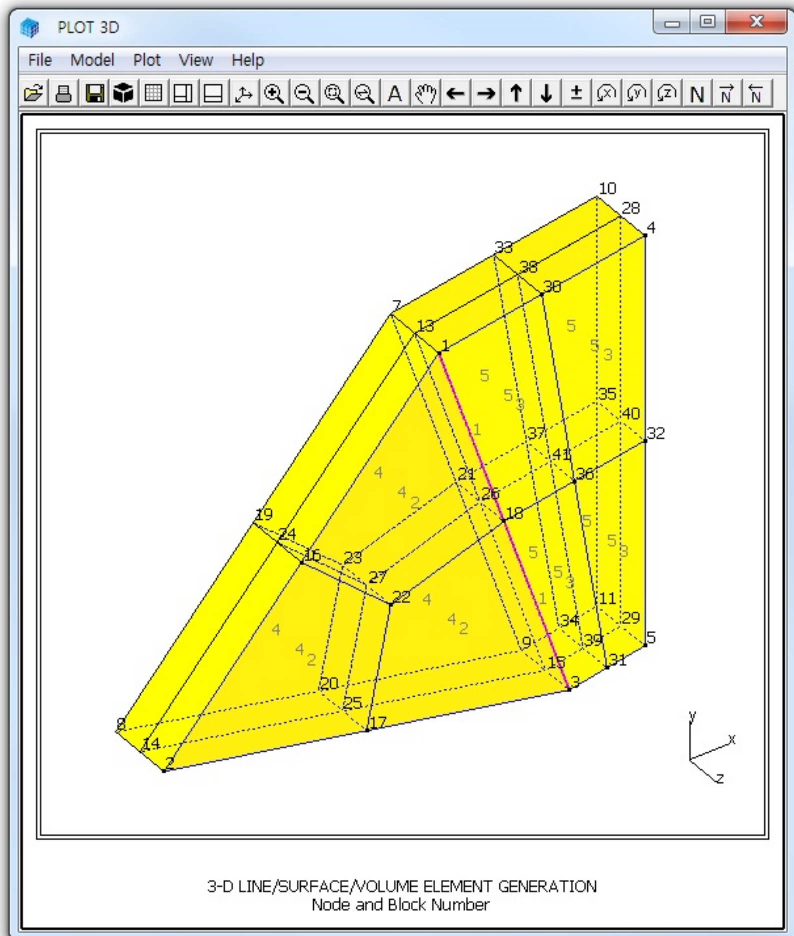


Figure 7.71 Node and block numbers for Example 1

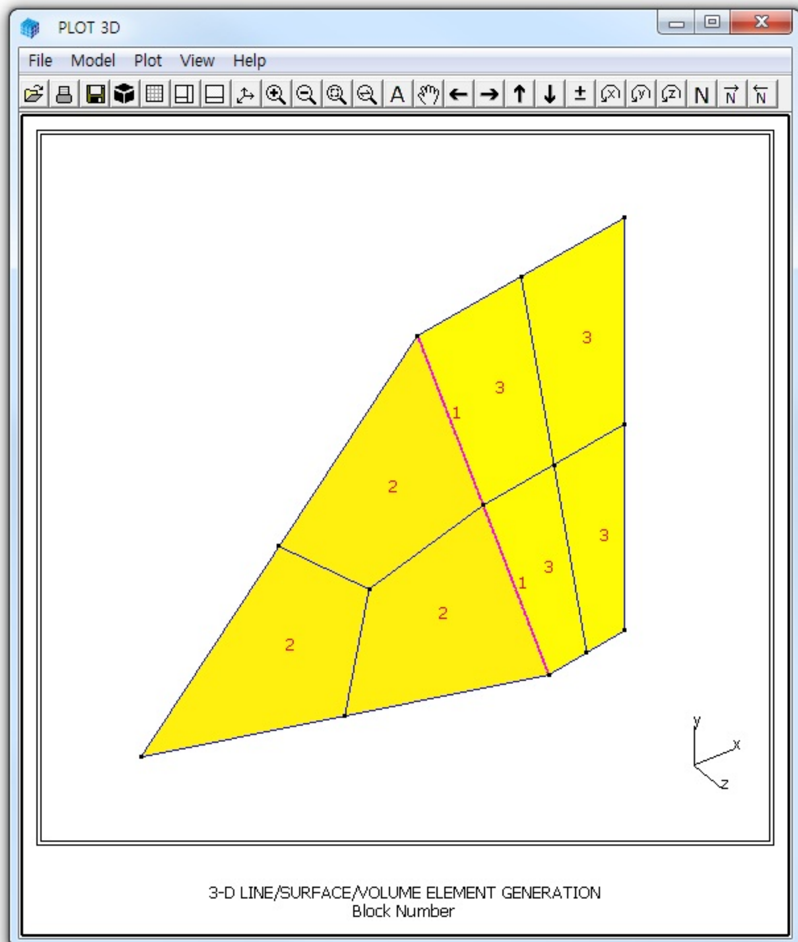


Figure 7.72 Block numbers for line and surface blocks

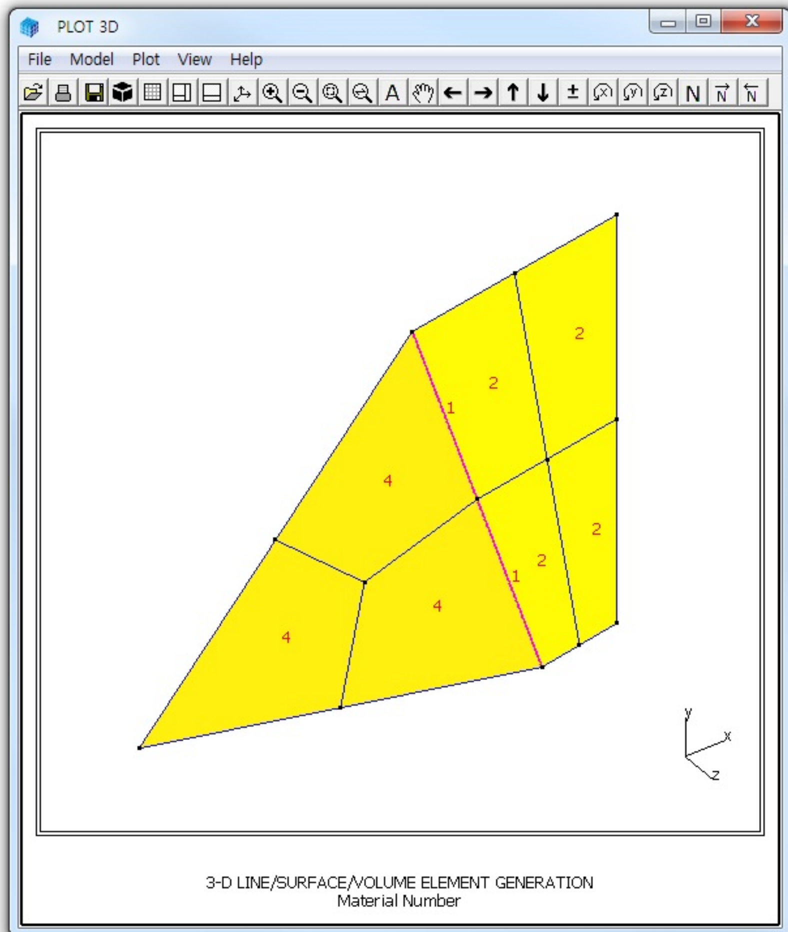


Figure 7.73 Material numbers for line and surface blocks

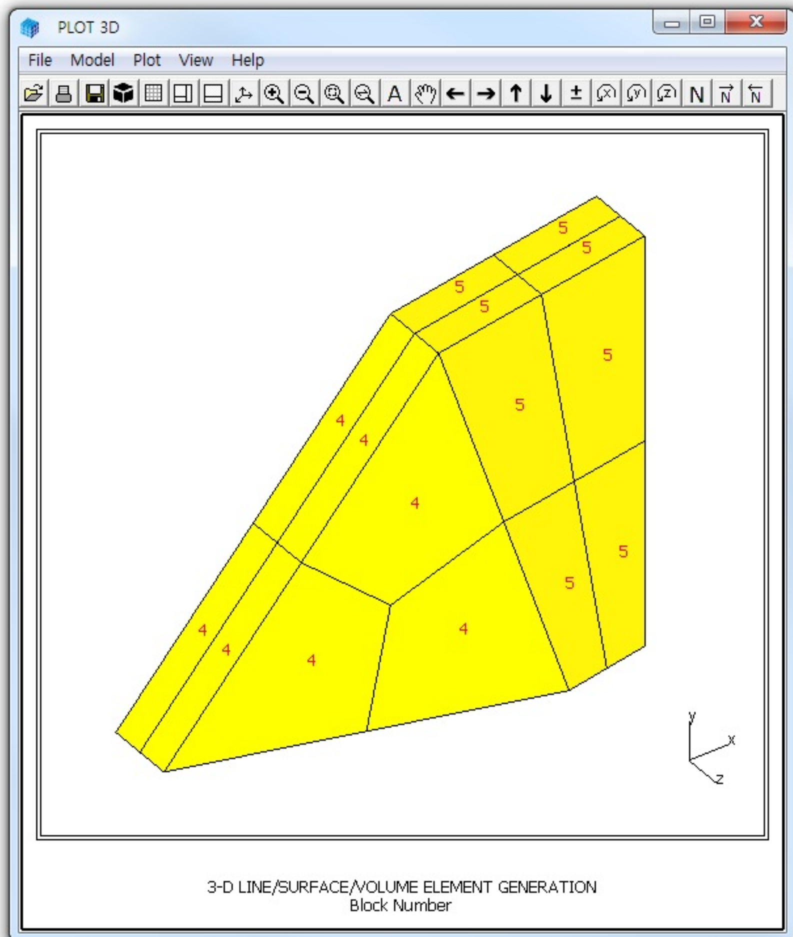


Figure 7.74 Block numbers for volume blocks

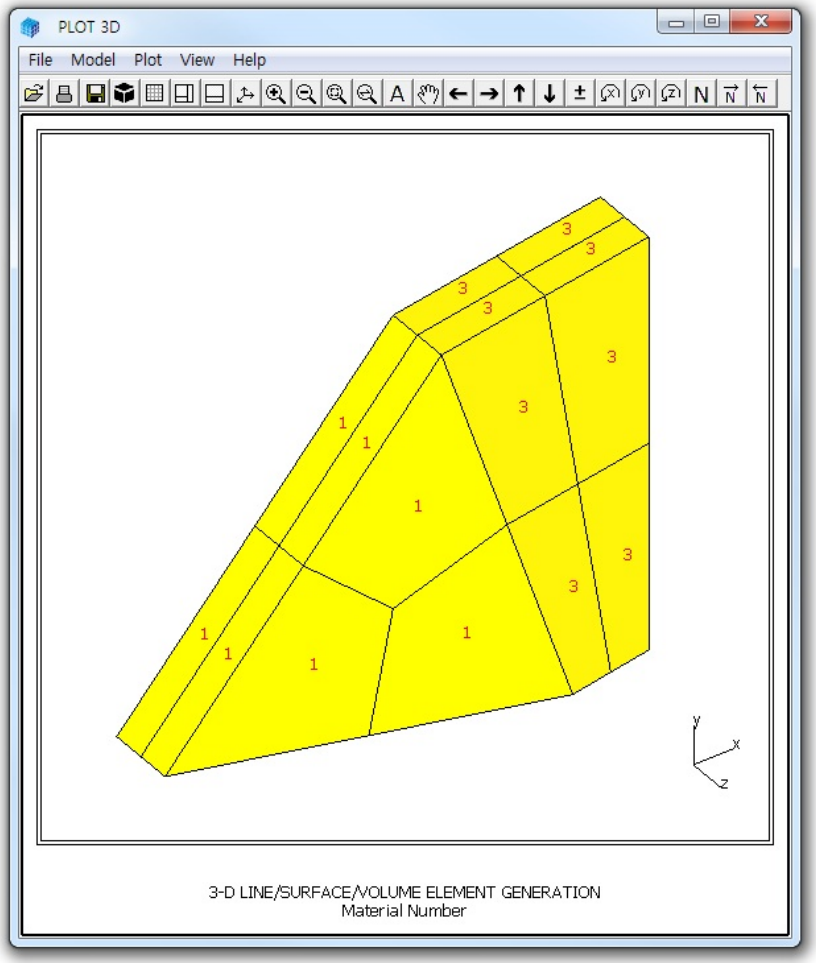


Figure 7.75 Material numbers for volume blocks

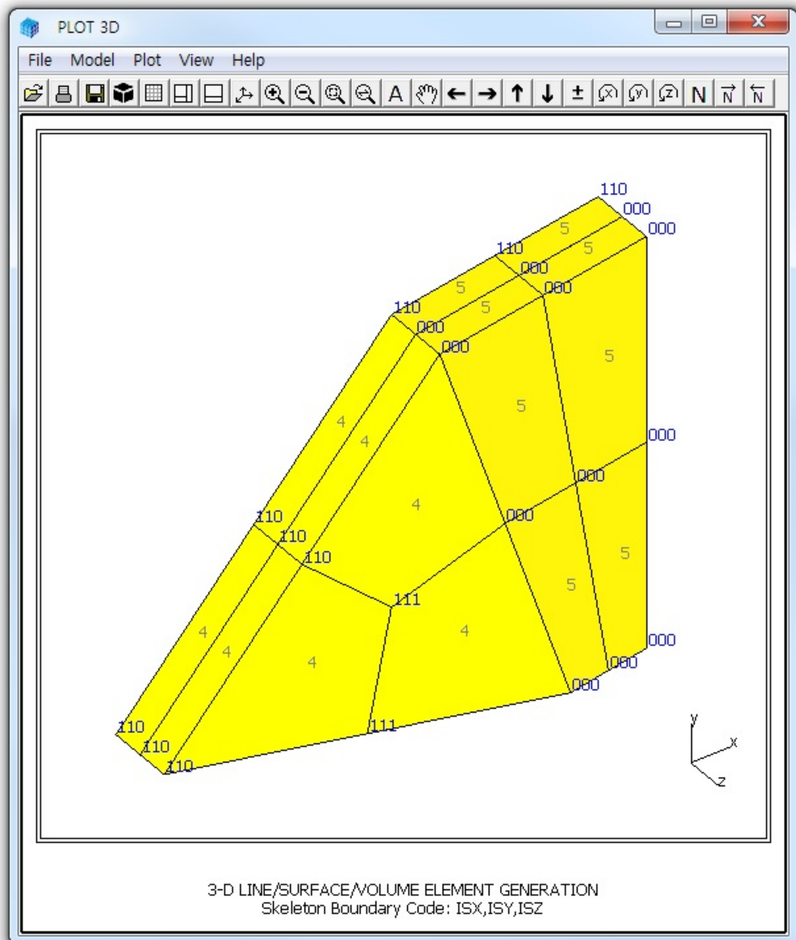


Figure 7.76 Skeleton boundary codes

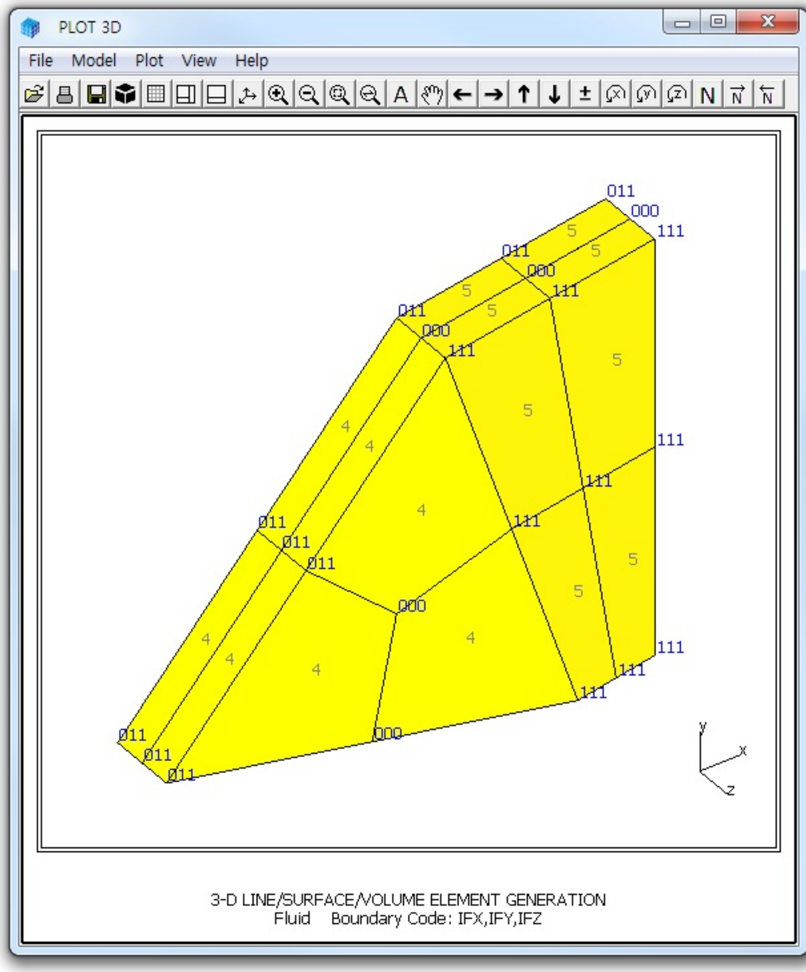


Figure 7.77 Fluid boundary codes

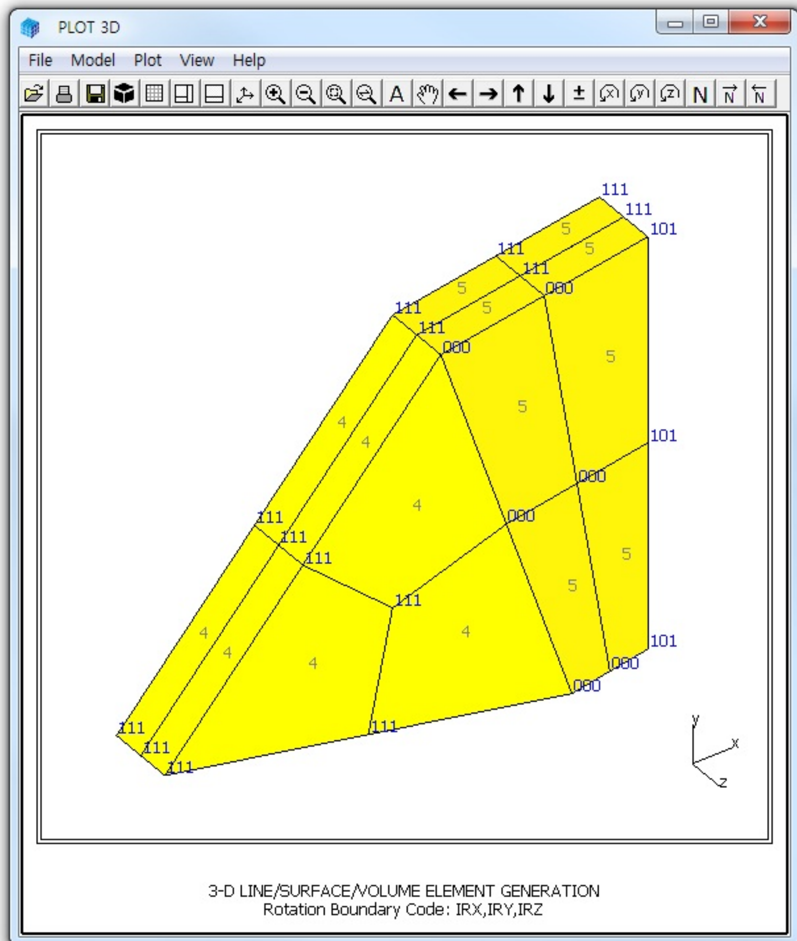


Figure 7.78 Rotation boundary codes

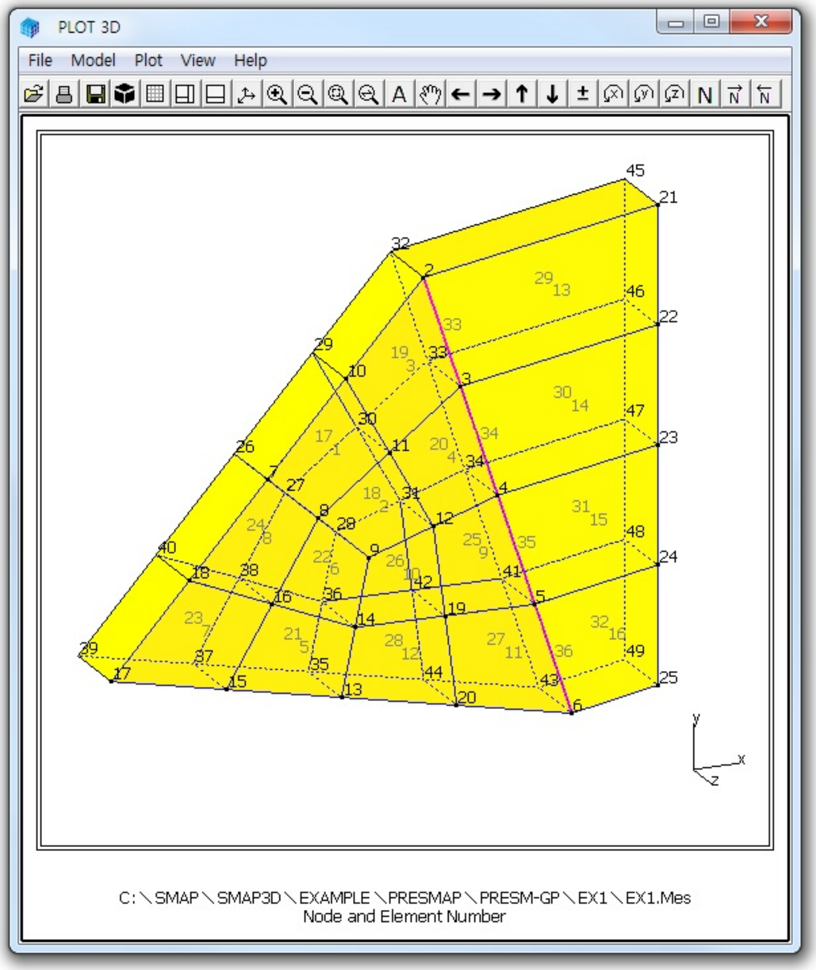


Figure 7.79 Node and element numbers for Example 1

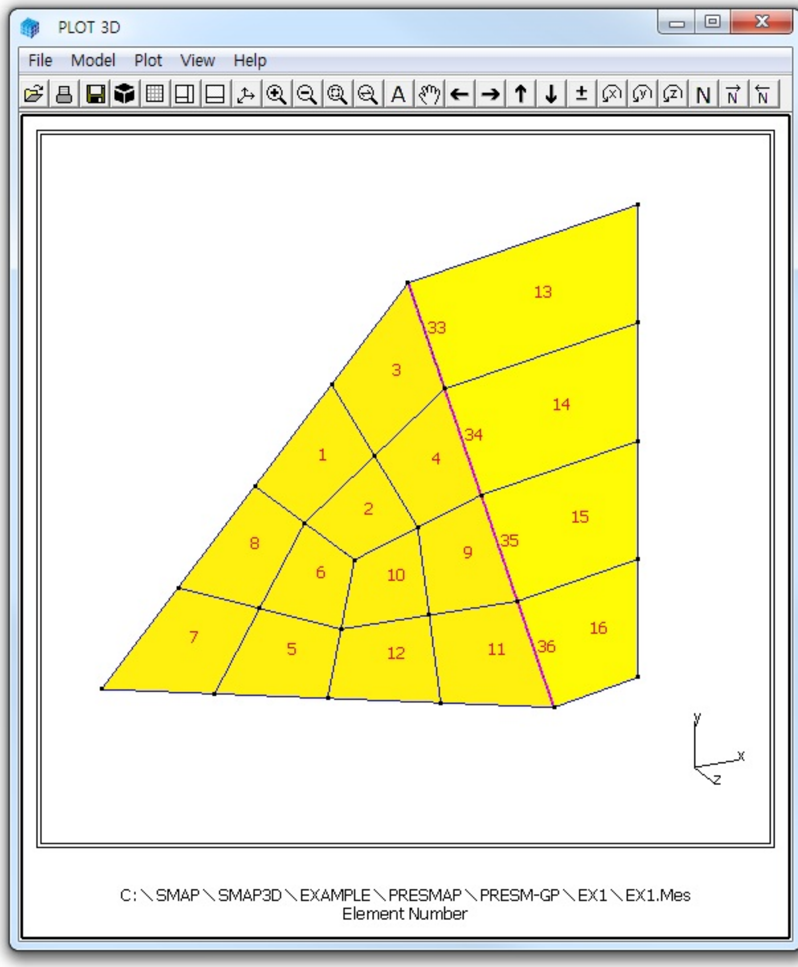


Figure 7.80 Element numbers for beam and shell elements

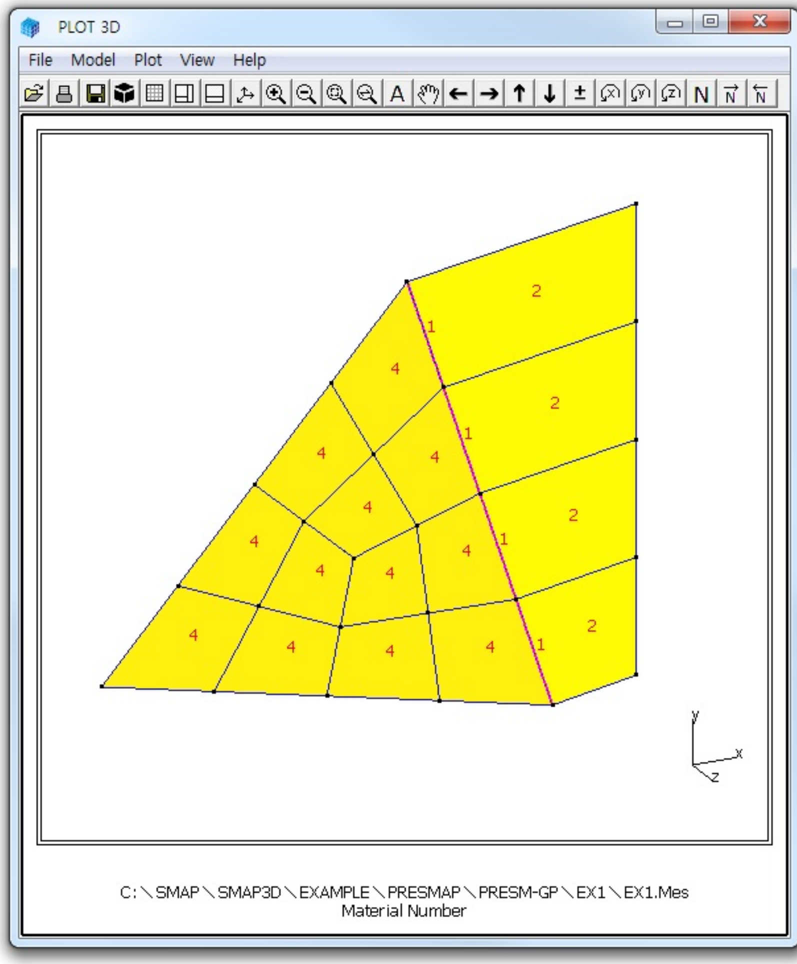


Figure 7.81 Material numbers for beam and shell elements

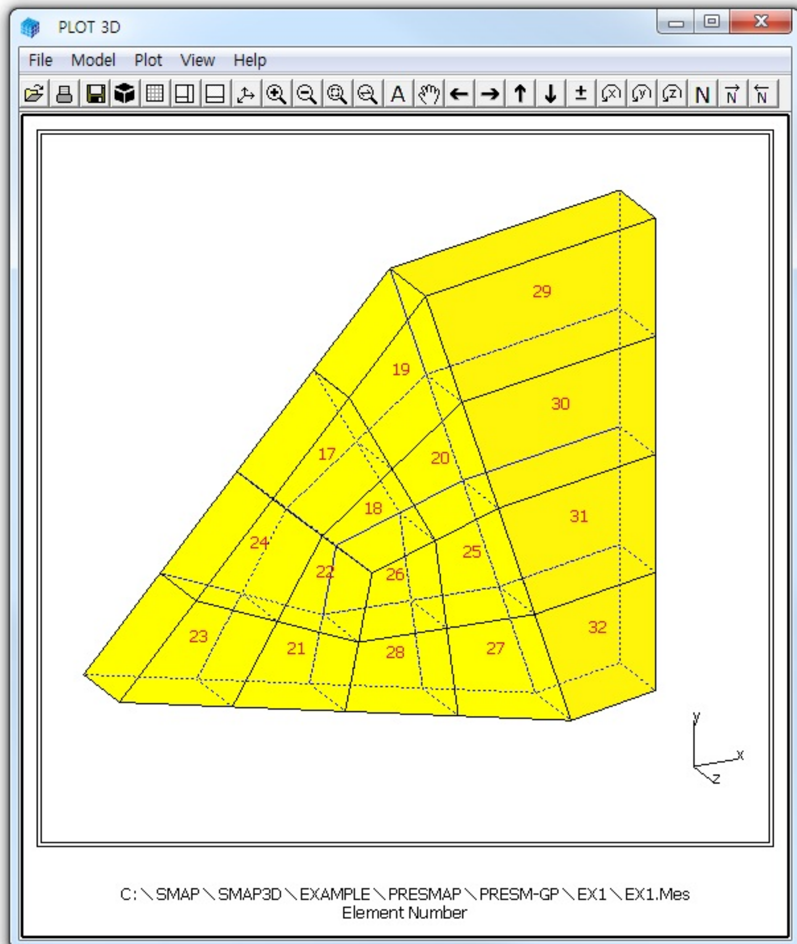


Figure 7.82 Element numbers for continuum elements

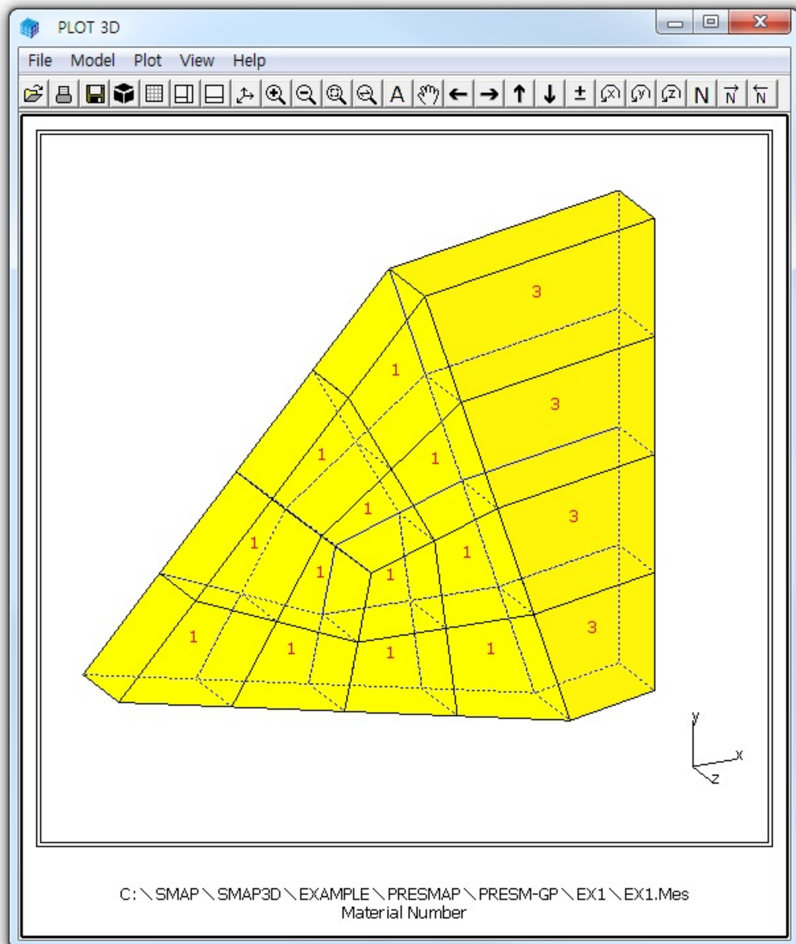


Figure 7.83 Material numbers for continuum elements

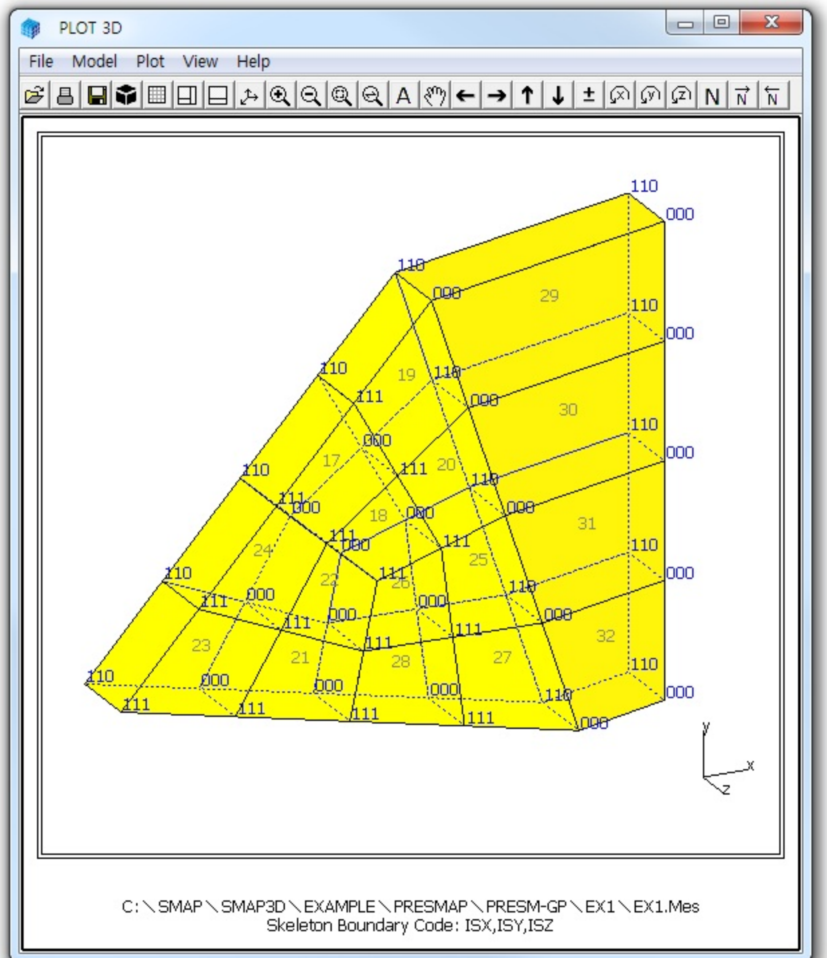


Figure 7.84 Skeleton boundary codes

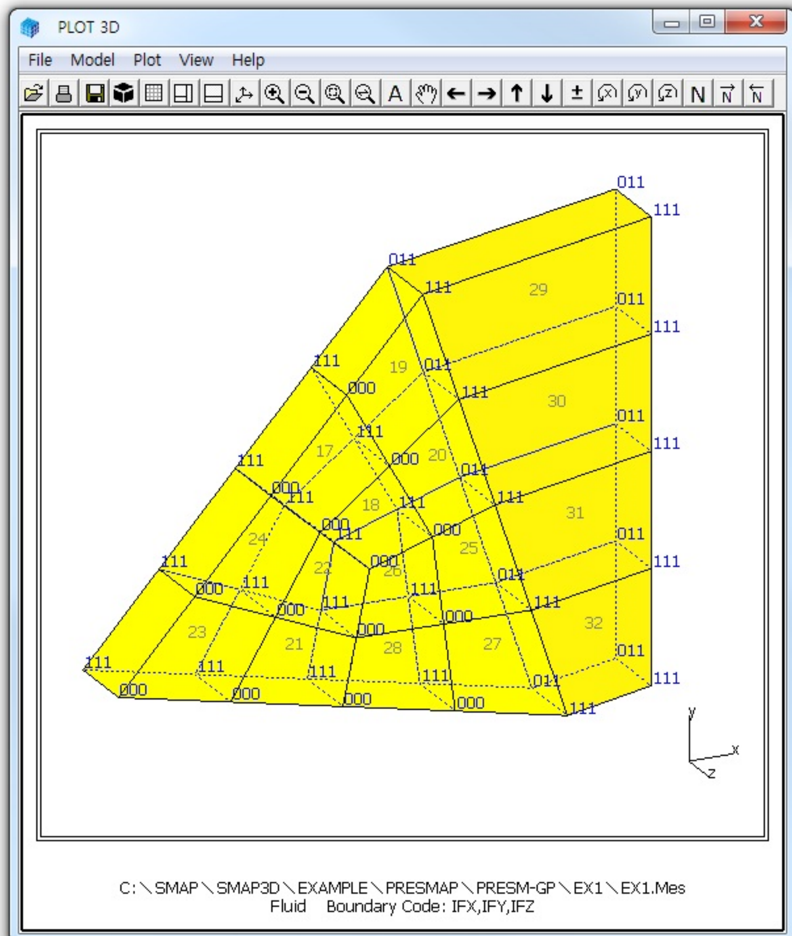


Figure 7.85 Fluid boundary codes

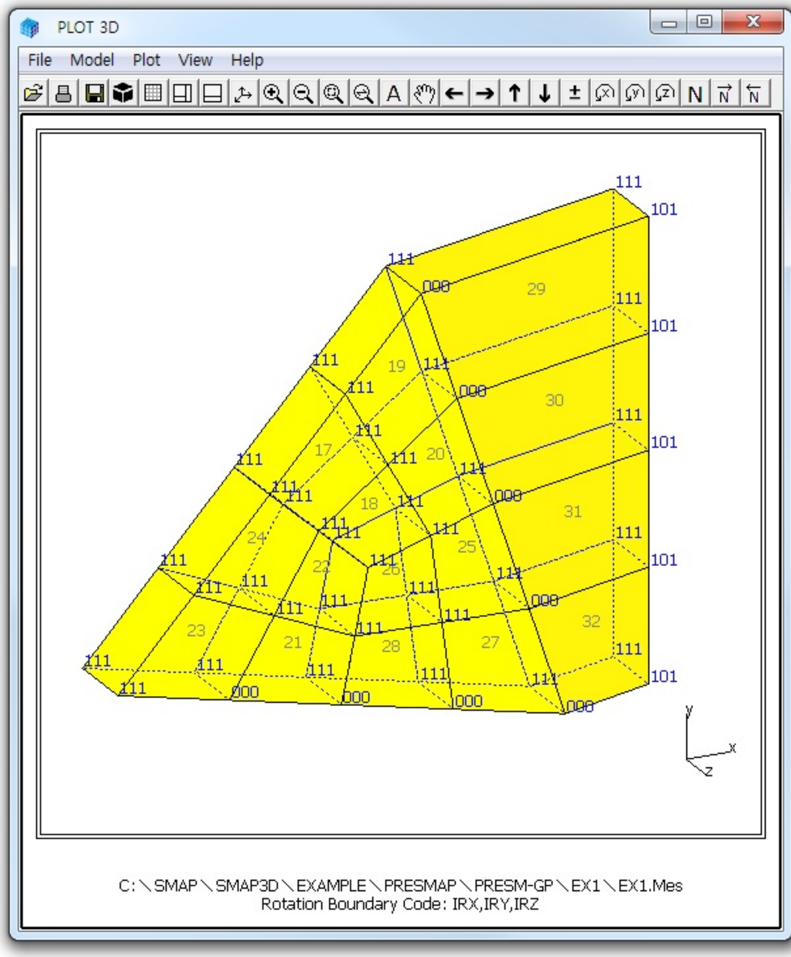


Figure 7.86 Rotation boundary codes

7.8.2 Example 2: Surface with Corner Triangles

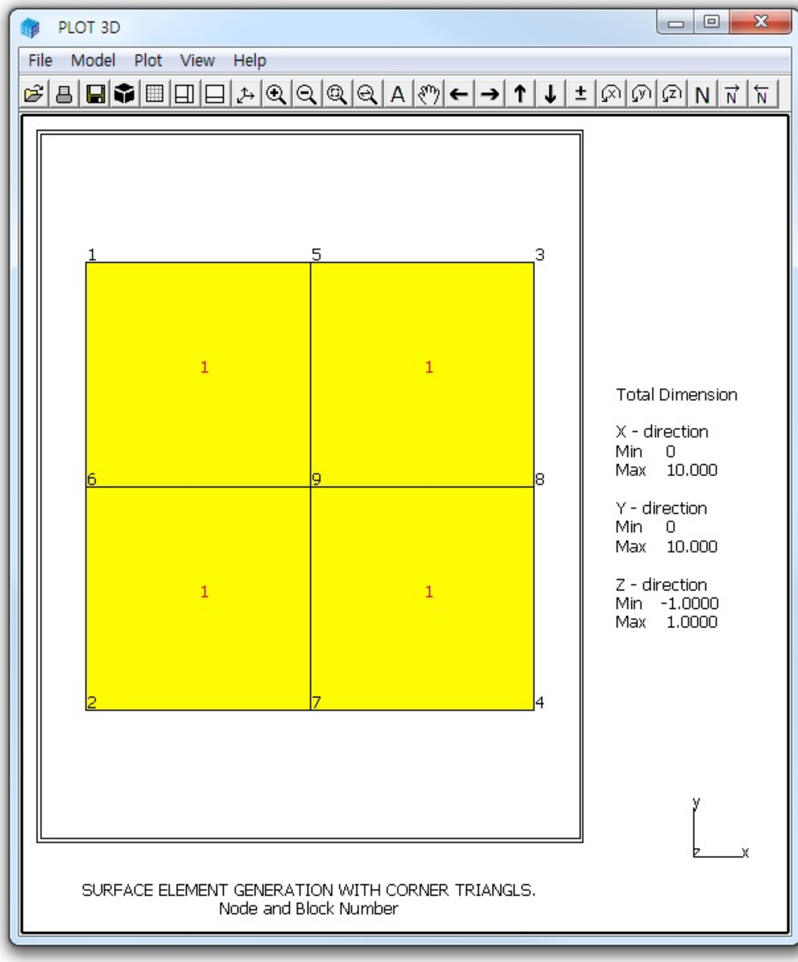


Figure 7.87 Block mesh for Example 2

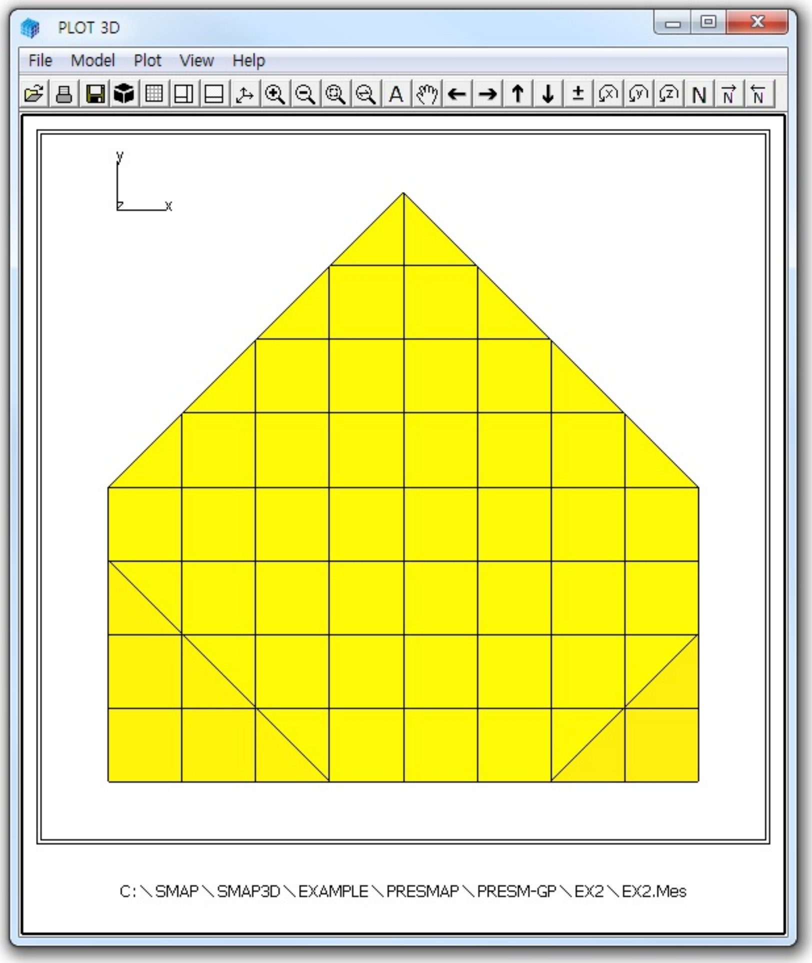


Figure 7.88 Finite element mesh for Example 2

7.8.3 Example 3: Circular Sector

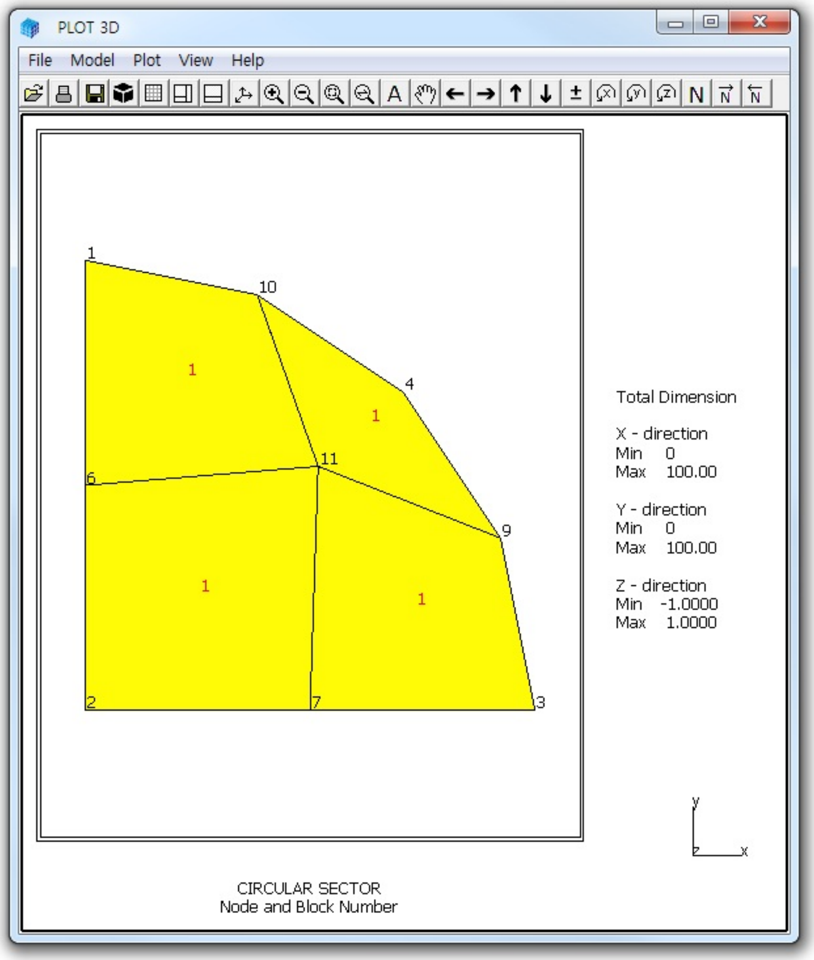


Figure 7.89 Block mesh for Example 3

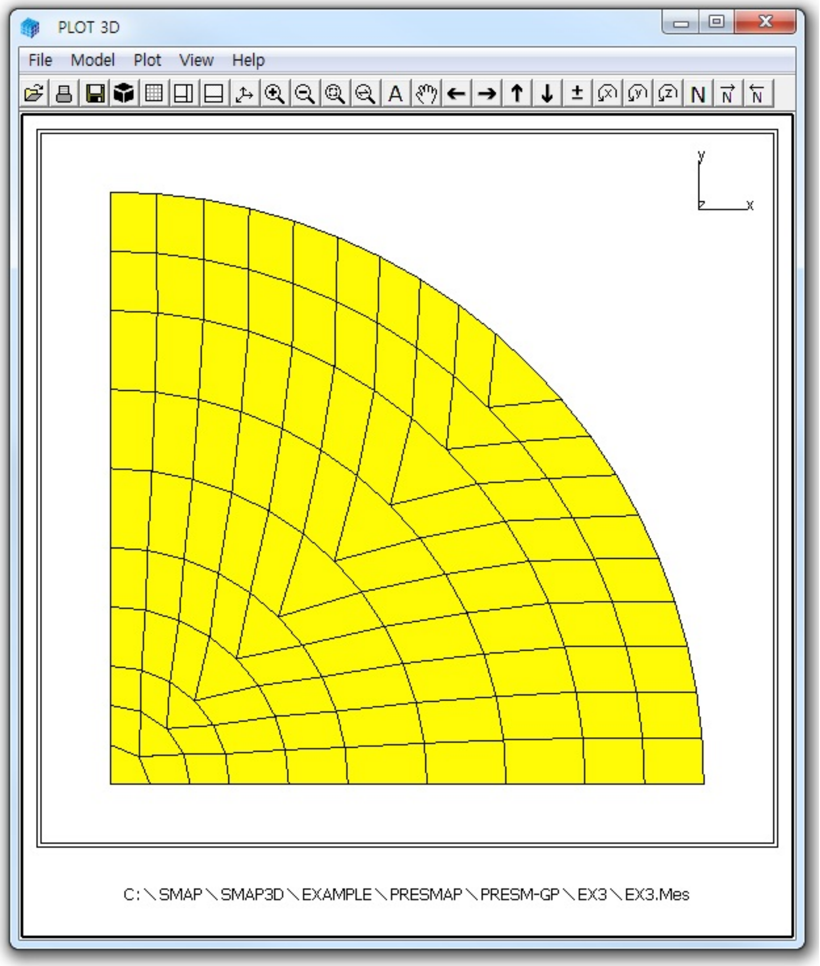


Figure 7.90 Finite element mesh for Example 3

7.8.4 Example 4: Straight Line Sector

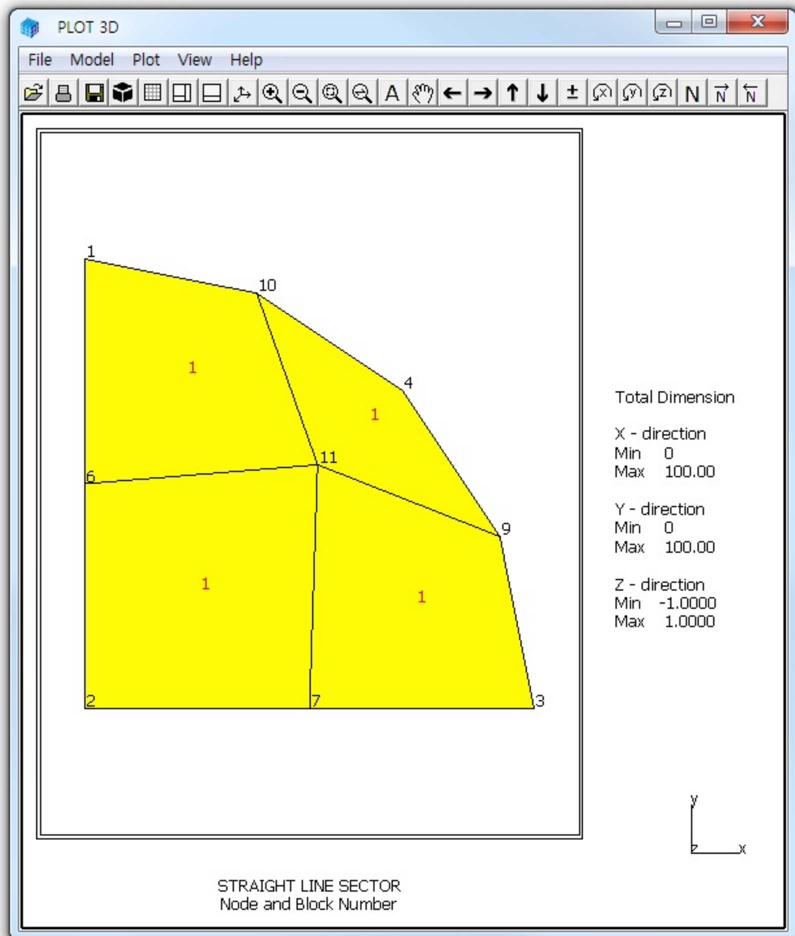


Figure 7.91 Block mesh for Example 4

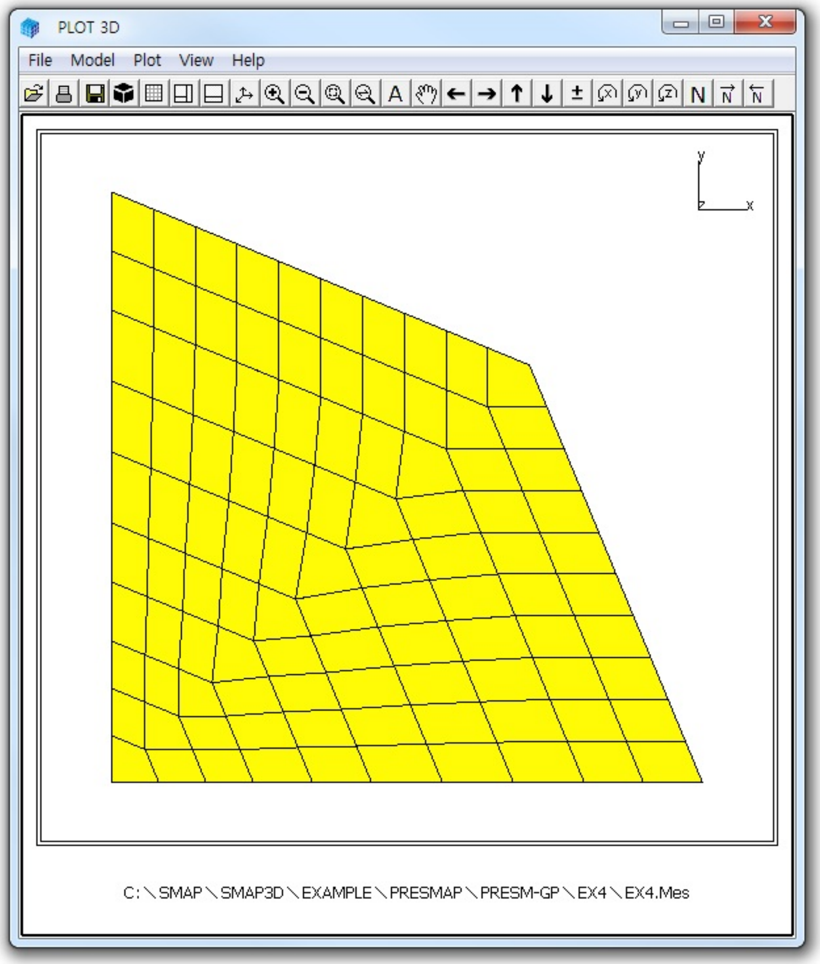


Figure 7.92 Finite element mesh for Example 4

7.8.5 Example 5: Surface and Line Element (1)

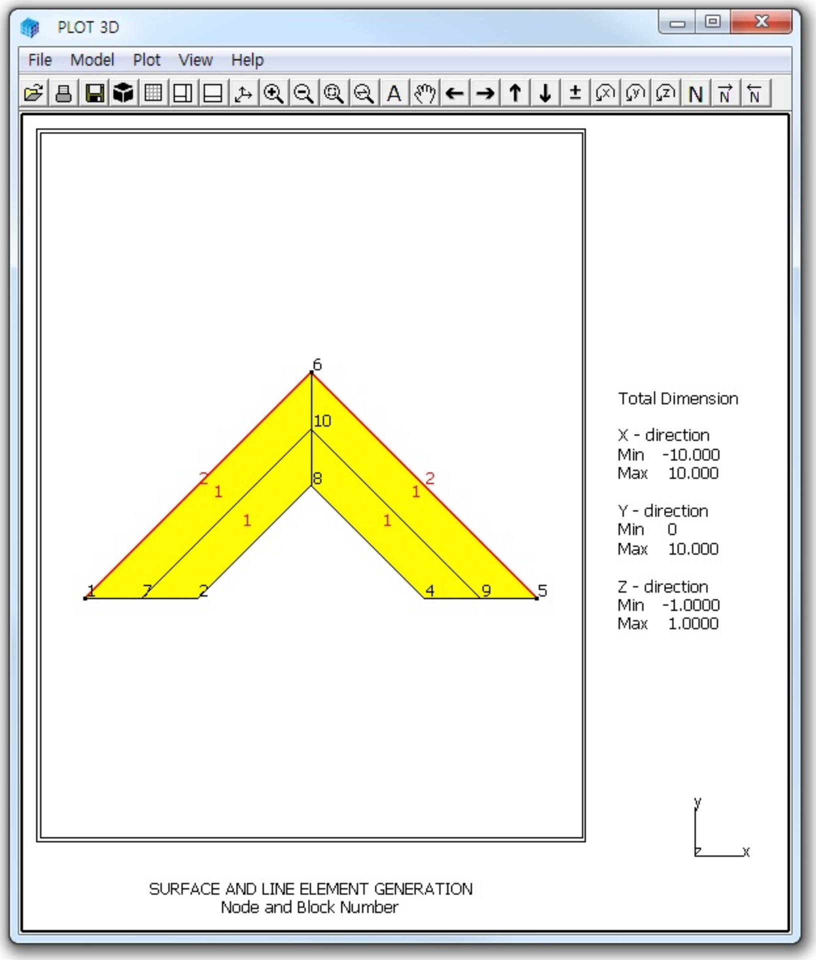


Figure 7.93 Block mesh for Example 5

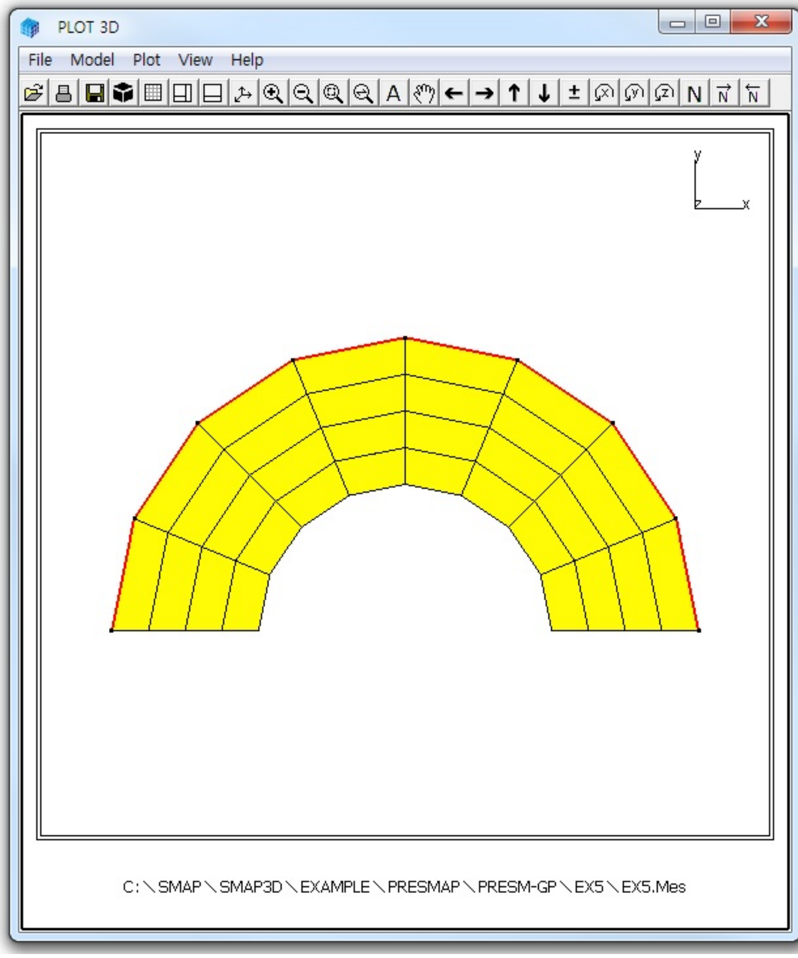


Figure 7.94 Finite element mesh for Example 5

7.8.6 Example 6: Surface and Line Element (2)

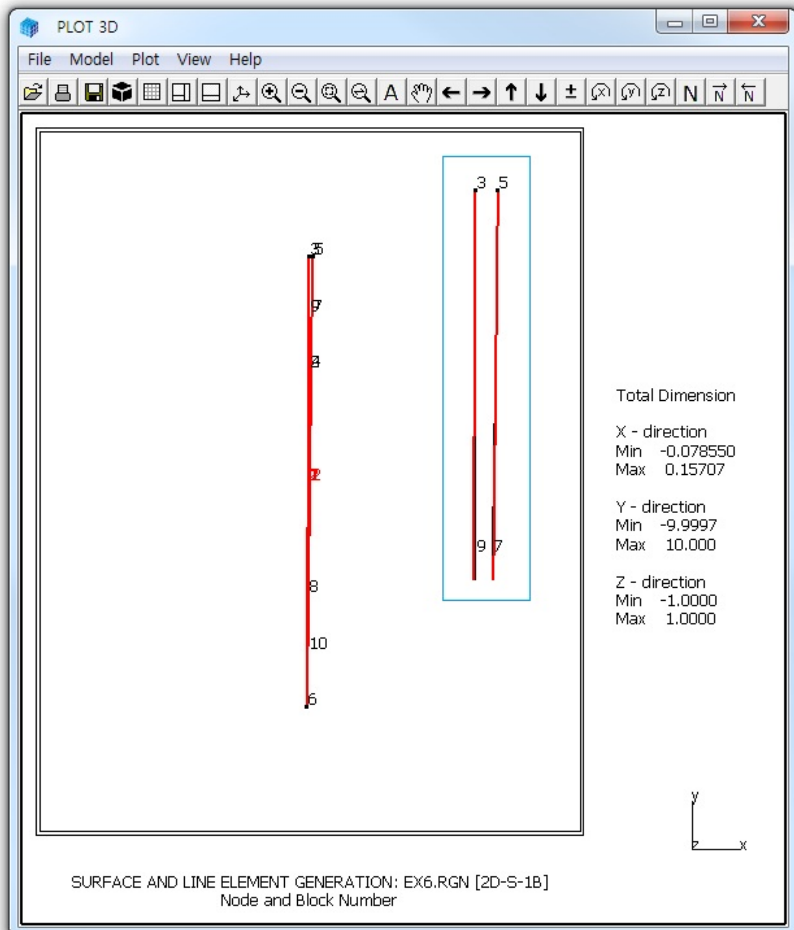


Figure 7.95 Block mesh for Example 6

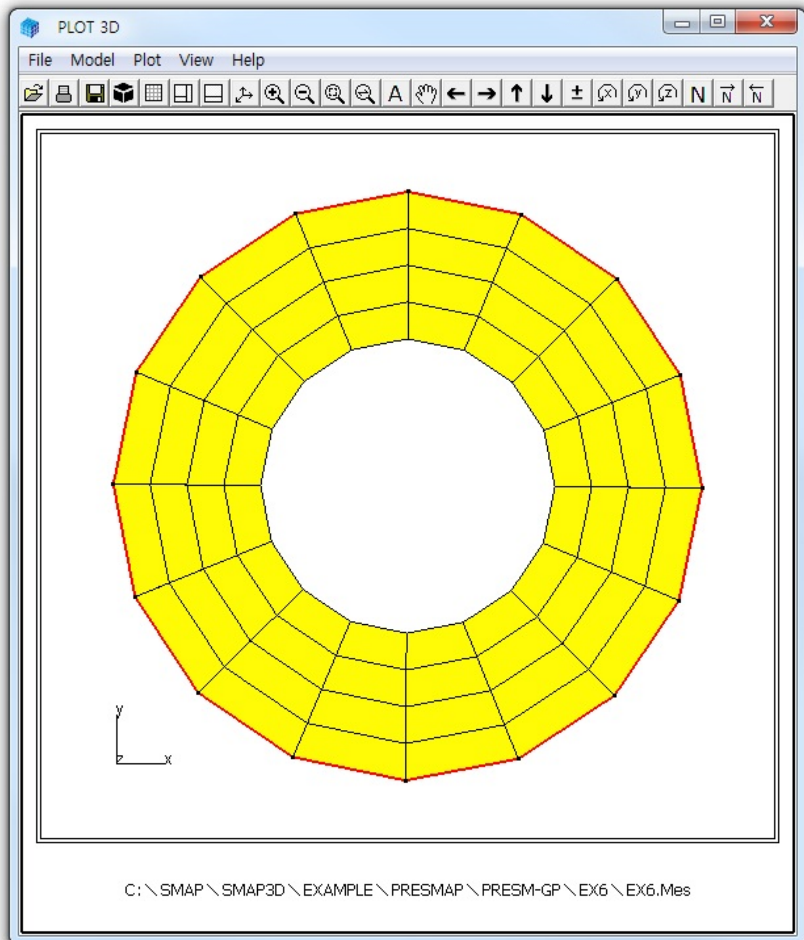


Figure 7.96 Finite element mesh for Example 6

7.8.7 Example 7: Surface and Line Element (3)

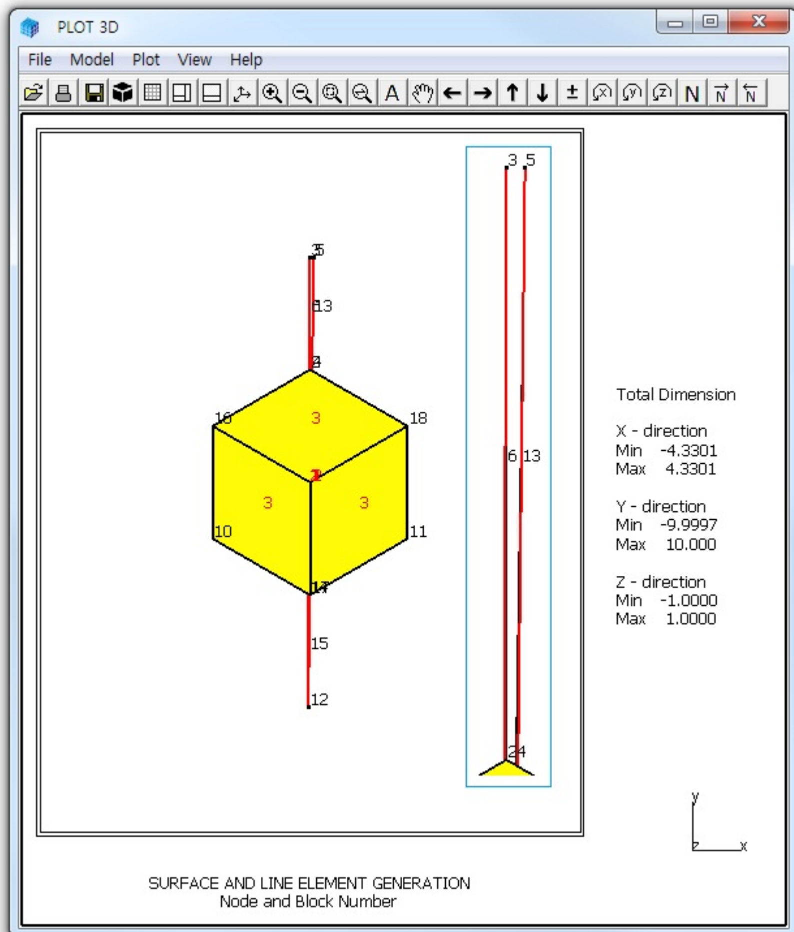


Figure 7.97 Block mesh for Example 7

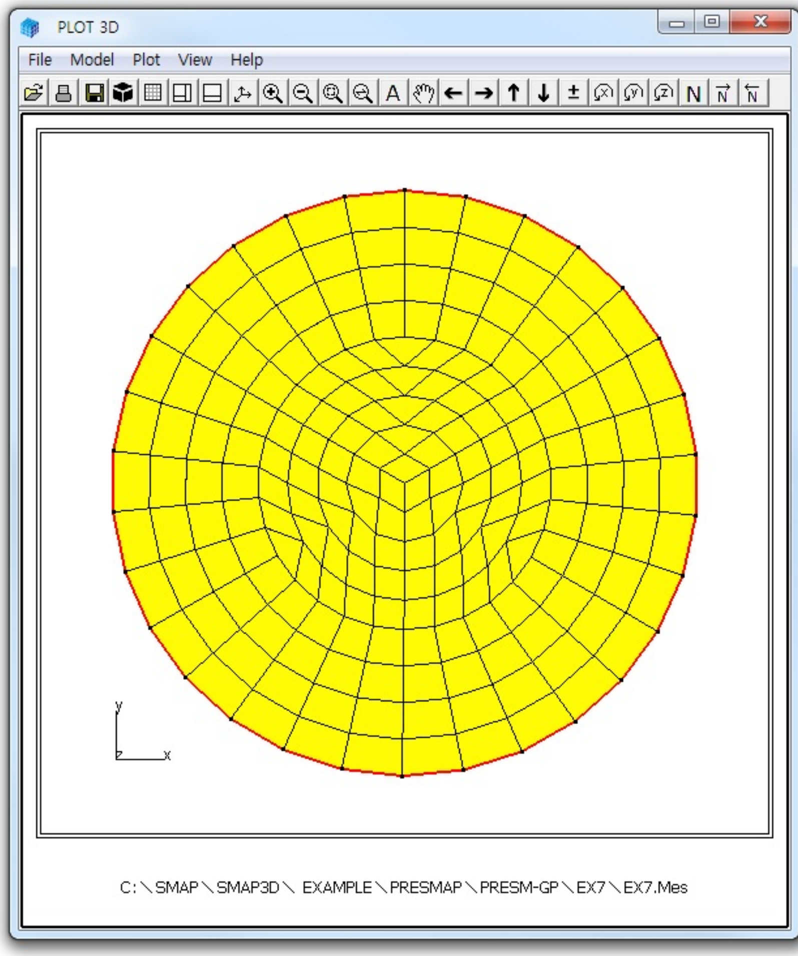


Figure 7.98 Finite element mesh for Example 7

7.8.8 Example 8: Cement-Soil Road

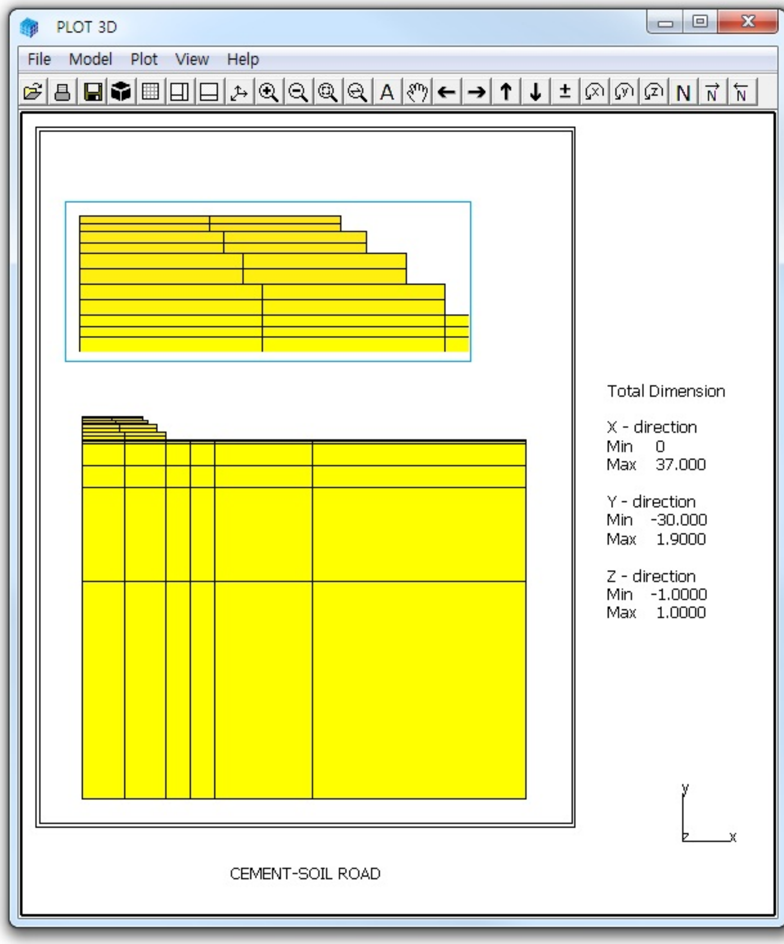


Figure 7.99 Block mesh for Example 8

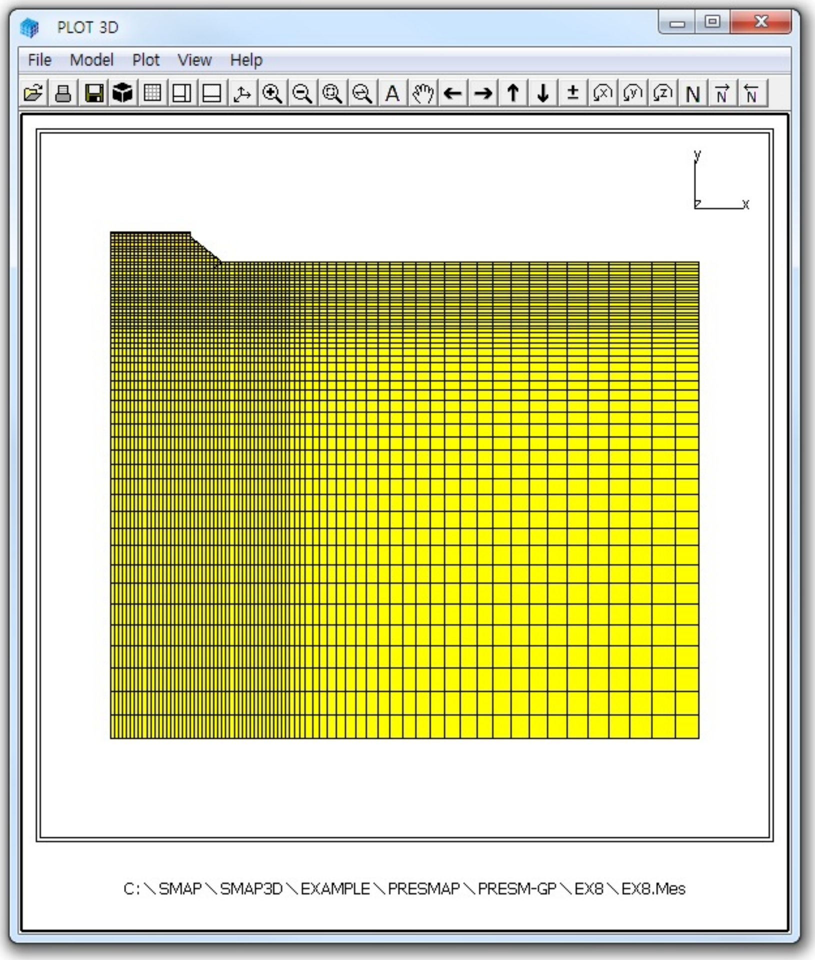


Figure 7.100 Finite element mesh for Example 8

7.8.9 Example 9: Tunnel in Spherical Geometry

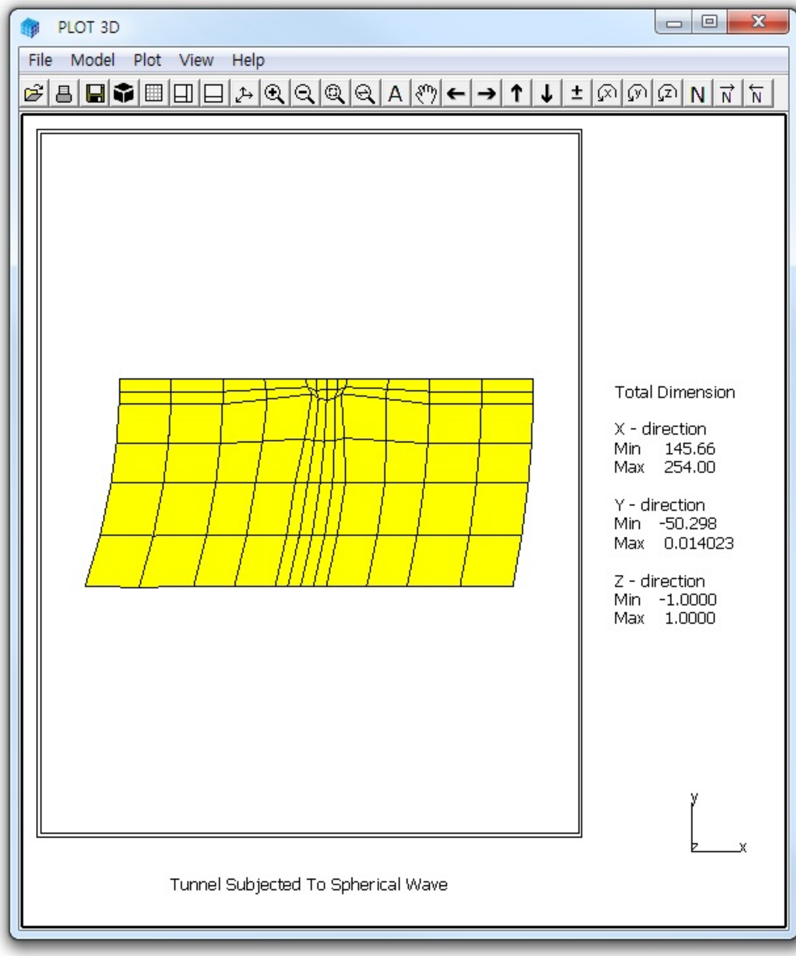


Figure 7.101 Block mesh for Example 9

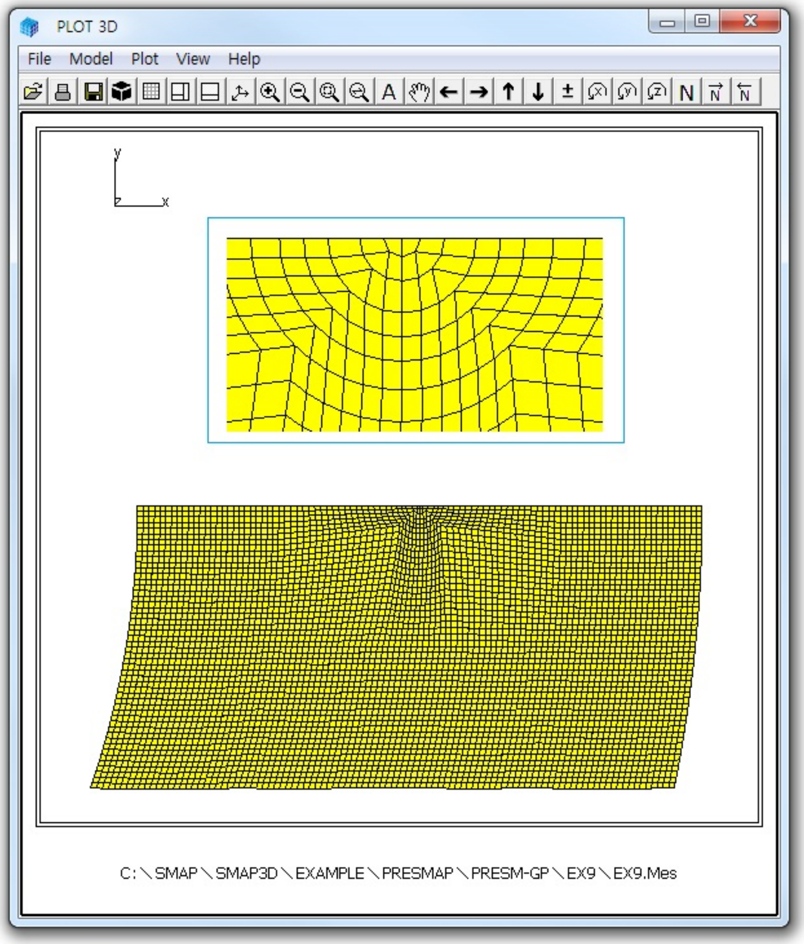


Figure 7.102 Finite element mesh for Example 9

7.8.10 Example 10: Horseshoe Tunnel

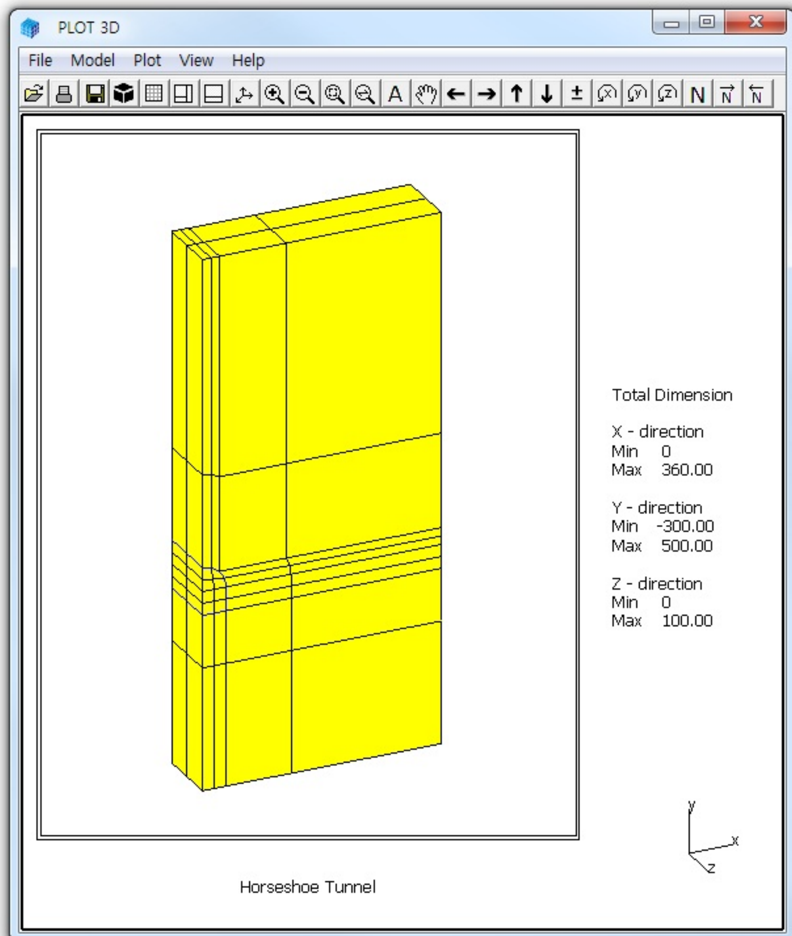


Figure 7.103 Block mesh for Example 10

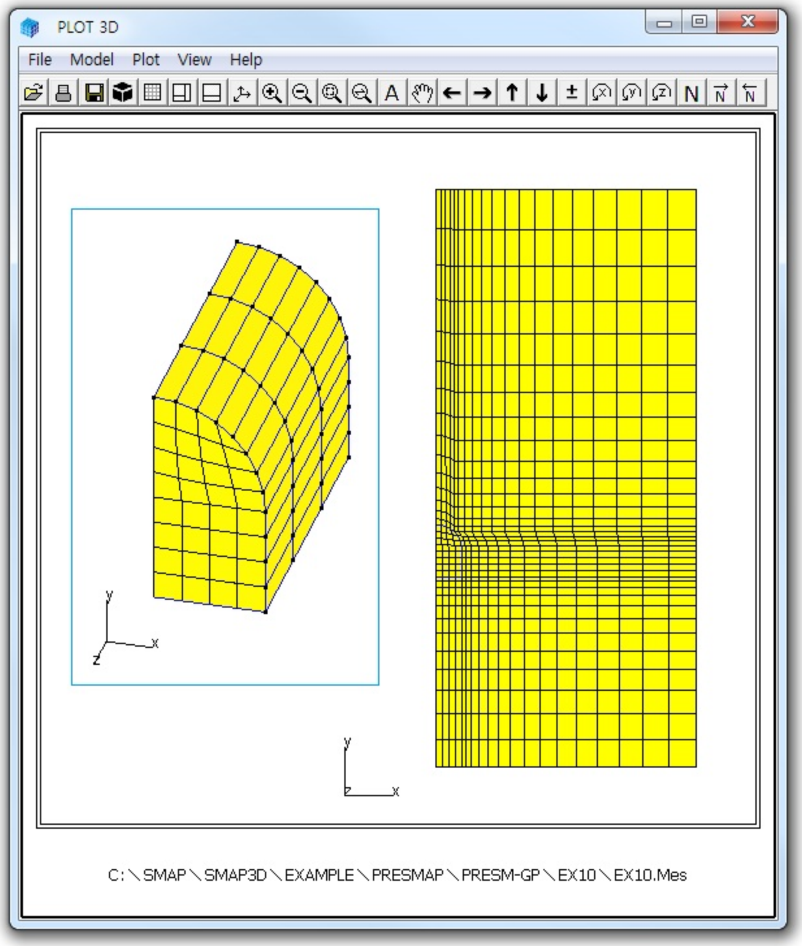


Figure 7.104 Finite element mesh for Example 10

7.8.11 Example 11: Wedge Volume and Surface Block

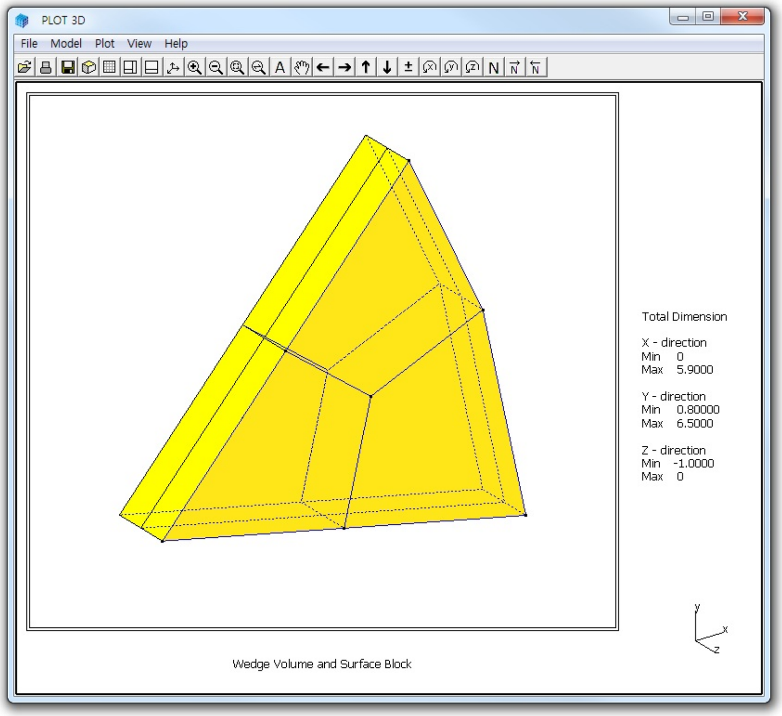


Figure 7.105 Block mesh for Example 11

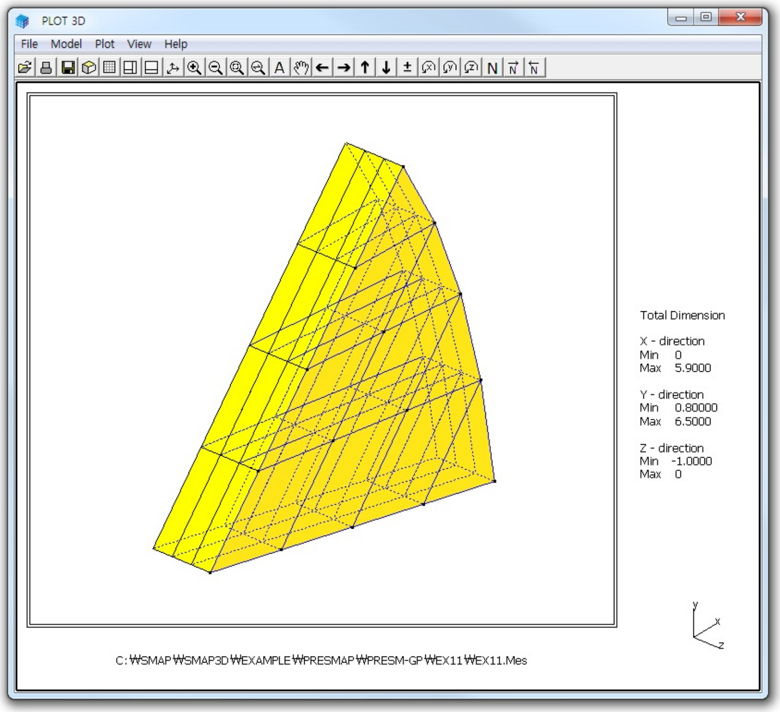


Figure 7.106 Finite element mesh for Example 11

7.9 JOINT-3D

JOINT-3D is the special pre-processor which can be used to generate jointed continuum finite element meshes given the conventional continuum SMAP-3D Mesh File input. For the jointed continuum analysis, each continuum finite element is surrounded by joint elements which allow slippage along the joint when reaching shear strength and debonding normal to the joint face when exceeding tensile strength.

JOINT-3D includes following features:

- Internal Joints within the specified group of materials
- Boundary Joints along the specified group of materials
- Surface Joints along the specified group of element surfaces

First, you need to prepare SMAP-3D Mesh File consisting of continuum elements. Copy C:\Smap\Ct\Ctdata\Joint-3D.dat into Working Directory and then modify input parameters as described in Section 7.10 of User's Manual.

JOINT-3D can be selected in the following order.

Run → Mesh Generator → PreSmap → Joint

Dialog for Input and Output File Names will be displayed as in Fig. 7.107.

7.9.1 Example 1: Horseshoe Tunnel

Example 1 shows you how jointed continuum elements are generated around the horseshoe tunnel. Figure 7.108 shows material numbers of continuum elements: 1 representing for Far Field, 2 for Tunnel Core and 3 for Near Field in the input mesh. Joint data is prepared to generate internal joints within the Near Field as listed in Table 7.32. Note that it also specify Outer Shell between Tunnel Core and and Near Field to generate tunnel liner.

Figure 7.109 shows generated jointed finite element meshes around tunnel core along with shell elements representing for tunnel liner.

Table 7.32 Listing of input file Joint.inp for Example 1

```
****************************************************************
* Jointed Continuum Generation                                 *
* =============================================================*
*                                                              *
* Card 1.1                                                     *
* Title                                                        *
  Example 1: Horseshoe Tunnel
* Card 1.2                                                     *
* AllJoint                                                     *
*  = 0 Generate Joint Elements along all interfaces            *
*      between continuum elements.                             *
*      Cards 2, 3 and 4 are not used.                          *
*                                                              *
*  = 1 Generate Joint Elements for material numbers of         *
*      continuum elements as specified in Cards 2 and 3.       *
*      Card 4 is not used.                                     *
*                                                              *
*  = 2 Generate Joint Elements for element surface numbers of  *
*      continuum elements as specified in Card 4.              *
*      Cards 2 and 3 are ignored.                              *
*                                                              *
* ThicAJ  Joint Thickness Used For AllJoint = 0                *
*                                                              *
*--------------------------------------------------------------*
*                                                              *
*  To Run JOINT-3D                                             *
*                                                              *
*  Method 1                                                    *
*  ========                                                    *
*                                                              *
*  SMAP-3D > Run > Mesh Generator > PreSmap > Joint            *
*  Specify input and output file names shown on the screen.    *
*                                                              *
*  Method 2                                                    *
*  ========                                                    *
*                                                              *
*  1. Select SMAP-3D > Setup > PLOT 3D                         *
*  Specify Joint Thickness View Factor greater than 0.0        *
*  Example: Joint Thickness View Factor = 1.0                  *
*                                                              *
*  2. Select SMAP-3D > Mesh > F.E. Mesh > Open
*
*  This wil open Mesh File of Continuum Elements.              *
*                                                              *
*  Input file Joint.inp should exist in Working Directory.     *
*  Output file JointedMesh.Mes is shown in Working Directory.  *
*                                                              *
```

```
* AllJoint  ThicAJ                                                *
*-----------------------------------------------------------------*
  1         0.03
*                                                                 *
*******************************************************************
* Card 2                                                          *
* Internal Joint Generation By AllJoint = 1                       *
*******************************************************************
*                                                                 *
* Card 2.1                                                        *
* NumIJ  (Number of Continuum Materials for Internal Joints)      *
* ThicIJ (Joint Thickness)                                        *
*                                                                 *
* NumIJ     ThicIJ                                                *
*-----------------------------------------------------------------*
  1         0.02
*                                                                 *
* Card 2.2                                                        *
* MatIJ (Material No of Continuum Element for Internal Joints)    *
*           InnerShell = 0: No  1: Includes Inner Shell           *
*           OuterShell = 0: No  1: Includes Outer Shell           *
* MatIJ     InnerShell  OuterShell                                *
*-----------------------------------------------------------------*
  3         0           1
*                                                                 *
*******************************************************************
* Card 3                                                          *
* Boundary Joint Generation By AllJoint = 1                       *
*******************************************************************
*                                                                 *
* Card 3.1                                                        *
* NumBJ  (Number of Continuum Materials for Boundary Joints)      *
* ThicBJ (Joint Thickness)                                        *
*         InterfaceJoint = 0: No  1: Includes Joint Element       *
* NumBJ     ThicBJ      InterfaceJoint                            *
*-----------------------------------------------------------------*
* 3         0.03        1
  0         0.03        1
*                                                                 *
* Card 3.2                                                        *
* MatBJ (Material No of Continuum Element for Boundary Joints)    *
*        InnerShell = 0: No  1: Includes Inner Shell              *
*        OuterShell = 0: No  1: Includes Outer Shell              *
*                                                                 *
* MatBJ     InnerShell  OuterShell                                *
*-----------------------------------------------------------------*
* 1         1           1
* 2         1           1
* 3         1           1
*                                                                 *
*******************************************************************
```

```
* Card 4                                                        *
* Surface Joint Generation By AllJoint = 2                      *
*****************************************************************
*                                                               *
* Card 4.1                                                      *
* NumSJG (Number of Groups for Surface Joints)                  *
*                                                               *
* NumSJG                                                        *
*---------------------------------------------------------------*
  0
* 2
*                                                               *
* Card 4.2                                                      *
* NumSJG [i]   : Number of Element Surfaces in Group i          *
* ThicSJG[i]   : Thickness of Surface Joint in Group i          *
*                                                               *
* NumSJG [i]   ThicSJG[i]                                       *
*---------------------------------------------------------------*
*  2           0.5
*  2           0.4
*****************************************************************
* Group (1)                                                     *
* ElementNo    SurfaceNo                                        *
*---------------------------------------------------------------*
*  1           1
*  2           2
*****************************************************************
* Group (2)                                                     *
* ElementNo    SurfaceNo                                        *
*---------------------------------------------------------------*
*  3           4
*  4           4
* End of Data                                                   *
*****************************************************************
```

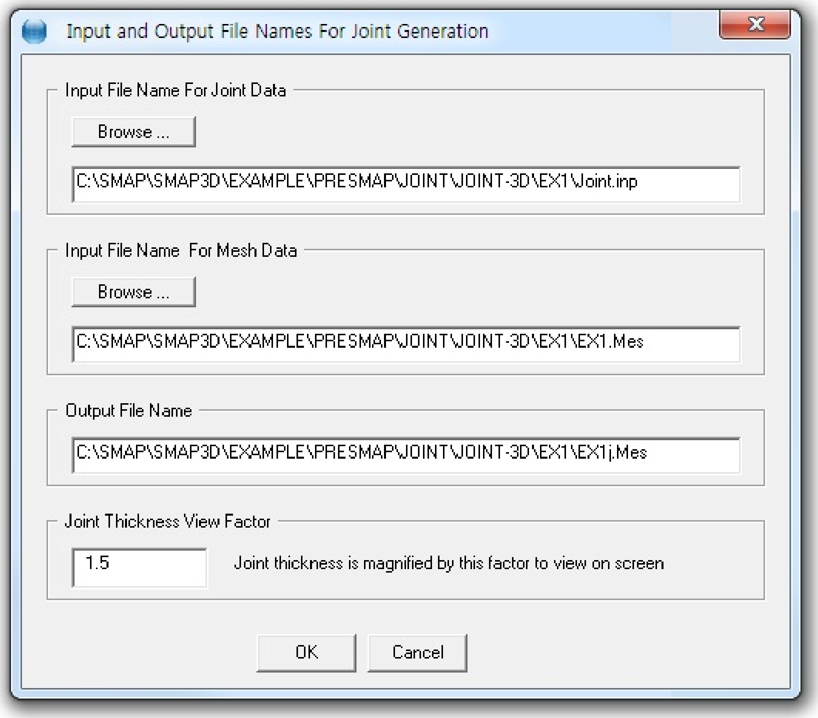


Figure 7.107 Dialog for input and output file names for joint generation

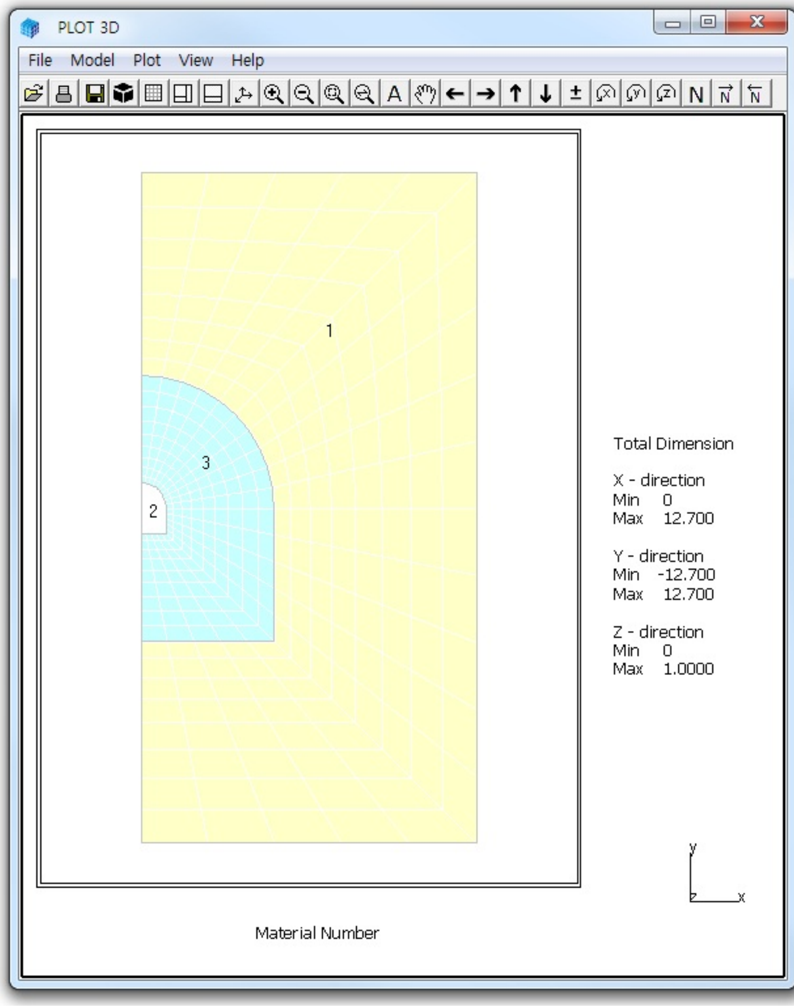


Figure 7.108 Material numbers in input mesh for Example 1

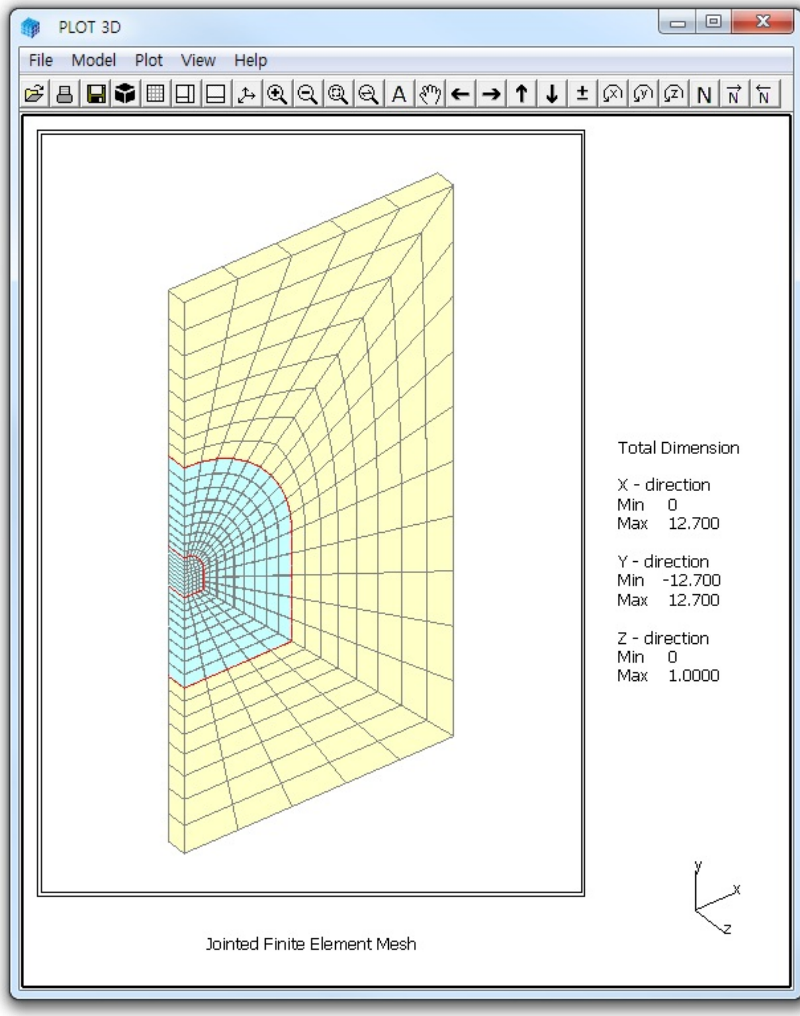


Figure 7.109 Generated jointed finite element mesh for Example 1

7.9.2 Example 2: Vertical Tank with Internal Joints

Example 2 shows jointed continuum elements which are generated within the vertical tank. Figure 7.110 shows material numbers of continuum elements: 1 to 3 representing for vertical tank in the input mesh. Joint data is prepared to generate internal joints within the vertical tank as listed in Table 7.33. Note that it also specify Inner and Outer Shells between vertical tank and surrounding soils.

Figure 7.111 shows generated jointed finite element meshes within vertical tank and shell elements along the boundary.

Table 7.33 Listing of input file Joint.inp for Example 2

```
****************************************************************
* Jointed Continuum Generation                                 *
* ==============================================================*
*                                                              *
* Card 1.1                                                     *
* Title                                                        *
  Example 2: Vertical Tank with Internal Joints
* Card 1.2                                                     *
* AllJoint                                                     *
*  = 0 Generate Joint Elements along all interfaces            *
*      between continuum elements.                             *
*      Cards 2, 3 and 4 are not used.                          *
*                                                              *
*  = 1 Generate Joint Elements for material numbers of         *
*      continuum elements as specified in Cards 2 and 3.       *
*      Card 4 is not used.                                     *
*                                                              *
*  = 2 Generate Joint Elements for element surface numbers of  *
*      continuum elements as specified in Card 4.              *
*      Cards 2 and 3 are ignored.                              *
*                                                              *
* ThicAJ  Joint Thickness Used For AllJoint = 0                *
*                                                              *
*--------------------------------------------------------------*
*                                                              *
* AllJoint  ThicAJ                                             *
*--------------------------------------------------------------*
  1         0.03
*                                                              *
****************************************************************
```

```
* Card 2                                                          *
* Internal Joint Generation By AllJoint = 1                       *
*******************************************************************
*                                                                 *
* Card 2.1                                                        *
* NumIJ  (Number of Continuum Materials for Internal Joints)      *
* ThicIJ (Joint Thickness)                                        *
*                                                                 *
* NumIJ     ThicIJ                                                *
*-----------------------------------------------------------------*
  3         0.03
* Card 2.2                                                        *
* MatIJ (Material No of Continuum Element for Internal Joints)    *
*           InnerShell = 0: No  1: Includes Inner Shell           *
*           OuterShell = 0: No  1: Includes Outer Shell           *
* MatIJ     InnerShell  OuterShell                                *
*-----------------------------------------------------------------*
  1         1           1
  2         1           1
  3         1           1
*                                                                 *
*******************************************************************
* Card 3                                                          *
* Boundary Joint Generation By AllJoint = 1                       *
*******************************************************************
*                                                                 *
* Card 3.1                                                        *
* NumBJ  (Number of Continuum Materials for Boundary Joints)      *
* ThicBJ (Joint Thickness)                                        *
*         InterfaceJoint = 0: No  1: Includes Joint Element       *
* NumBJ     ThicBJ      InterfaceJoint                            *
*-----------------------------------------------------------------*
  0         0.03        1
*
*******************************************************************
* Card 4                                                          *
* Surface Joint Generation By AllJoint = 2                        *
*******************************************************************
*                                                                 *
* Card 4.1                                                        *
* NumSJG (Number of Groups for Surface Joints)                    *
*                                                                 *
* NumSJG                                                          *
*-----------------------------------------------------------------*
  0
* End of Data                                                     *
*******************************************************************
```

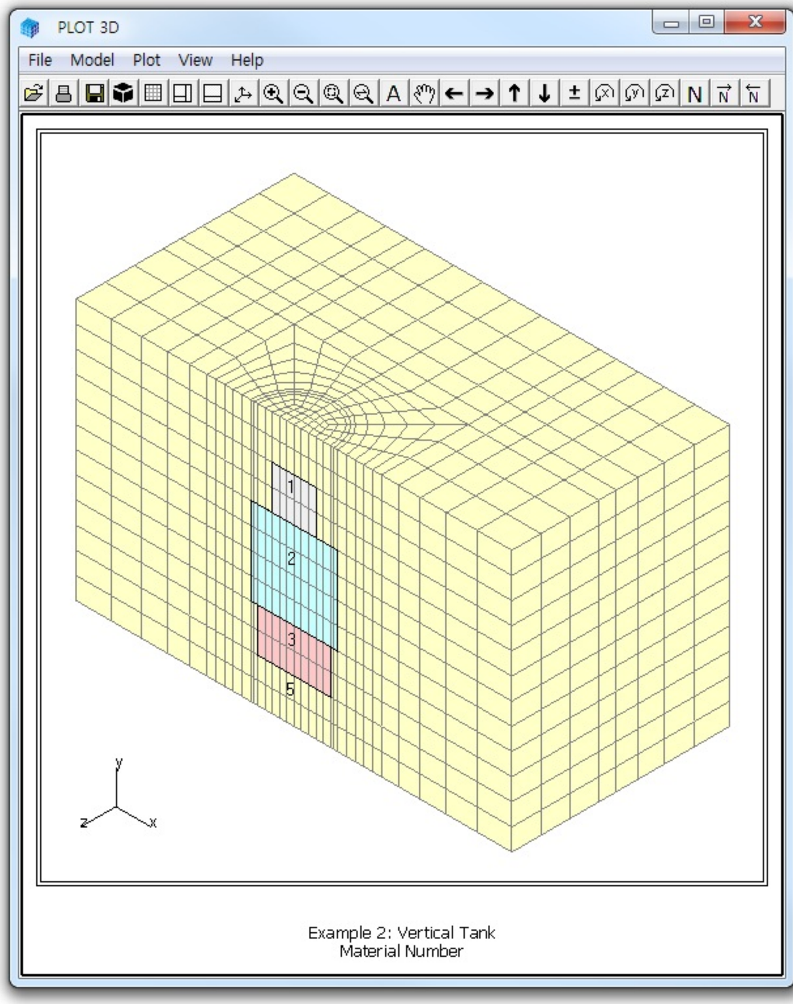


Figure 7.110 Material numbers in input mesh for Example 2

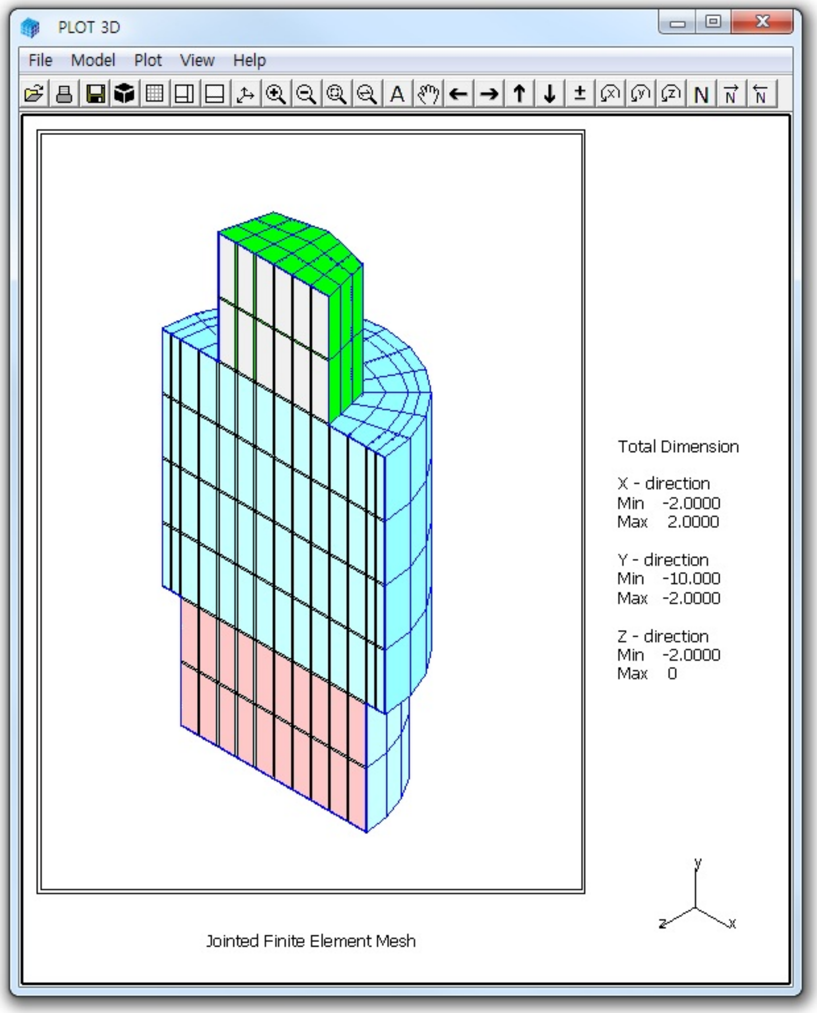


Figure 7.111 Generated jointed finite element mesh for Example 2

7.9.3 Example 3: Vertical Tank with Boundary Joints

Example 3 is the same as Example 2 except that it generates boundary joints along the interface between the vertical tank and surrounding soils. Joint data is prepared to generate boundary joints along the interface as listed in Table 7.34. Note that it also specify Inner and Outer Shells between vertical tank and surrounding soils.

Figure 7.112 shows generated boundary joint elements and shell elements along the interface between vertical tank and surrounding soils.

Table 7.34 Listing of input file Joint.inp for Example 3

```
****************************************************************
* Jointed Continuum Generation                                 *
* ==============================================================*
*                                                              *
* Card 1.1                                                     *
* Title                                                        *
  Example 3: Vertical Tank with Boundary Joints
* Card 1.2                                                     *
* AllJoint                                                     *
*  = 0 Generate Joint Elements along all interfaces            *
*      between continuum elements.                             *
*      Cards 2, 3 and 4 are not used.                          *
*                                                              *
*  = 1 Generate Joint Elements for material numbers of         *
*      continuum elements as specified in Cards 2 and 3.       *
*      Card 4 is not used.                                     *
*                                                              *
*  = 2 Generate Joint Elements for element surface numbers of  *
*      continuum elements as specified in Card 4.              *
*      Cards 2 and 3 are ignored.                              *
*                                                              *
* ThicAJ  Joint Thickness Used For AllJoint = 0                *
*                                                              *
*--------------------------------------------------------------*
*                                                              *
* AllJoint  ThicAJ                                             *
*--------------------------------------------------------------*
  1         0.03
*                                                              *
****************************************************************
```

```
* Card 2                                                        *
* Internal Joint Generation By AllJoint = 1                     *
*****************************************************************
*                                                               *
* Card 2.1                                                      *
* NumIJ  (Number of Continuum Materials for Internal Joints)    *
* ThicIJ (Joint Thickness)                                      *
*                                                               *
* NumIJ     ThicIJ                                              *
*---------------------------------------------------------------*
  0         0.03
*                                                               *
*****************************************************************
* Card 3                                                        *
* Boundary Joint Generation By AllJoint = 1                     *
*****************************************************************
*                                                               *
* Card 3.1                                                      *
* NumBJ  (Number of Continuum Materials for Boundary Joints)    *
* ThicBJ (Joint Thickness)                                      *
*         InterfaceJoint = 0: No  1: Includes Joint Element     *
* NumBJ     ThicBJ      InterfaceJoint                          *
*---------------------------------------------------------------*
  3         0.03        1
*                                                               *
* Card 3.2                                                      *
* MatBJ (Material No of Continuum Element for Boundary Joints) *
*        InnerShell = 0: No  1: Includes Inner Shell            *
*        OuterShell = 0: No  1: Includes Outer Shell            *
*                                                               *
* MatBJ     InnerShell  OuterShell                              *
*---------------------------------------------------------------*
  1         1           1
  2         1           1
  3         1           1
*                                                               *
*****************************************************************
* Card 4                                                        *
* Surface Joint Generation By AllJoint = 2                      *
*****************************************************************
*                                                               *
* Card 4.1                                                      *
* NumSJG (Number of Groups for Surface Joints)                  *
*                                                               *
* NumSJG                                                        *
*---------------------------------------------------------------*
  0
* End of Data                                                   *
*****************************************************************
```

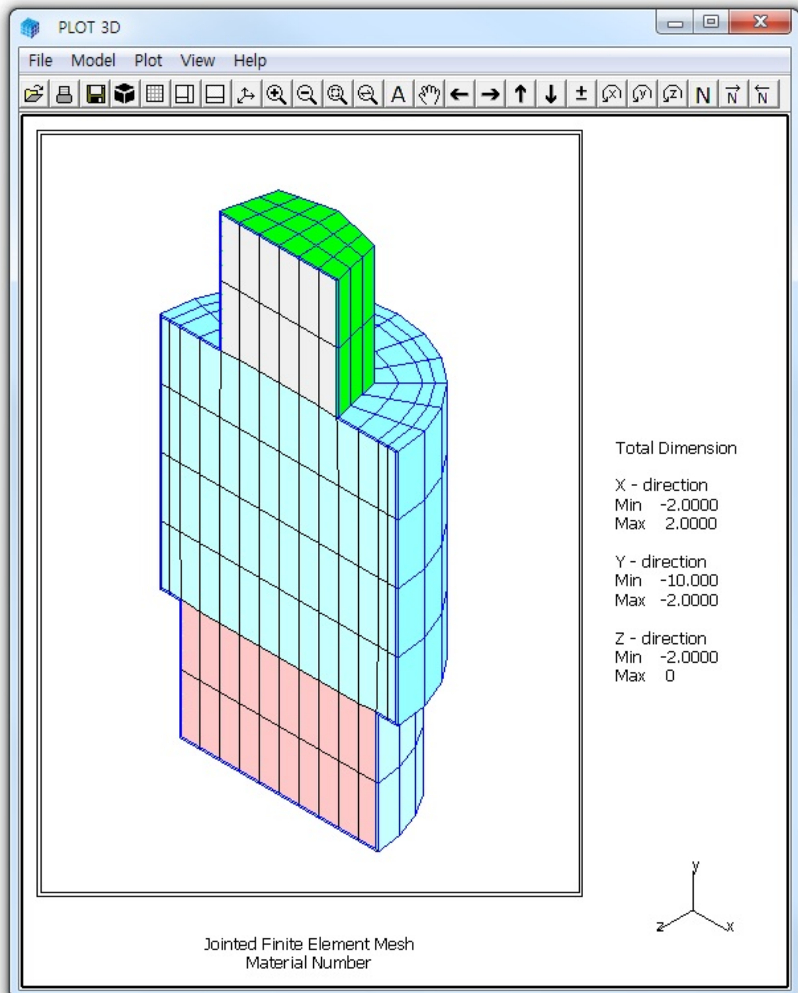


Figure 7.112 Generated jointed finite element mesh for Example 3

7.10 INTERSECTION

INTERSECTION programs are mainly used to compute the locations of the 3D surfaces crossing each other. These surfaces consist of Shell Elements with different materials. The computed coordinates of intersections can be used for the construction of complicated three-dimensional meshes. Refer to detailed descriptions in Section 7.11 of User's Manual.

There are two INTERSECTION programs provided in this manual; SHELL ELEMENT and TWO TUNNELS.

7.10.1 Example 1: Shell Element

SHELL ELEMENT is the basic program which can be applied to find the line of intersection of three-dimensional surfaces. First, you need to prepare a SMAP-3D mesh file composed of Shell Elements with different material numbers.

SHELL ELEMENT can be accessed by selecting the following menu
Run → Mesh Generator → PreSmap → Intersection → Shell Element

or
Setup → PLOT 3D → Compute Intersection → Yes
and then open mesh file Plot → Mesh → F. E. Mesh → Open

Example 1 shows input finite element meshes where a smaller rectangular plate crossing a large square plate at right angles as shown in Fig. 7.113.

Figure 7.114 shows computed intersection between two plates. Note that computed coordinates of intersections are represented by Truss Elements.

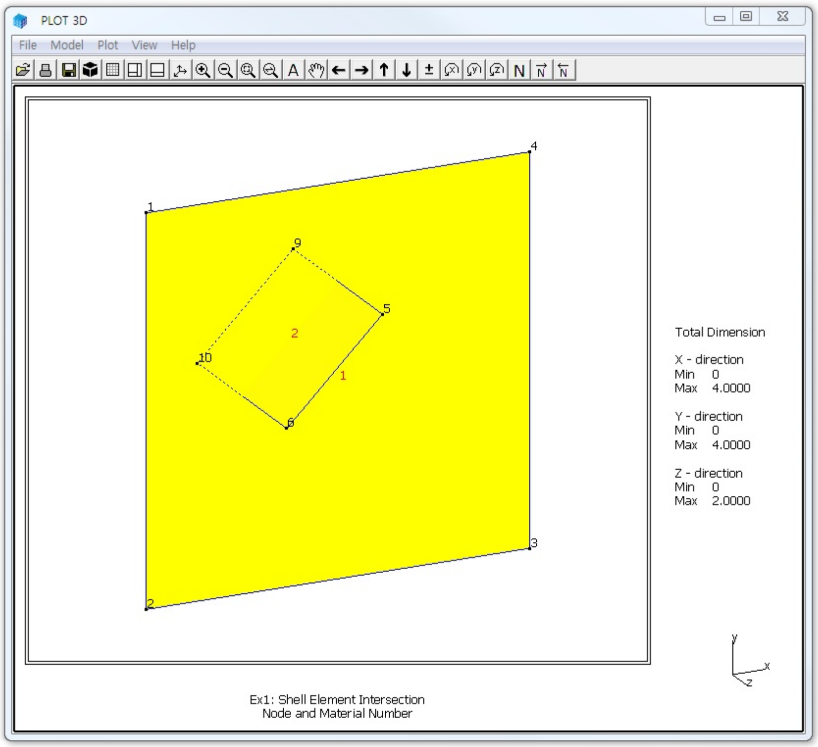


Figure 7.113 Input shell element intersection for Example 1

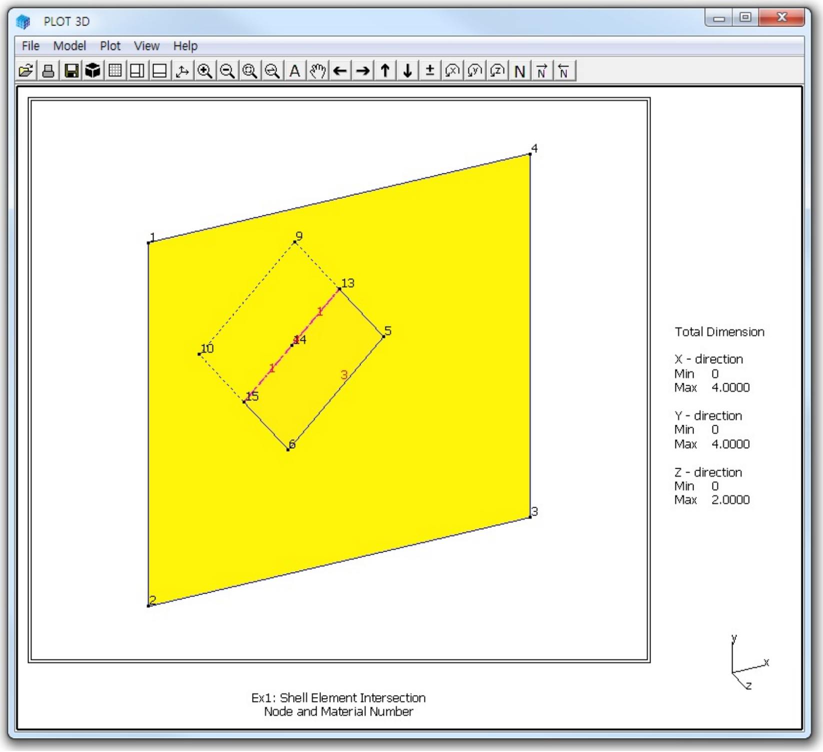


Figure 7.114 Output shell element intersection for Example 1

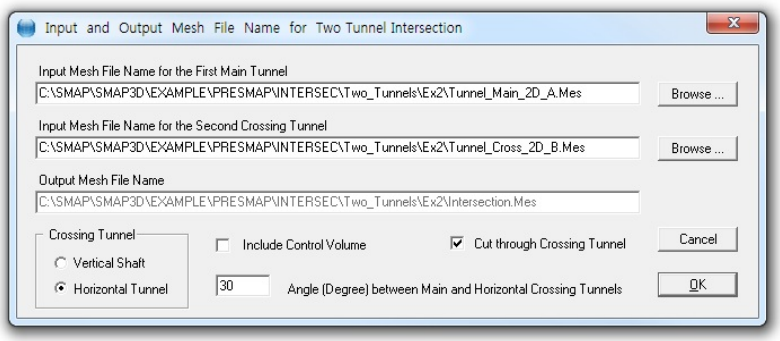
7.10.2 Example 2: Two Tunnels

TWO TUNNELS is the special program where the second crossing tunnel cuts through the first main tunnel at some angles. First, you need to prepare two SMAP-2D mesh files representing for cross sections of the first main and the second crossing tunnels. These cross sections are modeled by two-dimensional Beam Elements with different beam section numbers.

TWO TUNNELS can be accessed by selecting the following menu
Run → Mesh Generator → PreSmap → Intersection → Two Tunnels

Note that output file Intersection.Mes contains Shell Elements representing both main and crossing tunnels.

For best appearance of generated meshes, you need to
copy C:\SMAP\CT\CTDATA\DV-ADRGN.dat into Working Directory
and then modify control parameters in Intersection Calculation for PLOT as shown in Table 7.35.



Example 2 is to show computed intersection between the first main and second crossing tunnels at 30 degree angles. Figures 7.115 & 7.116 show two-dimensional cross sections of first main and second crossing tunnels, respectively, which are used as input meshes consisting of beam elements.

Figure 7.117 shows generated three-dimensional finite element meshes. And Figures 7.118 and 7.119 show the finite element meshes of the first main and second crossing tunnels, respectively, at the intersection points.

Table 7.35 Listing of input file ADDRGN.dat

```
**********************************************************
*                                                        *
*   USERS CAN CHANGE FOLLOWING VALUES TO CONTROL         *
*   ADDRGN-2D MESH GENERATION                            *
*                                                        *
*========================================================*
*                                                        *
*  A. COORDINATE COINCIDENCE:                            *
*     When distance between two adjacent coordinates     *
*     is less than RLMINV/RSMINV, those coordinates      *
*     are assumed to be coincident.                      *
*                                                        *
*   NF = 0: RLMINV is used for all cases.                *
*        1: RSMINV is used for all cases.                *
*        2: RSMINV for segment end points and            *
*           RLMINV for all other cases.                  *
*                                                        *
*   RSMINV = RSFAC * LMIN                                *
*     RSFAC : User input.                                *
*     LMIN  : Min. element length calculated by program  *
*                                                        *
*   NF  RLMINV   RSFAC   RDMINV                          *
*   --  ------   -----   ------                          *
    2   0.0001   0.05    0.005
*                                                        *
*========================================================*
*                                                        *
*  B. REMOVE SHORTER LINE ELEMENTS:                      *
*     When the length of line element (Na-Nb) is shorter *
*     than the specified value Smin = Amin x Save,       *
*     assign Nb as Na, remove such line elements,        *
*     adjust all associated element indexes, and         *
*     reorder element & node numbers in sqquence.        *
*                                                        *
*   NS = 0: Do not apply                                 *
*        1: Apply all line  elements                     *
*        2: Apply all beam  elements                     *
*        3: Apply all truss elements                     *
*        4: Apply specified beam  materials              *
*        5: Apply specified truss materials              *
*        6: Apply specified beam & truss materials       *
*                                                        *
*   bMat1, bMat2, bMat3: Specified beam  materials       *
*   tMat1, tMat2, tMat3: Specified truss materials       *
*                                                        *
```

```
*  C. MOVE NODAL COORDINATES:                                *
*     Node Nc moves along the line (Nc-Nr)                   *
*     NM : Number of nodes to be moved                       *
*     Nc : Current Node to be moved                          *
*     Nr : Reference Node                                    *
*     Ac : Percent movement from Nc to Nr                    *
*            = 0.5 moves half way to Node Nr                 *
*            = 1.0 merges to Node Nr                         *
*   Note : To use this method C                              *
*          1. Run the program with NM = 0 at first           *
*          2. Get the node numbers (Nc, Nr) from plot        *
*          3. Edit this file for NM, (Nc, Nr, Ac) set        *
*          4. Run the program again with data at step 3      *
*---------------------------------------------------------*
*   Standalone ADDRGN-2D                                     *
*   NS    Amin  bMat1  bmat2  bMat3  tMat1  tMat2  tMat3 *
*   ---   ----  -----  -----  -----  -----  -----  ----- *
    0     0.2   1      2      3      1      2      3
*   NM                                                       *
    0
*   Nc    Nr    Ac                                           *
*---------------------------------------------------------*
*                                                            *
*   Intersection Calculation for PLOT-3D                     *
*                                                            *
*   NS    Amin  bMat1  bmat2  bMat3  tMat1  tMat2  tMat3 *
*   ---   ----  -----  -----  -----  -----  -----  ----- *
    3     0.2   1      2      3      1      2      3
*                                                            *
*   NM                                                       *
    11
*   Nc    Nr    Ac                                           *
*   ----  ----  ----                                         *
    1236  1175  1.0
    1174  1175  1.0
    1113  1175  0.4
    1175  1237  0.4
    747   746   1.0
    626   686   1.0
    566   627   1.0
    567   566   0.5
    507   567   0.5
    456   455   1.0
    455   393   0.3
```

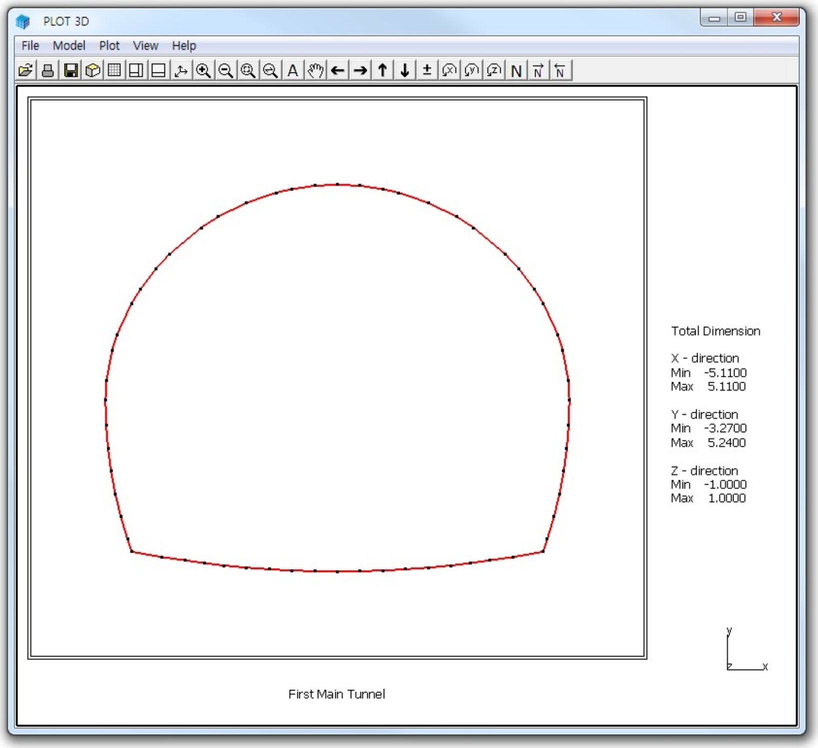


Figure 7.115 Input main tunnel cross section for Example 2

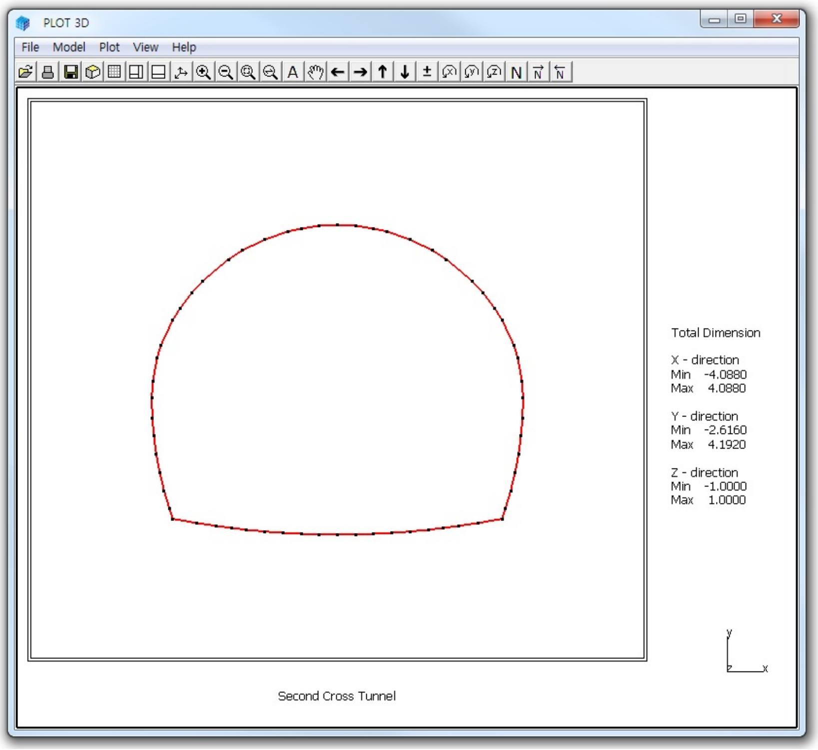


Figure 7.116 Input crossing tunnel cross section for Example 2

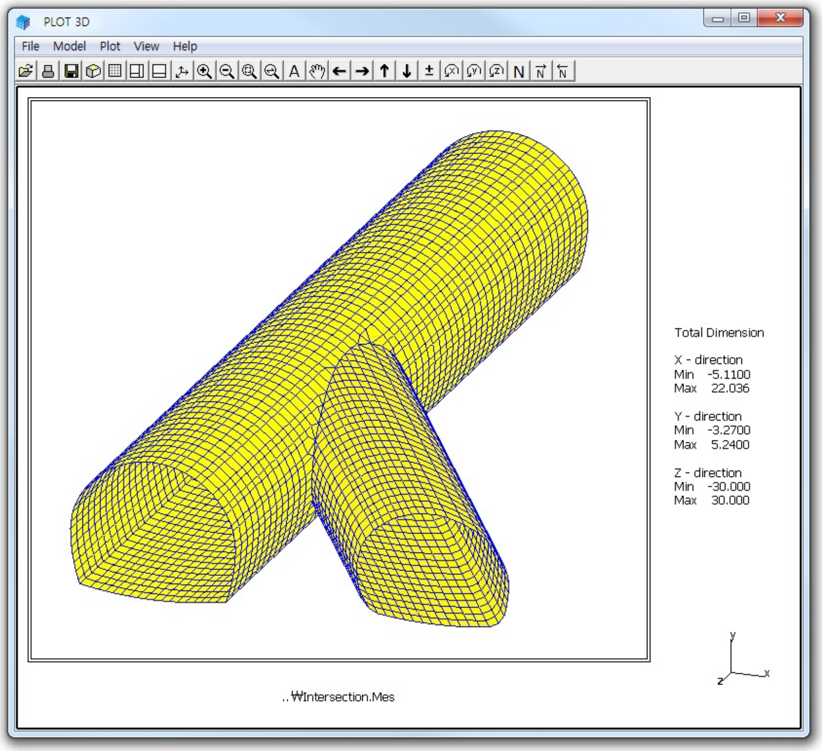


Figure 7.117 Generated finite element meshes for Example 2

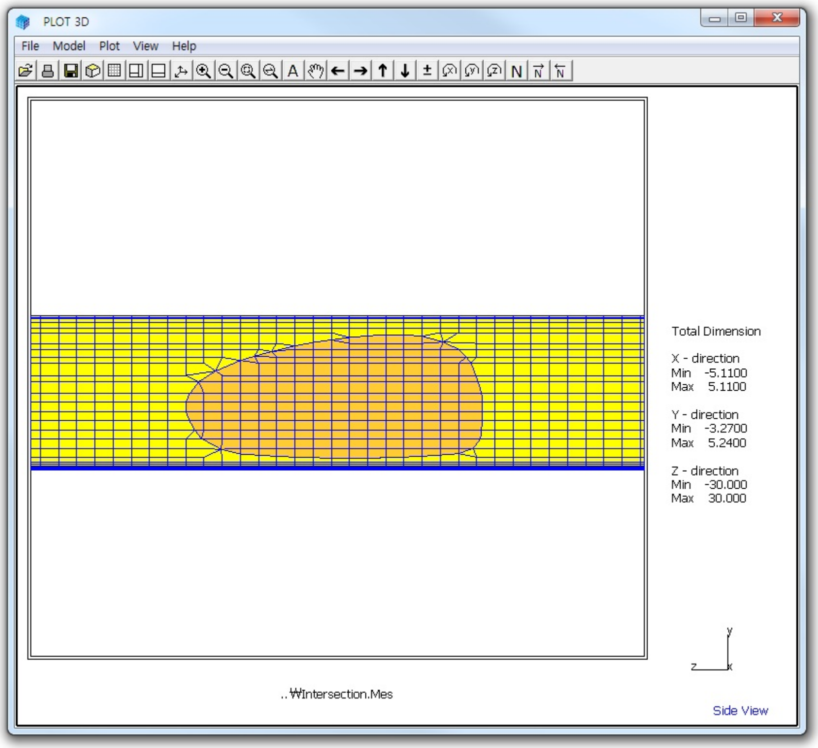


Figure 7.118 Generated main tunnel at intersection for Example 2

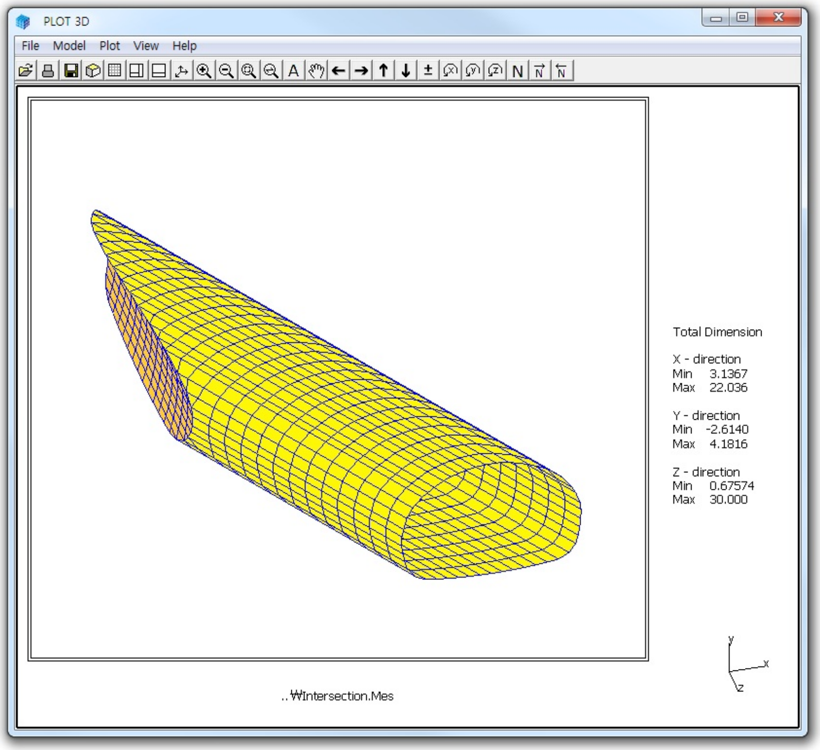


Figure 7.119 Generated crossing tunnel at intersection for Example 2

ADDRGN
Example Problem

ADDRGN is the pre-processing program which has the following functions:

- Combine two different meshes
- Modify existing meshes
  - Change coordinates
  - Change boundary codes
  - Cut elements
  - Change material numbers
- Generate finite element meshes (ADDRGN-2D)

Refer to SMAP-3D User's Manual:

- Section 5 for group mesh generation (ADDRGN-2D)
- Section 8 for input parameters

8.1 ADDRGN-2D

ADDRGN-2D is the two dimensional pre-processor which is used to combine, modify, or generate finite element meshes.

ADDRGN-2D can be selected in the following order:

Run → Mesh Generator → AddRgn → Addrgn 2D

When you finish the execution of ADDRGN-2D, select PLOT-3D to plot modified or generated mesh.

8.1.1 Combining Meshes

In the PRESMAP-2D Example Problem in Sections 7.1.1 and 7.1.2, three different regions (Core, Near-field, and Far-field) are generated using Models 1 and 2. Now, we want to combine all these different regions into one using ADDRGN-2D. Note that CORE.Mes, NEAR.Mes and FAR.Mes are the output files corresponding to the input file CORE.Rgn, NEAR.Rgn and FAR.Rgn respectively.

Element numbers 1 to 72 are assigned for CORE.Mes, 73 to 336 for NEAR.Mes and 337 to 464 for FAR.Mes. When we combine two regions, element numbers should be continuous through the regions. So, let's first add NEAR.Mes (called REGION B) to CORE.Mes (called REGION A) to make CONE.Mes (called COMBINED REGION). Next, let's add FAR.Mes (called REGION B) to CONE.Mes (called REGION A) to make the final mesh CNF.Mes (called COMBINED REGION). ADDRGN input files are listed in Tables 8.1 and 8.2.

Figure 8.1 shows the element meshes of combined region representing all three regions.

Table 8.1 Listing of input file ADD2D-1.Dat

```
* ADD2D-1.Dat
* CARD 1.1
* IMOD = 0 : ADD REGION B TO REGION A
  0
* CARD 2.1
* FILEA : Input file name containing REGION A
  CORE.Mes
* FILEB : Input file name containing REGION B
  NEAR.Mes
* FILEC : Output file name to store COMBINED REGION
  CONE.Mes
* CARD 2.2
* INTERFACE
  0
* END OF DATA
```

Table 8.2 Listing of input file ADD2D-2.Dat

```
* ADD2D-2.Dat
* CARD 1.1
* IMOD = 0 : ADD REGION B TO REGION A
  0
* CARD 2.1
* FILEA : Input file name containing REGION A
  CONE.Mes
* FILEB : Input file name containing REGION B
  FAR.Mes
* FILEC : Output file name to store COMBINED REGION
  CNF.Mes
* CARD 2.2
* INTERFACE
  0
* END OF DATA
```

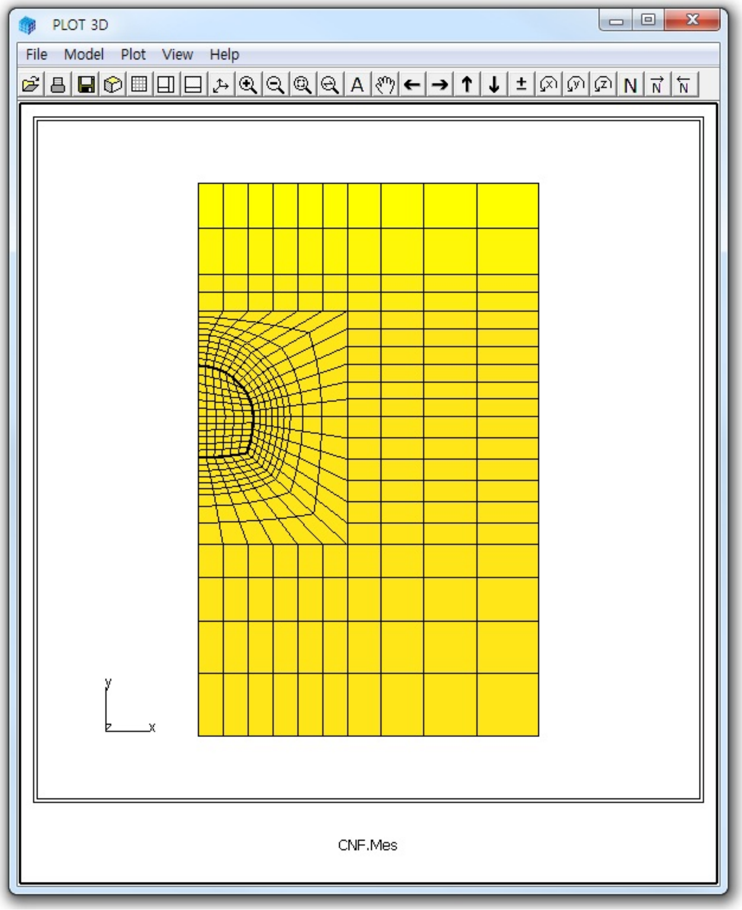


Figure 8.1 Final element meshes representing Core, Near-field, and Far-field regions, CNF.Mes

8.1.2 Modifying Mesh

In this example, we want to generate symmetric meshes using ADDRGN-2D. As the existing mesh, we take the CORE.Mes which has been generated using PRESMAP-2D Model 1 (refer to Section 7.1.1.2). Note that CORE.Mes represents the right side of the tunnel core. ADDRGN input file to generate Left Core is listed in Table 8.3. The output file LCORE.Mes contains Left Core whose graphical output is shown in Figure 8.2.

By combining both left and right core regions as instructed in Table 8.4, we can generate a whole core region, WCORE.Mes. Graphical output of WCORE.Mes is shown in Figure 8.3.

Table 8.3 Listing of input file ADD2D-3.Dat

```
* ADD2D-3.Dat
* CARD 1.1
* IMOD = 1 : MODIFY EXISTING MESH
  1
* CARD 3.1
* FILEA : Input file name to be modified
  CORE.Mes
* FILEM : Output file name to store modified mesh
  LCORE.Mes
* CARD 3.2
* NSNEL  NSNODE
  73     1
* CARD 3.3
* IEDIT = 0 : CHANGE COORDINATES
  0
* CARD 3.3.1.1
* Xo    Yo    Xonew   Yonew
  0.0   0.0   0.0     0.0
* CARD 3.3.1.2
* Xscale  Yscale
 -1.0      1.0
* END OF DATA
```

Table 8.4 Listing of input file ADD2D-4.Dat

```
* ADD2D-4.Dat
* CARD 1.1
* IMOD = 0 : ADD REGION B TO REGION A
  0
* CARD 2.1
* FILEA : Input file name containing REGION A
  CORE.Mes
* FILEB : Input file name containing REGION B
  LCORE.Mes
* FILEC : Output file name to store COMBINED REGION
  WCORE.Mes
* CARD 2.2
* INTERFACE
  0
* END OF DATA
```

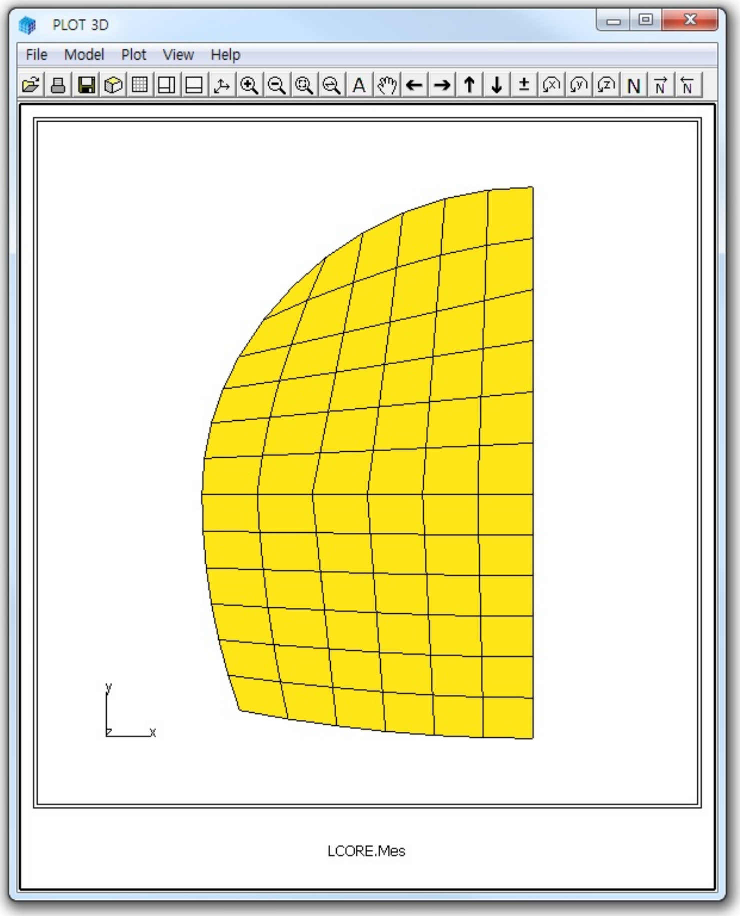


Figure 8.2 Left core mesh, LCORE.Mes

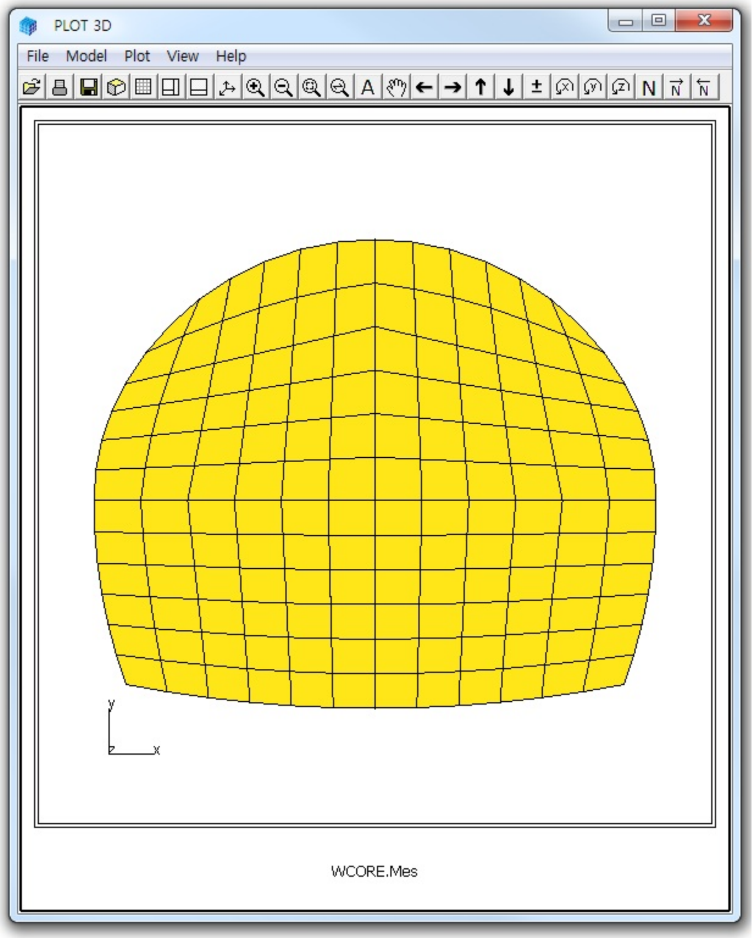


Figure 8.3 Combined whole core mesh, WCORE.Mes

8.1.3 Generating Mesh

This example is to show a powerful mesh generation feature using ADDRGN-2D. All you need to do is to specify the locations, dimensions and material numbers of structures along with few instructions for mesh generation. ADDRGN-2D will do the rest of the work to build the Mesh File.

As the first example, we take a simple problem as schematically shown in Figure 8.4. A utility tunnel with a diameter of 4 meters is located 6 meters below the ground surface. Table 8.5 shows the full listing of input file ADD2D-5.Dat. The base mesh consists of 3 blocks in the horizontal direction and 1 block in the vertical direction.

The first group represents soft rock underlying soil. And the second group represents the utility tunnel. Tunnel liner is modeled by beam element and the interface between the liner and the surrounding soil is modeled by joint element which will allow the slippage and separation. Finite element meshes generated by ADDRGN-2D are shown in Figures 8.5 and 8.6. It should be noted that the joint thickness in Figure 8.6 is exaggerated to show clearly both inner and outer joint faces. The real joint thickness is specified in material property card in Main File.

Table 8.5 Listing of input file ADD2D-5.Dat

```
* ADD2D-5.Dat
* CARD 1.1
* IMOD = 2 : GENERATE BASE MESH AND THEN MODIFY
* IMOD JK
   2    3
* CARD 4.1
* NBX  NBY
   3    1
* CARD 4.2
* XO    YO
  0.0   0.0
* CARD 4.3
* W     DX     ALPAX
  14.0  0.3   -0.3
  21.0  0.3    0.5
  11.0  0.3    0.3
* CARD 4.4
* H     DY     ALPAY
  20.0  0.3    0.5
* CARD 4.5
* IGMOD
  1
* -------------------------------------------------------------
* CARD 3.1
* FILEA
  BMESH.DAT
* FILEM
  ADD2D-5.Mes
* CARD 3.2
* NSNEL  NSNODE
      1       1
* CARD 3.3
* IEDIT = 4 : BUILD USER-SPECIFIED CURVES.
     4
* CARD 3.3.5.1
* NODE
     0
* CARD 3.3.5.2
* NOEL
     0
* CARD 3.3.5.3
* IBOUND
     0
```

```
* CARD 3.3.5.4
* NGROUP
    2
* XREF  YREF
  14.0  20.0
* --------------------- GROUP 1  ------------------------------
*
*                      SOFT ROCK
*
* CARD 3.3.5.4.1.1
* MTYPE
     3
* CARD 3.3.5.4.1.2
* MATNO  KF   LTPI  LMAT
     7   0     0     0
* CARD 3.3.5.4.2.1
* NPOINT  MOVE  IREF  XLO   YLO
     6     1     0    0.0   0.0
* CARD 3.3.5.4.2.2
* NP    X     Y
   1   0.0   0.0
   2  46.0   0.0
   3  46.0  13.0
   4  31.0  12.0
   5  19.0   8.0
   6   0.0   4.0
* CARD 3.3.5.4.3
* NSEGMENT
     6
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     1      1     0     3
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     2      1     0     3
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     3      1     0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     4      1     0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     5      1     0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     6      1     0     2
```

```
* --------------------- GROUP 2 -------------------------------
*                  UTILITY TUNNEL
* CARD 3.3.5.4.1.1
* MTYPE
    -3
* CARD 3.3.5.4.1.2
* MATNO  KF  MATNOJT  KFJT  THICJT  LTPI, LMATI, LTPO, LMATO
    3   0     4       0     0.1     2     5      2     6
* CARD 3.3.5.4.2.1
* NPOINT  MOVE  IREF  XLO   YLO
    1      0    1    8.0  -6.0
* CARD 3.3.5.4.2.2
* NP   X     Y
  1   2.0   0.0
* CARD 3.3.5.4.3
* NSEGMENT
    1
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV IEND
    1      2     0   2
* CARD 3.3.5.4.3.2
* X0    Y0    RX   RY   THETA_B   THETA_E
  0.0   0.0   2.0  2.0  0.0       360.
* ------------------------------------------------------------
* END OF DATA
```

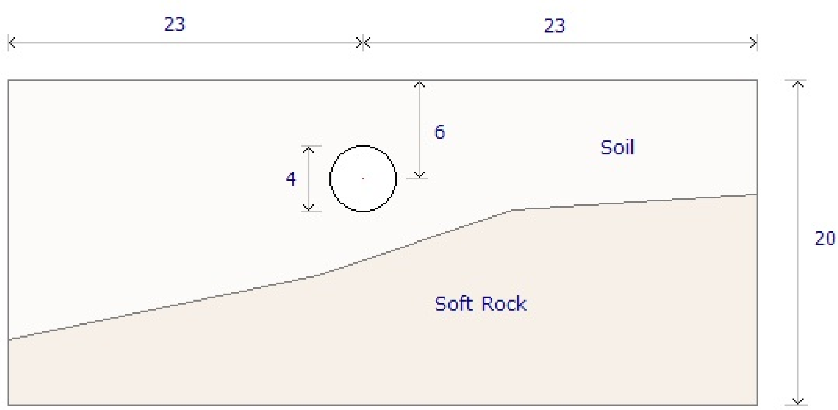


Figure 8.4 Schematic section view.

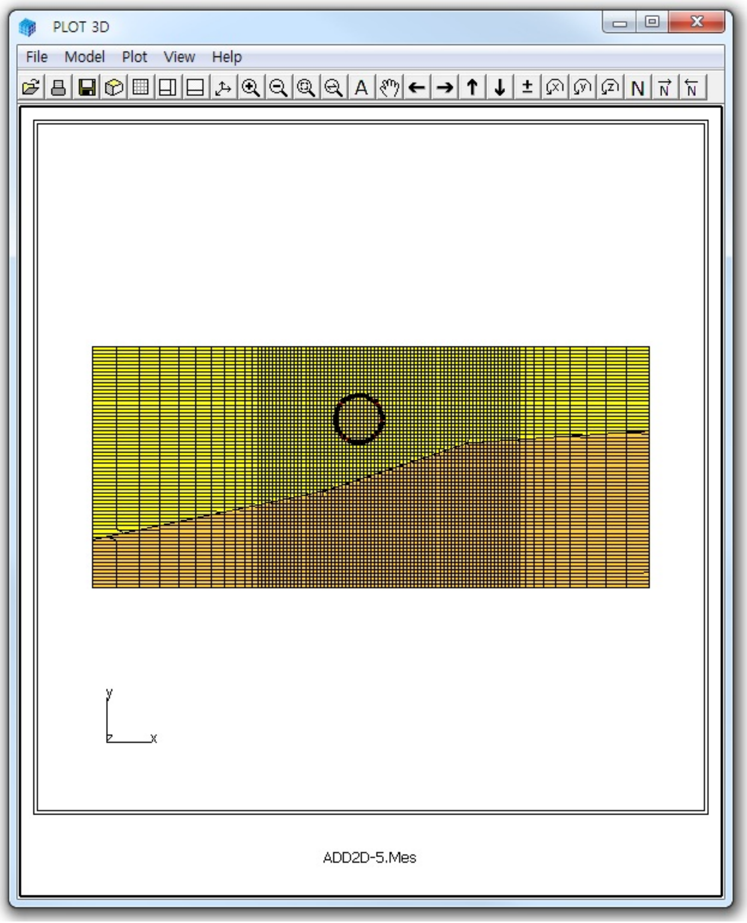


Figure 8.5 Overall finite element mesh

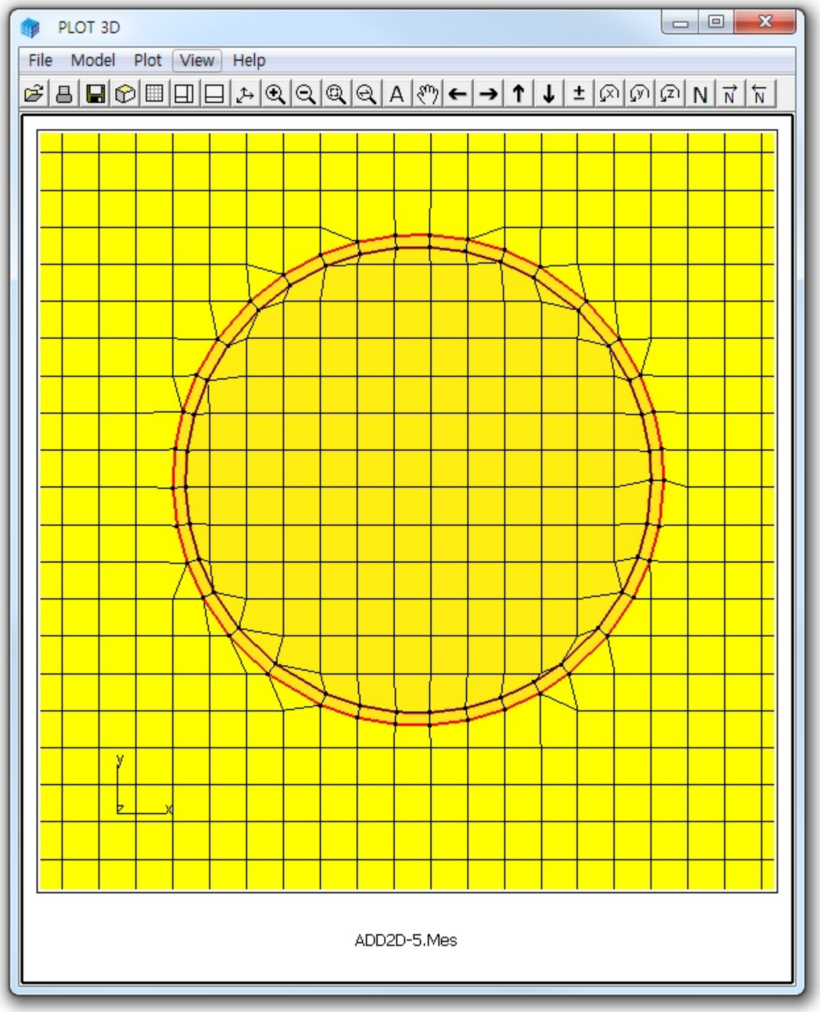


Figure 8.6 Finite element mesh around utility tunnel.

As the second example, we take a complex problem as schematically shown in Figure 8.7. The problem geometry includes different types of underground structures; strut, anchor bar, pile, utility tunnel, subway tunnel, rock bolt, foundation and fault zone. Table 8.6 shows the partial listing of input file ADD2D-6.Dat. The base mesh consists of 3 blocks in the horizontal direction and 2 blocks in the vertical direction.

For detailed description of input parameters, refer to Section 8.2 in SMAP-3D User's Manual. Joint elements are used to model the fault zone and the interfaces between surrounding medium and the structures such as pile and tunnels. Figure 8.8 shows overall finite element mesh generated by ADDRGN-2D. Detailed finite element meshes are shown in Figure 8.9 for the excavation zone and in Figure 8.10 for the tunnels and foundation. As in the previous example, the joint thickness in Figures 8.9 and 8.10 is exaggerated to show clearly both inner and outer joint faces. The real joint thickness is specified in material property card in Main File.

Table 8.6 Listing of input file ADD2D-6.Dat (Partial Listing)

```
* ADD2D-6.Dat
* CARD 1.1
* IMOD = 2 : GENERATE BASE MESH AND THEN MODIFY
* IMOD JK
   2    3
* CARD 4.1
* NBX  NBY
   3    2
* CARD 4.2
* XO    YO
  0.0   0.0
* CARD 4.3
* W     DX     ALPAX
  14.0  0.3   -0.3
  21.0  0.3    0.5
  11.0  0.3    0.3
* CARD 4.4
* H     DY     ALPAY
  23.0  0.3    0.5
  16.0  0.3    0.3
```

```
* CARD 4.5
* IGMOD
  1
* -------------------------------------------------------------
* CARD 3.1
* FILEA
  BMESH.DAT
* FILEM
  ADD2D-6.Mes
* CARD 3.2
* NSNEL  NSNODE
     1       1
* CARD 3.3
* IEDIT = 4 : BUILD USER-SPECIFIED CURVES.
     4
* CARD 3.3.5.1
* NODE
     0
* CARD 3.3.5.2
* NOEL
     0
* CARD 3.3.5.3
* IBOUND
     0
* CARD 3.3.5.4
* NGROUP
   22
* XREF  YREF
  14.0  39.0
* --------------------- GROUP 1  ------------------------------
*
*               MAKING GROUND SURFACE
*
* CARD 3.3.5.4.1.1
* MTYPE
    -1
* CARD 3.3.5.4.2.1
* NPOINT  MOVE  IREF  XLO   YLO
     8     1     0    0.0   0.0
* CARD 3.3.5.4.2.2
* NP   X     Y
   1  46.0  34.0
   2  39.0  34.0
   3  33.0  39.0
   4  18.0  39.0
   5  12.0  34.0
   6   0.0  34.0
   7   0.0   0.0
   8  46.0   0.0
```

```
* CARD 3.3.5.4.3
* NSEGMENT
     8
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     1      1     0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEDN
     2      1     0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     3      1     0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEDN
     4      1     0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     5      1     0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEDN
     6      1     0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     7      1     0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEDN
     8      1     0     2
* --------------------- GROUP 2  ------------------------------
*
*                      SOFT ROCK
*
* CARD 3.3.5.4.1.1
* MTYPE
     3
* CARD 3.3.5.4.1.2
* MATNO  KF   LTPI  LMAT
     7   0     0     0
* CARD 3.3.5.4.2.1
* NPOINT  MOVE  IREF  XLO   YLO
     6     1     0    0.0   0.0
* CARD 3.3.5.4.2.2
* NP   X     Y
   1  46.0   0.0
   2  46.0  33.0
   3  31.0  32.0
   4  19.0  28.0
   5   0.0  24.0
   6   0.0   0.0
```

```
* CARD 3.3.5.4.3
* NSEGMENT
     6
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     1      1    0     3
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     2      1    0     3
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     3      1    0     0
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     4      1    0     0
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     5      1    0     0
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     6      1    0     3
* --------------------- GROUP 3  ------------------------------
*
*                        FAULT
*
* MTYPE
    -2
* CARD 3.3.5.4.1.2
* MATNOJT  KFJT  THICJT  LTPI, LMATI, LTPO, LMATO
    5        0   -0.1     0     0      0     0
* CARD 3.3.5.4.2.1
* NPOINT  MOVE  IREF  XLO   YLO
     4     1     0    0.0   0.0
* CARD 3.3.5.4.2.2
* NP    X     Y
   1  46.0  29.0
   2  29.0  19.0
   3  16.0  14.0
   4   0.0  10.0
* CARD 3.3.5.4.3
* NSEGMENT
     3
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     1      1    0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEDN
     2      1    0     2
```

```
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     3      1    0     2
* --------------------- GROUP 4  ------------------------------
*
*                      FOUNDATION
*
* CARD 3.3.5.4.1.1
* MTYPE
     4
* CARD 3.3.5.4.1.2
* MATNO   KF  LTPI  LMAT
     2    0    0     0
* CARD 3.3.5.4.2.1
* NPOINT  MOVE  IREF  XLO   YLO
     8     1     0    0.0   0.0
* CARD 3.3.5.4.2.2
* NP    X      Y
   1  34.5  29.0
   2  34.5  30.0
   3  32.5  30.5
   4  32.5  39.0
   5  31.5  39.0
   6  31.5  30.5
   7  29.5  30.0
   8  29.5  29.0
* CARD 3.3.5.4.3
* NSEGMENT
     8
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     1      1    0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     2      1    0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     3      1    0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     4      1    0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     5      1    0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     6      1    0     2
* CARD 3.3.5.4.3.1
```

```
* SEGNO  LTYPE  NDIV  IEND
    7      1     0     2
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
    8      1     0     2
* --------------------- GROUP 5 -------------------------------
*
*                 LEFT UTILITY TUNNEL
*
* CARD 3.3.5.4.1.1
* MTYPE
   -3
* CARD 3.3.5.4.1.2
* MATNO  KF  MATNOJT  KFJT  THICJT  LTPI, LMATI, LTPO, LMATO
    3   0     4       0    -0.1     2     5      2     6
* CARD 3.3.5.4.2.1
* NPOINT  MOVE  IREF  XLO   YLO
    1      0     1    8.0  -6.0
* CARD 3.3.5.4.2.2
* NP   X     Y
  1   2.0   0.0
* CARD 3.3.5.4.3
* NSEGMENT
    1
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV IEND
    1      2     0   2
* CARD 3.3.5.4.3.2
* X0    Y0    RX   RY   THETA_B   THETA_E
  0.0   0.0   2.0  2.0  0.0       360.
* --------------------- GROUP 6 -------------------------------
*
*                 RIGHT UTILITY TUNNEL
*
* CARD 3.3.5.4.1.1
* MTYPE
   -3
* CARD 3.3.5.4.1.2
* MATNO  KF  MATNOJT  KFJT  THICJT  LTPI, LMATI, LTPO, LMATO
    3   0     4       0    -0.1     2     5      2     6
* CARD 3.3.5.4.2.1

---
---
```

```
* --------------------- GROUP 22 ------------------------------
*
*                      SUBWAY TUNNEL
*
* CARD 3.3.5.4.1.1
* MTYPE IGPOST OVERLAY GCOLOR GLTYPE GLTHIC GHIDE
  -3     0      0       0      0      0      0
* Card 3.3.5.4.1-1
* MAT  KF  MATj KFj  THICj  LTi LMi LTo LMo
    3   0    4   0  -0.100   2   5   2   6
* CARD 3.3.5.4.2.1
* NPOINT  MOVE  IREF  XLO   YLO
    4      1     1    0.0   0.0
* CARD 3.3.5.4.2.2
* NP   X     Y
   1   26.  24.
   2   20.  24.
   3   20.  20.
   4   26.  20
* CARD 3.3.5.4.3
* NSEGMENT
     4
* CARD 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV  IEND
     1      2    0     2
* Card 3.3.5.4.3.1-1
* Xo     Yo     Rx    Ry    Qb    Qe
  23.    24.    3.0   3.0   0.0   180.
* Card 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV   IEND
    2     1       0     2
* Card 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV   IEND
    3     1       0     2
* Card 3.3.5.4.3.1
* SEGNO  LTYPE  NDIV   IEND
    4     1       0     2
* ------------------------------------------------------------
* END OF DATA
```

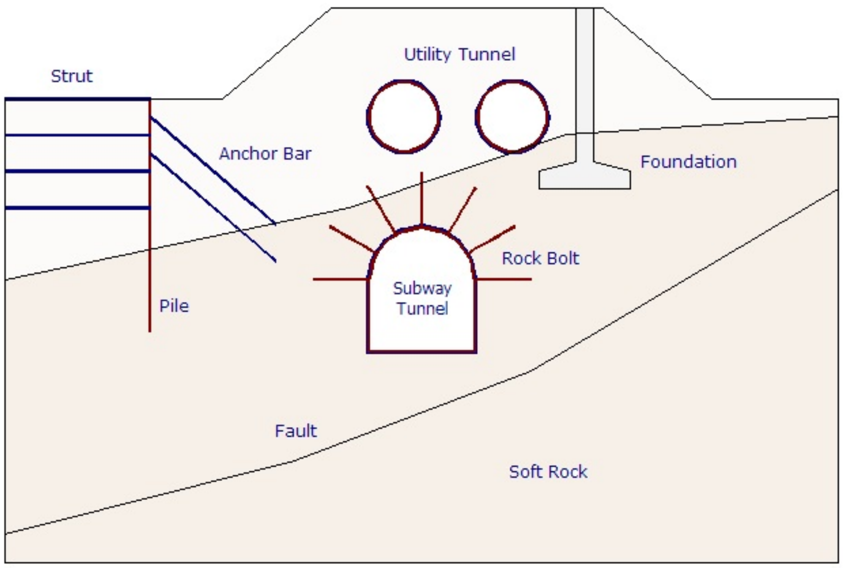


Figure 8.7 Schematic section view

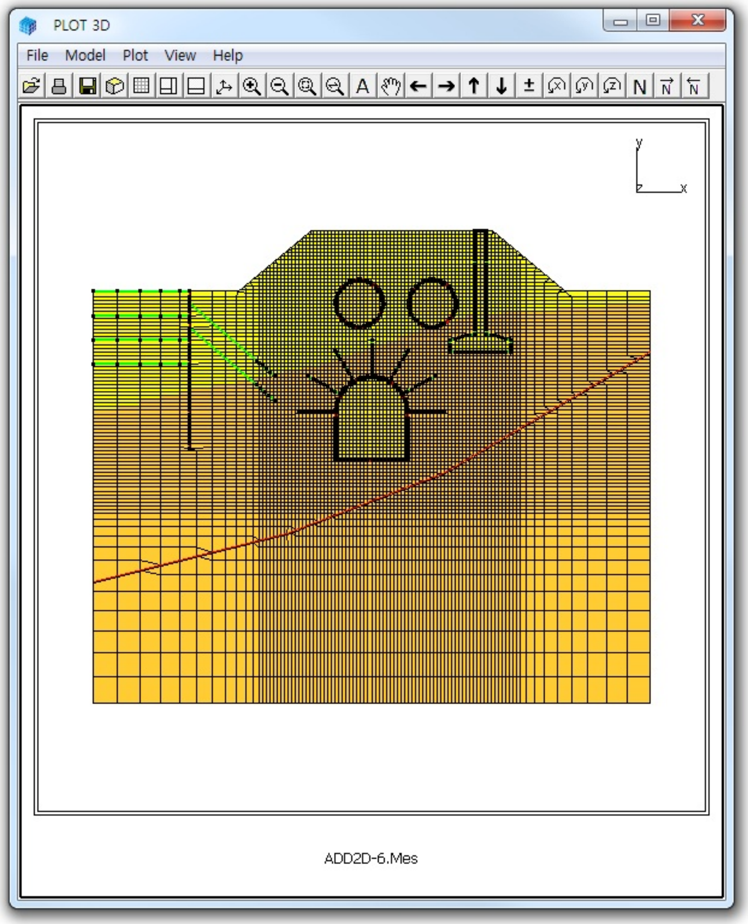


Figure 8.8 Overall finite element mesh

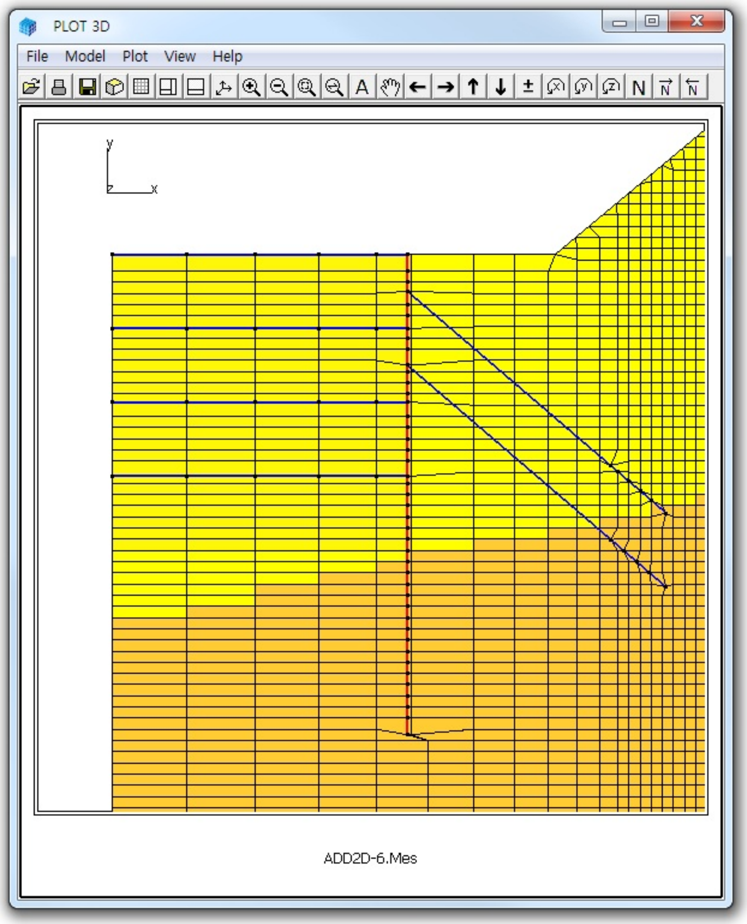


Figure 8.9 Finite element mesh around excavation zone

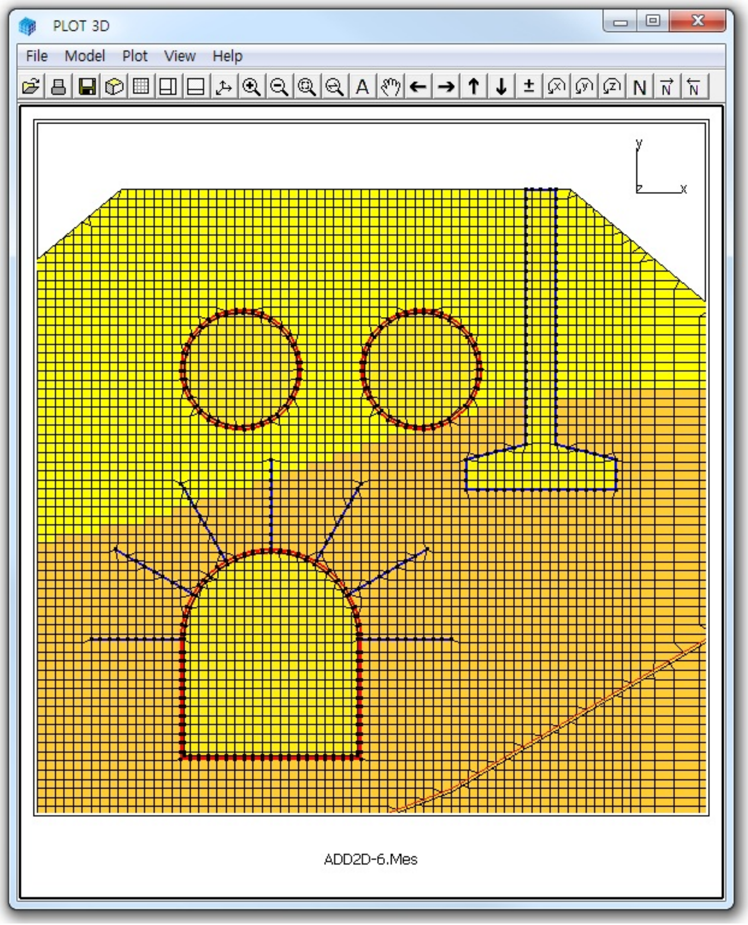


Figure 8.10 Finite element mesh around tunnels and foundation

8.2 ADDRGN-3D

ADDRGN-3D is mainly used to combine or modify the existing three dimensional continuum meshes.

ADDRGN-3D can be selected in the following order:

Run → Mesh Generator → AddRgn → Addrgn 3D

When you finish the execution of ADDRGN-3D, select PLOT-3D to plot the combined or modified mesh.

8.2.1 Combining Meshes

In this example, ADDRGN-3D is used to combine two different regions; FARA3D and FARB3D. FARA3D has 63 nodes and 24 elements as shown in Figure 8.11. FARB3D has 84 nodes and 36 elements as shown in Figure 8.12.

Both FARA3D and FARB3D have the common plane at y=10 where both regions share the identical nodal coordinates. Element numbers 1 to 24 are assigned for FARA3D and 25 to 60 for FARB3D. Note that element numbers should be continuous when combining two regions. The output file, FAR3D.Mes, is obtained by adding FARB3D.Mes (called REGION B) to FARA3D.Mes (called REGION A) as specified in input file ADD3D-1.Dat in Table 8.7. Graphical output for the combined region FAR3D is presented in Figure 8.13.

This example also demonstrates that ADDRGN-3D combines not only meshes but also nodal damping constants for transmitting boundary. Combined nodal damping constants are listed at the end of element indexes in the output file FAR3D.Mes.

Table 8.7 Listing of input file ADD3D-1.Dat

```
* ADD3D-1.Dat
* CARD 1.1
* IMOD = 0 : ADD REGION B TO REGION A
  0
* CARD 2.1
* FILEA : Input file name containing REGION A
  FARA3D.Mes
* FILEB : Input file name containing REGION B
  FARB3D.Mes
* FILEC : Output file name to store COMBINED REGION
  FAR3D.Mes
* END OF DATA
```

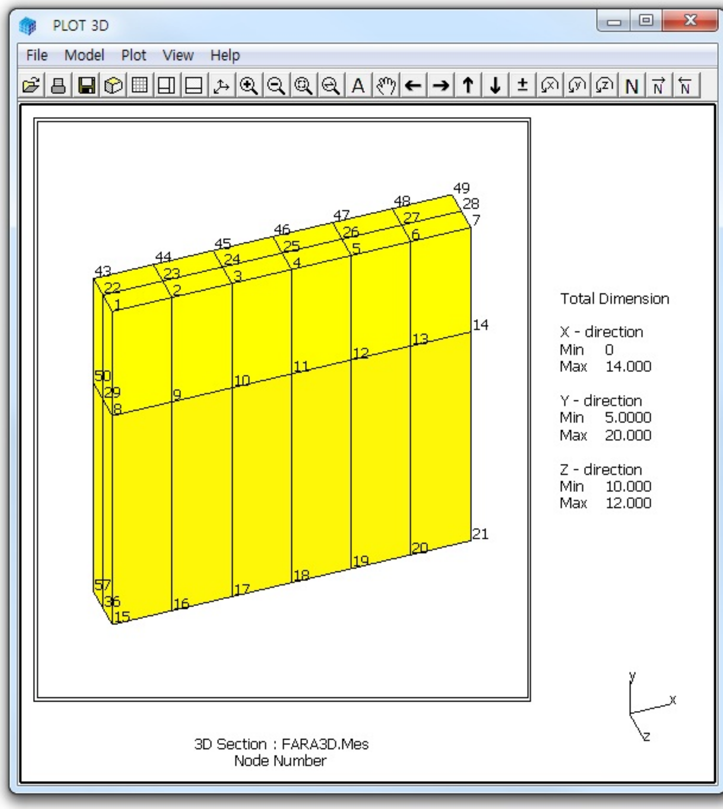


Figure 8.11 Node numbers for FARA3D.Mes

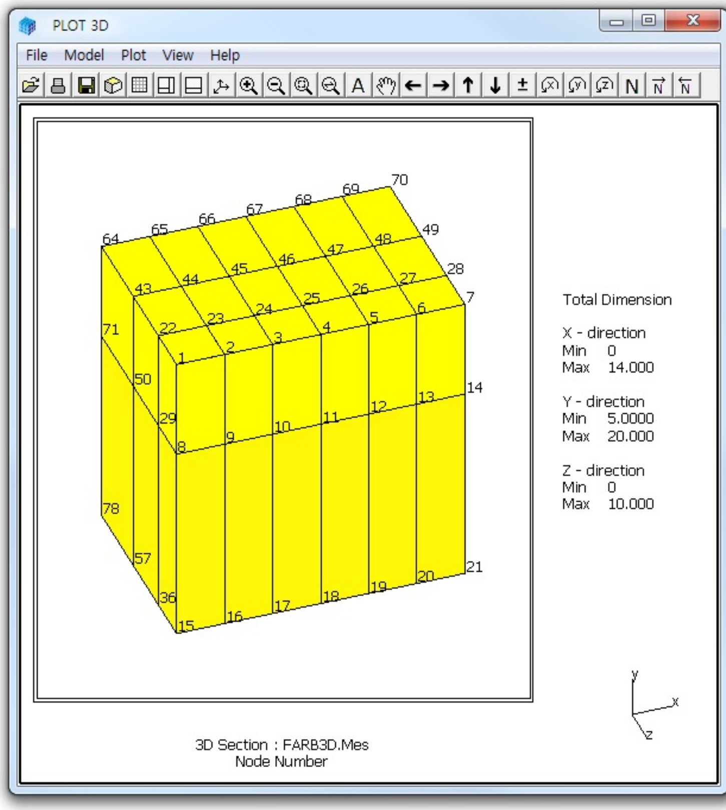


Figure 8.12 Node numbers for FARB3D.Mes

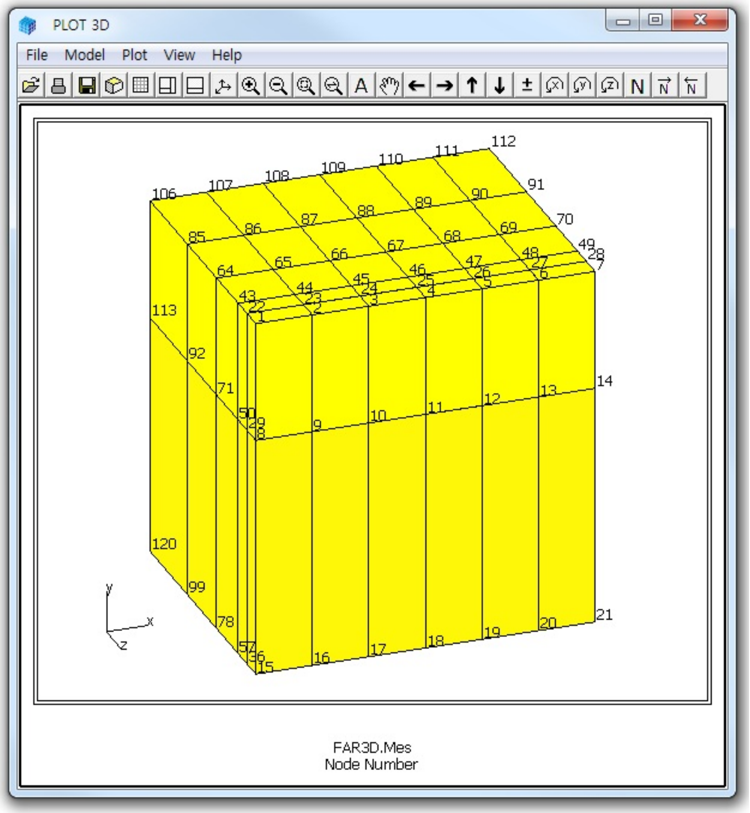


Figure 8.13 Node numbers for generated output FAR3D.Mes

8.2.2 Modifying Mesh

In this example, we want to generate symmetric meshes using ADDRGN-3D. As the existing mesh, we take the CROSS-3D Model 1 example problem, but generates only top half by specifying IPART=1 in card Group 2.1.2. Table 8.8 shows the listing of CROSS-3D input file CRM1-TOP.Dat. Graphical output is shown in Figure 8.14.

To generate bottom half which is symmetric about the plane at y=0, you can execute the input file ADD3D-2.Dat in Table 8.9. Graphical output is shown in Figure 8.15.

By combining both top and bottom regions, we can generate a whole region WCRM1.Mes. Input file ADD3D-3.Dat in Table 8.10 is used to build the combined mesh. Graphical output of this combined region is shown in Figure 8.16.

Table 8.8 Listing of CROSS-3D input file CRM1-TOP.Dat

```
* CARD 1.1
* TITLE
  Identical two crossing tunnels (MODELNO = 1)
* CARD 1.2
* MODELNO  KF  NSNODE  NSNEL  CMFAC
    1       1    1       1      1.0
* CARD 2.1.1
* XL     YB     YT     ZL     t
 100.   50.   100.   100.   3.0
* CARD 2.1.2
* IPART  NDR  NTBND  NTOPN
    1      2   20     20
* CARD 2.1.3
* NTNODE
    9
* NODE  X       Y
    1   0.0     4.0
    2   2.8284  2.8284
    3   4.0     0.0
    4   4.0    -2.0
    5   0.0    -3.0
    6   1.53    3.7
    7   3.7     1.53
    8   4.0    -1.0
    9   2.0    -2.7
* CARD 3.1
* NBOUND
    6
* CARD 3.2
* IBTYPE ISX  ISY  ISZ  IFX  IFY  IFZ
    1     0    0    0    1    1    1
    2     0    0    1    1    1    1
    3     0    0    1    1    1    1
    4     1    0    0    1    1    1
    5     1    0    0    1    1    1
    7     0    1    0    1    1    1
* END OF DATA
```

Table 8.9 Listing of input file ADD3D-2.Dat

```
* ADD3D-2.Dat
* CARD 1.1
* IMOD = 1 : MODIFY EXISTING MESH
  1
* CARD 3.1
* FILEA : Input file name to be modified
  CRM1-TOP.Mes
* FILEM : Output file name to store modified mesh
  CRM1-BOT.Mes
* CARD 3.2
* NSNEL  NSNODE
  746    1
* CARD 3.3
* IEDIT = 0 : CHANGE COORDINATES
  0
* CARD 3.3.1.1
* Xo    Yo    Zo      Xonew   Yonew   Zonew
  0.0   0.0   0.0     0.0     0.0     0.0
* CARD 3.3.1.2
* Xscale  Yscale  Zscale
  1.0     -1.0     1.0
* END OF DATA
```

Table 8.10 Listing of input file ADD3D-3.Dat

```
* ADD3D-3.Dat
* CARD 1.1
* IMOD = 0 : ADD REGION B TO REGION A
  0
* CARD 2.1
* FILEA : Input file name containing REGION A
  CRM1-TOP.Mes
* FILEB : Input file name containing REGION B
  CRM1-BOT.Mes
* FILEC : Output file name to store COMBINED REGION
  WCRM1.Mes
* END OF DATA
```

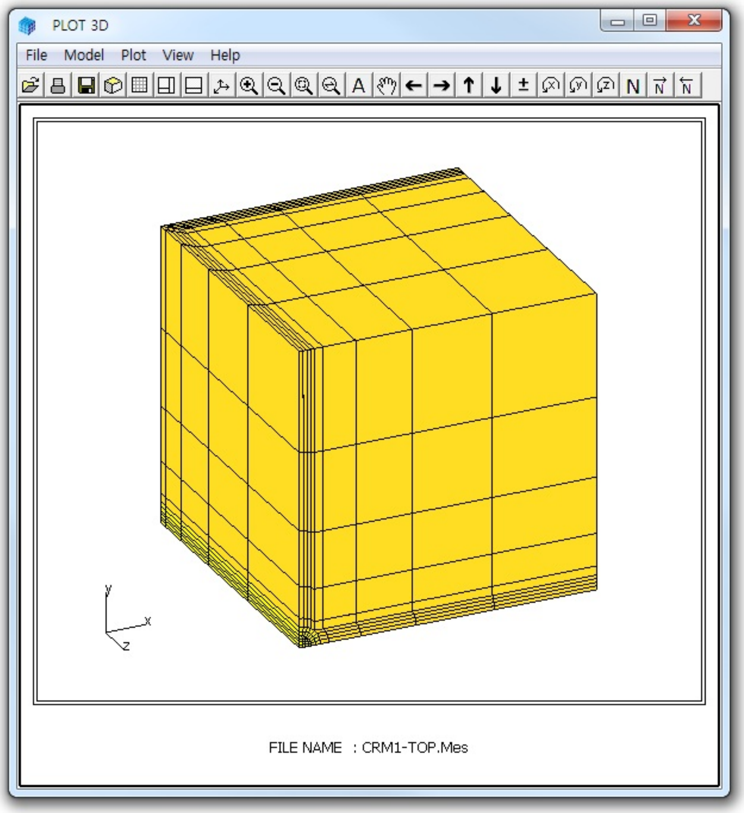


Figure 8.14 Finite element mesh for top half region

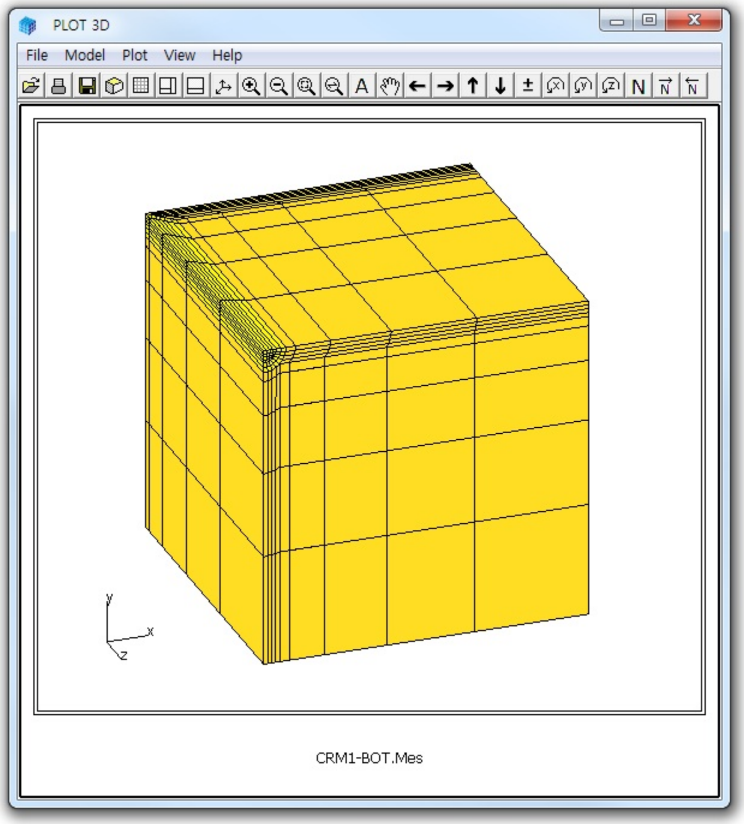


Figure 8.15 Finite element mesh for bottom half region

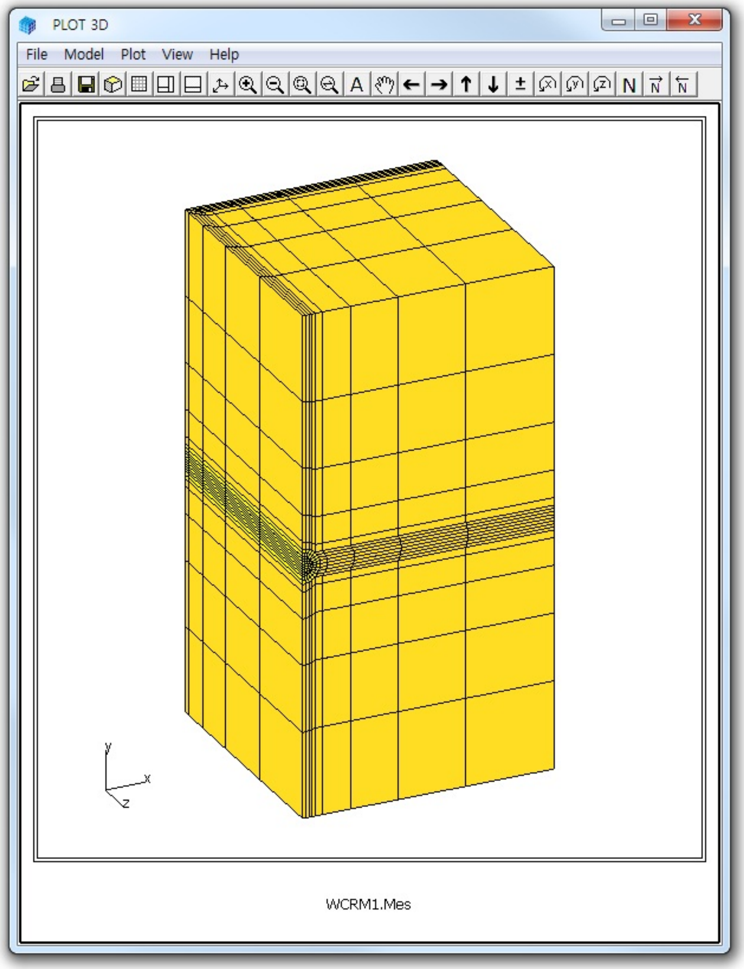


Figure 8.16 Finite element mesh for combined region

SUPPLEMENT
Example Problem

SUPPLEMENT Menu contains supporting programs which are useful to prepare input data for pre- and main-processing programs of SMAP-3D.

Running SUPPLEMENT is described in Section 3.2.6 of User's Manual and can be selected in the following order:

Run → Mesh Generater → Supplement → Edit, XY. Cards or Shrink File

EDIT is used to run text editor.

XY computes coordinates of mid points, cross points, or normal points.

CARDS generates element activity data in Card 8 in Section 4.4 Main File.

SHRINK FILE removes extra blank spaces before carriage return.
This will reduce the size of the file.

9.1 XY Example Problem

XY is the supporting program which computes coordinates of mid points, cross points, or normal points. Full description of XY is presented in Section 9.3 of User's Manual.

As an example, we select NF=6 which computes coordinates of point normal to the circular arc as shown in Figure 9.1.

Table 9.1 illustrates options available to the program XY and the user inputs specific to NF=6. Computed coordinates of the normal point are stored in the output file XY.Out and are listed in bottom part of Table 9.l.

Table 9.1 XY Example Problem

Type file name to store output: XY.Out

NF =	0	END OF COMPUTATION.
	1	COMPUTE MIDPOINT ON STRAIGHT LINE.
	2	COMPUTE MIDPOINT ON CIRCULAR ARC.
	3	COMPUTE INTERSECTION POINT OF TWO STRAIGHT LINES.
	4	COMPUTE INTERSECTION POINT OF CIRCULAR ARC AND STRAIGHT LINE.
	5	COMPUTE POINTS NORMAL TO STRAIGHT LINE.
	6	COMPUTE POINTS NORMAL TO CIRCULAR ARC.

NF= **6**

R, Xo, Yo, TA

5.0 0.0 0.0 0.0

TAC, CD

45.0 3.0

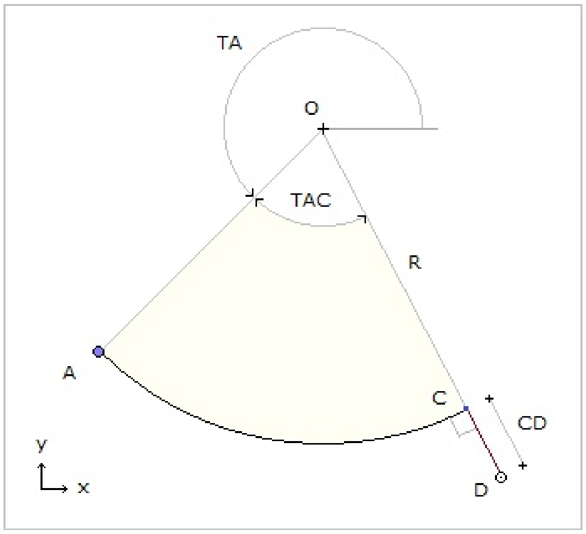
User inputs are **bold**.

Output file contains following information:

COMPUTED POINTS NORMAL TO CIRCULAR ARC

R	= 5.000000		
Xo	= 0.000000E+00	Yo	= 0.000000E+00
TA	= 0.000000E+00		
TAC	= 45.000000	CD	= 3.000000
XC	= 3.535527	YC	= 3.535540
XD	= 5.656844	YD	= 5.656865

NF = 6 Compute Points Normal to Circular Arc



INPUT:

R, X_o, Y_o, TA
TAC, CD

R	=	5.0
X_o, Y_o	=	0.0, 0.0
TA	=	0.0
TAC	=	45.0
CD	=	3.0

Figure 9.1 XY example problem

9.2 CARDS Example Problem

CARDS is the supporting program which is written to aid the preparation of SMAP-3D input cards. Currently, there is only one routine available to generate element activity data in Card Group 8.2 of Users Manual.

Table 9.2 shows user inputs for the example problem. Generated element activity data is stored in the output file, CARDS.Out, which is listed in Table 9.3.

Table 9.2 User inputs for CARDS example problem

CARD NO =	0	EXIT
	8.2	ELEMENT ACTIVITY

CARD NO = **8.2**
Type file name to store output: **CARDS.OUT**

NF =	0	END OF GENERATION
	1	GENERATE ELEMENT ACTIVITY/ DEACTIVITY

NF = **1**
NEL (start), NEL (end), NAC, NDAC
101 120 0 6

NF =	0	END OF GENERATION
	1	GENERATE ELEMENT ACTIVITY/ DEACTIVITY

NF = **1**
NEL (start), NEL (end), NAC, NDAC
121 130 3 50

NF =	0	END OF GENERATION
	1	GENERATE ELEMENT ACTIVITY/ DEACTIVITY

NF = **0**

User inputs are **bold**.

Table 9.3 Listing of output file CARDS.Out

```
* NEL   NAC  NDAC
*
  101     0     6
  102     0     6
  103     0     6
  104     0     6
  105     0     6
  106     0     6
  107     0     6
  108     0     6
  109     0     6
  110     0     6
  111     0     6
  112     0     6
  113     0     6
  114     0     6
  115     0     6
  116     0     6
  117     0     6
  118     0     6
  119     0     6
  120     0     6
*
  121     3    50
  122     3    50
  123     3    50
  124     3    50
  125     3    50
  126     3    50
  127     3    50
  128     3    50
  129     3    50
  130     3    50
* NFAD =    30
```

LOAD
Example Problem

10.1 LOAD-2D

LOAD-2D is the pre-processing program which can be used to generate external force (pressure), specified velocity, initial velocity, acceleration, and transmitting boundary. For the detailed description of input parameters, refer to section 11 of User's Manual.

LOAD-2D can be selected in the following order:

Run → Load Generator → Load 2D

When you select LOAD-2D, Load Generation Dialog will be displayed as in Figure 10.1. You need to specify input file names for Load and Mesh Data.

10.1.1 Example 1

Example 1 is to show the pressure load generation along the surfaces of elements 1, 2, 3 and 4 as schematically shown in Figure 10.2. Triangular pressure loads are acting on the surfaces of elements 1, 2 and 3. Right surfaces of elements 3 and 4 are subjected to the uniformly distributed pressure of 1.0. Two different load time histories, as shown in Figure 10.3, are considered.

Mesh Data contains information for nodal coordinates and element indexes. Mesh2D.Mes represents Mesh Data graphically shown in Figure 10.4 along with listing in Table 10.1. Load Data contains information for loads to be generated. Load2D.Dat in Table 10.2, has been prepared according to LOAD-2D User's Manual.

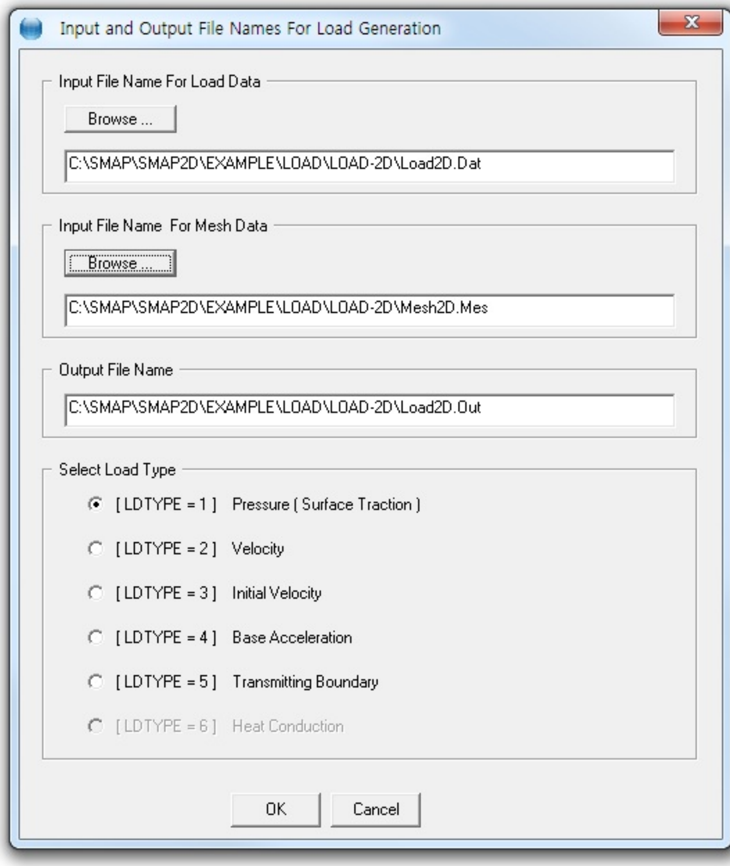
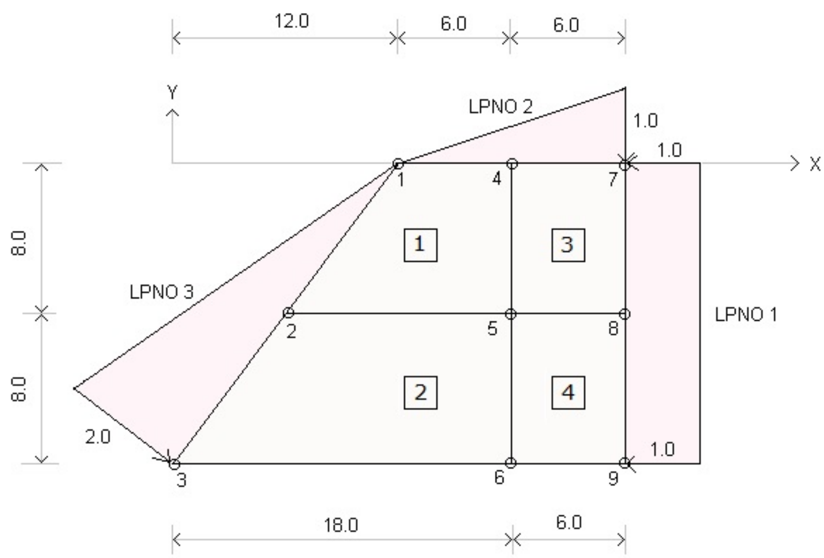


Figure 10.1 Load generation dialog



Loading Surface 1 (LSNO = 1) consists of nodes 9, 7, 8

Loading Surface 2 (LSNO = 2) consists of nodes 7, 4, 1

Loading Surface 3 (LSNO = 3) consists of nodes 1, 2, 3

Pressure Function 1 (LPNO = 1) $P_x = -1.0$

Pressure Function 2 (LPNO = 2) $P_Y = 1.0 - (1/12)X$

Pressure Function 3 (LPNO = 3) $P_n = -0.125Y$

Note: Mesh is axially symmetric about Y axis

Figure 10.2 Schematic view of pressure loads for Example 1

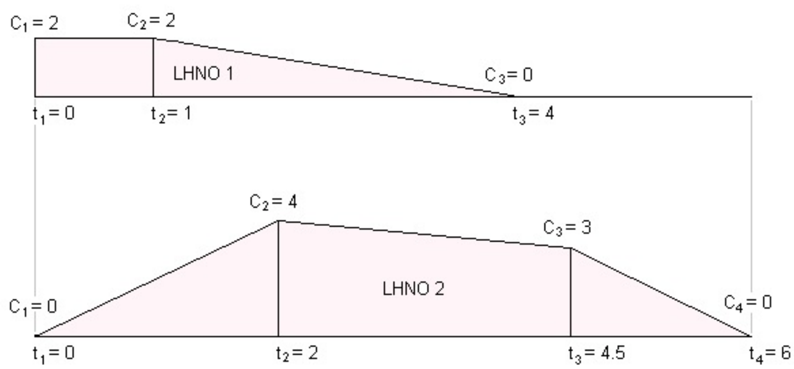


Figure 10.3 Load time histories for Example 1

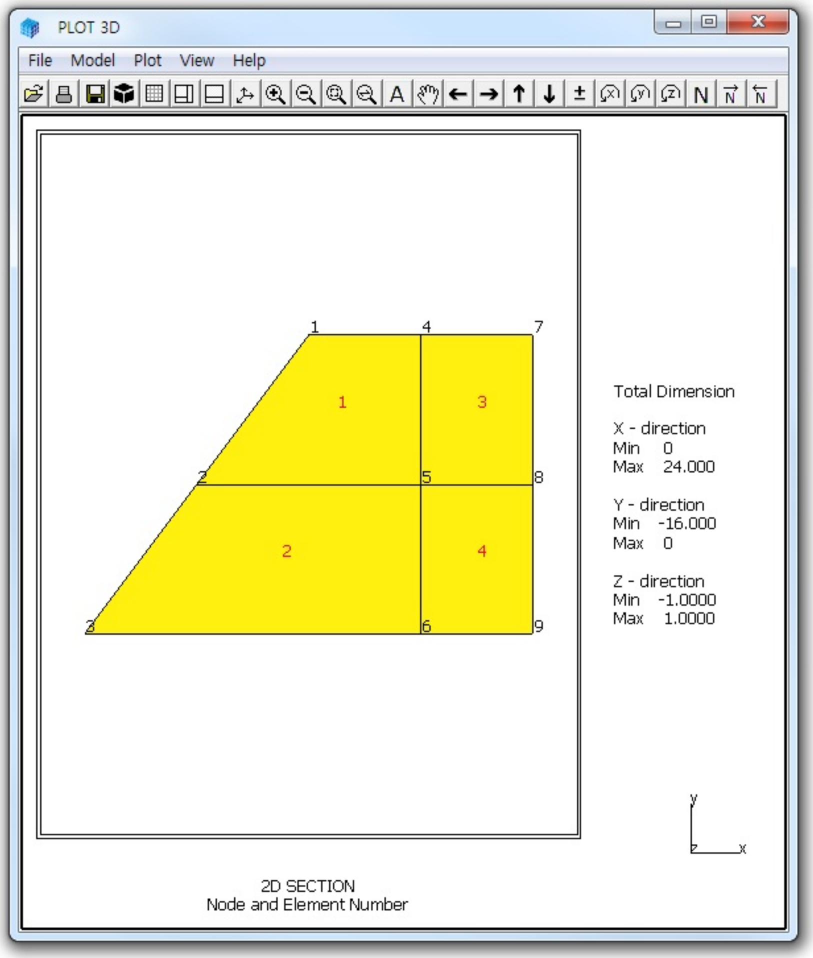


Figure 10.4 Finite element mesh for Example 1

Table 10.1 Listing of mesh data input file Mesh2D.Mes for Example 1

```
2D SECTION
NUMNP   NCONT   NBEAM  NTRUS
   9      4       0      0
NODAL COORDINATES
NODE  ISX  ISY  IFX  IFY  IRZ      XC           YC
  1    1    0    1    1    1      12.           0.
  2    0    0    1    1    0       6.          -8.
  3    0    0    1    1    0       0.         -16.
  4    0    0    1    1    0      18.           0.
  5    0    0    1    1    0      18.          -8.
  6    0    0    1    1    0      18.         -16.
  7    0    0    1    1    0      24.           0.
  8    0    0    1    1    0      24.          -8.
  9    0    0    1    1    0      24.         -16.
ELEMENT INDEX
NEL   I1   I2   I3   I4   M5   M6   M7   M8 MATC KS KF IR IS TBJWL
  1    4    1    2    5    0    0    0    0    4  0  1 2  2  .000E+00
  2    5    2    3    6    0    0    0    0    4  0  1 2  2  .000E+00
  3    7    4    5    8    0    0    0    0    4  0  1 2  2  .000E+00
  4    8    5    6    9    0    0    0    0    4  0  1 2  2  .000E+00
```

Table 10.2 Listing of load data inut file Load2D.Dat for Example 1

```
*
* LOAD-2D  INPUT
*
* CARD 1.1
* TITLE
  EXAMPLE 1  LOAD-2D Pressure [LDTYPE = 1]
* -----------------------------------------
* CARD 1.2
* NCTYPE
   0
* =========================================
* CARD 2.1
* NUMLS
   3
* -----------------------------------------
* CARD 2.2.1
* LSNO
   1
* CARD 2.2.2
* NUMNODE
   3
* CARD 2.2.3
* LISTING OF NODES
   9, 7, 8
* -----------------------------------------
* CARD 2.2.1
* LSNO
   2
* CARD 2.2.2
* NUMNODE
   3
* CARD 2.2.3
* LISTING OF NODES
   7, 4, 1
* -----------------------------------------
* CARD 2.2.1
* LSNO
   3
* CARD 2.2.2
* NUMNODE
   3
```

```
* CARD 2.2.3
* LISTING OF NODES
  1, 2, 3
* =========================================
* CARD 3.1
* NUMLF
   3
* -----------------------------------------
* CARD 3.2.1
* LFNO   LPTYPE
   1      0
* CARD 3.2.2
* A-X0   A-XX   A-XY
  -1.,   0.0,   0.0
* CARD 3.2.3
* A-Y0   A-YX   A-YY
  0.0,   0.0,   0.0
* CARD 3.2.4
* A-N0   A-NX   A-NY
  0.0,   0.0,   0.0
* -----------------------------------------
* CARD 3.2.1
* LFNO   LPTYPE
   2      0
* CARD 3.2.2
* A-X0   A-XX   A-XY
  0.0,   0.0,   0.0
* CARD 3.2.3
* A-Y0   A-YX   A-YY
  1.0,-0.083333,0.0
* CARD 3.2.4
* A-N0   A-NX   A-NY
  0.0,   0.0,   0.0
* -----------------------------------------
* CARD 3.2.1
* LFNO   LPTYPE
   3      1
* CARD 3.2.2
* A-X0   A-XX   A-XY
  0.0,   0.0,   0.0
* CARD 3.2.3
* A-Y0   A-YX   A-YY
  0.0,   0.0,   0.0
```

```
* CARD 3.2.4
* A-N0    A-NX    A-NY
  0.0,    0.0,   -0.125
* =========================================
* CARD 4.1
* NUMLH
   2
* -----------------------------------------
* CARD 4.2.1
* LHNO
   1
* CARD 4.2.2
* NUMTP
   3
* CARD 4.2.3
* T1   T2   T3
  0.0  1.0  4.0
* CARD 4.2.4
* C1   C2   C3
  2.0  2.0  0.0
* -----------------------------------------
* CARD 4.2.1
* LHNO
   2
* CARD 4.2.2
* NUMTP
   4
* CARD 4.2.3
* T1   T2   T3   T4
  0.0  2.0  4.5  6.0
* CARD 4.2.4
* C1   C2   C3   C4
  0.0  4.0  3.0  0.0
* =========================================
* CARD 5.1
* LSNO  LFNO  LHNO
   1,    1,    1
   2,    2,    1
   3,    3,    2
   0,    0,    0
* END OF INPUT DATA
```

The output file, Load2D.Out listed in Table 10.3, contains generated concentrated nodal forces and load time histories. Figure 10.5 shows time history curves for each load history number. The format of the generated load output is compatible to the format of Card Group 9 in SMAP-2D main input.

Table 10.3 Listing of load output file Load2D.Out for Example 1

```
* CARD 9.2.1
* NUMLP
   12
* LOAD HISTORY NO:  1
* CARD 9.2.2
* NODE   IDOF   LHNO   CINT
    1      2      1   -.74998E+01
    4      2      1   -.56999E+02
    7      1      1   -.96000E+02
    7      2      1   -.55500E+02
    8      1      1   -.19200E+03
    9      1      1   -.96000E+02
* LOAD HISTORY NO:  2
* CARD 9.2.2
* NODE   IDOF   LHNO   CINT
    1      1      2    .12000E+02
    1      2      2   -.90000E+01
    2      1      2    .40000E+02
    2      2      2   -.30000E+02
    3      1      2    .12000E+02
    3      2      2   -.90000E+01
* END OF LOAD HISTORY
* CARD 9.2.3.1
* NTFUN  NUMLH
    0      2
* CARD 9.2.3.2
* NUMTP  NTYPE   DTXX
    6      1    .00000E+00
* CARD 9.2.3.3
* LISTING OF TIME POINTS
  .0000E+00  .10000E+01  .20000E+01  .40000E+01  .4500E+01  .6000E+01
* CARD 9.2.3.4
* LISTING OF LOAD FOR HISTORY NO:  1
  .2000E+01  .20000E+01  .13333E+01 -.59605E-07  .0000E+00  .0000E+00
* CARD 9.2.3.4
* LISTING OF LOAD FOR HISTORY NO:  2
  .0000E+00  .20000E+01  .40000E+01  .32000E+01  .3000E+01  .0000E+00
* END OF LOAD DATA
```

Generated load vectors for concentrated forces can be plotted graphically. Refer to the step by step procedure in the file Running LOAD-2D.pdf. The effect of LPTYPE (Effective vs Actual Surface) is described in the file LOAD-2D Example.pdf.

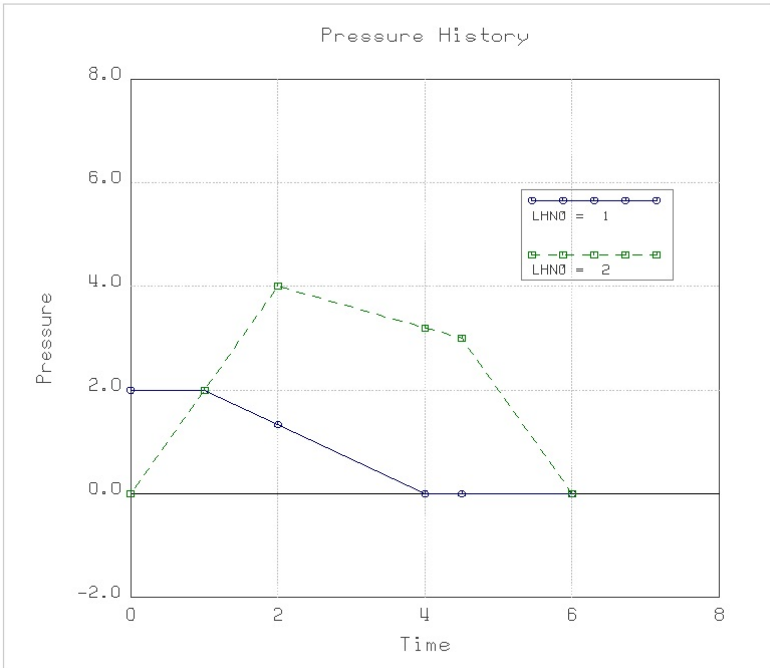


Figure 10.5 Generated load time histories for Example 1

10.2 LOAD-3D

LOAD-3D is the pre-processing program which can be used to generate external force (pressure), specified velocity, initial velocity, acceleration, and transmitting boundary. For the detailed description of input parameters, refer to section 11 of User's Manual.

LOAD-3D can be selected in the following order:

Run → Load Generator → Load 3D

When you select LOAD-3D, Load Generation Dialog will be displayed as in Figure 10.6. You need to specify input file names for Load and Mesh Data.

10.2.1 Example 1

Example 1 is to show the pressure load generation along the surfaces of elements 1 and 2 as schematically shown in Figure 10.7. Triangular pressure loads are acting on the right surfaces of elements 1 and 2. Top and rear surfaces of element 2 are subjected to the uniformly distributed pressures of 0.5 and 1.0, respectively. Three different load time histories, as shown in Figure 10.8, are considered.

Mesh Data contains information for nodal coordinates and element indexes. Mesh3D.Mes represents Mesh Data graphically shown in Figure 10.9 along with listing in Table 10.3. Load Data contains information for loads to be generated. Load3D.Dat in Table 10.4, has been prepared according to LOAD-3D User's Manual.

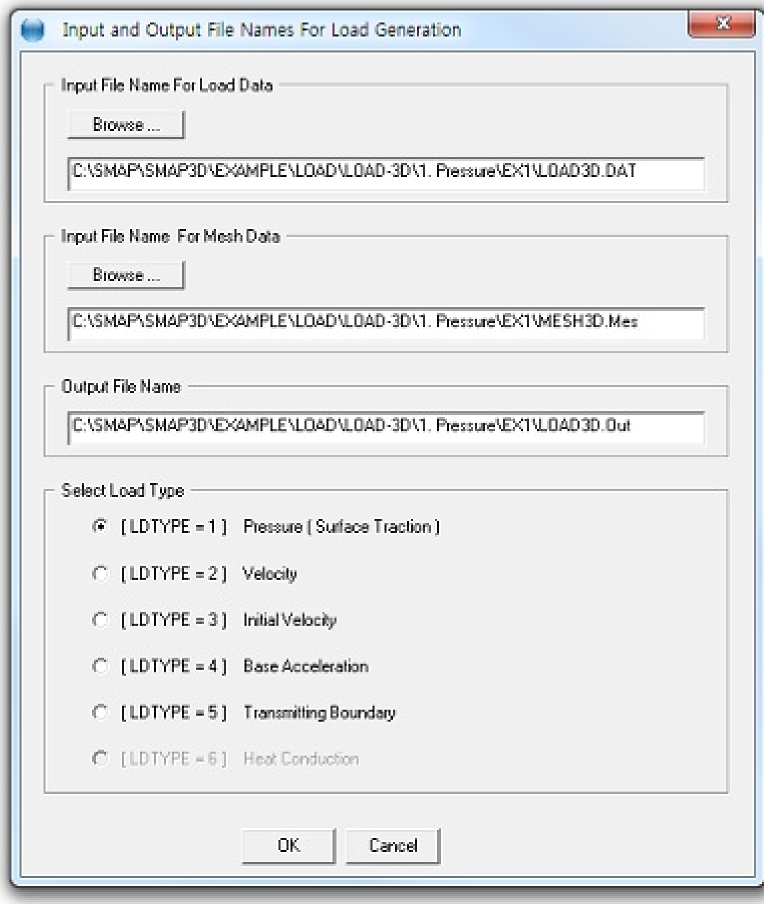
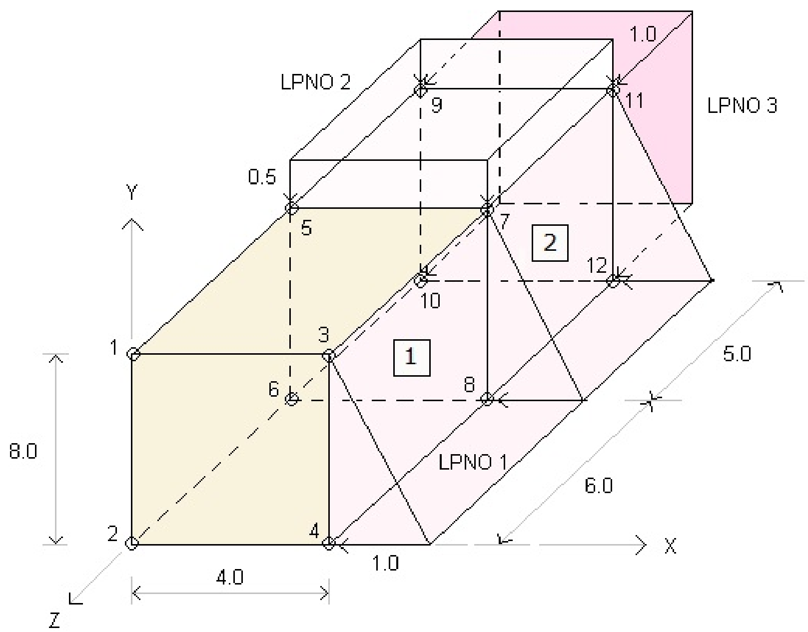


Figure 10.6 Load generation dialog



Loading Surface 1 (LSNO = 1) consists of nodes: 12, 9, 10, 11

Loading Surface 2 (LSNO = 2) consists of nodes: 11, 12, 3, 4, 7, 8

Loading Surface 3 (LSNO = 3) consists of nodes: 5, 7, 11, 9

Pressure Function 1 (LPNO = 1): $P_x = -1.0 + 0.125\,Y$

Pressure Function 2 (LPNO = 2): $P_Y = -0.5$

Pressure Function 3 (LPNO = 3): $P_n = 1.0$

Figure 10.7 Schematic view of pressure loads for Example 1

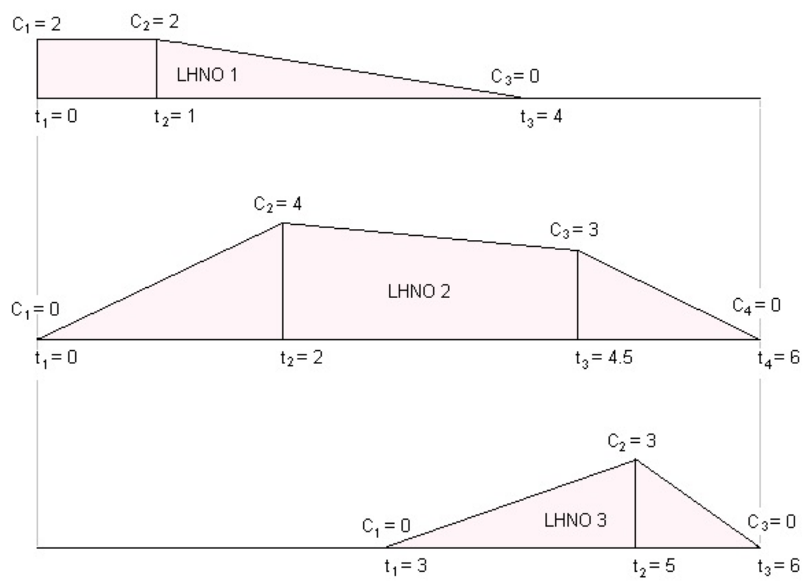


Figure 10.8 Load time histories for Example 1

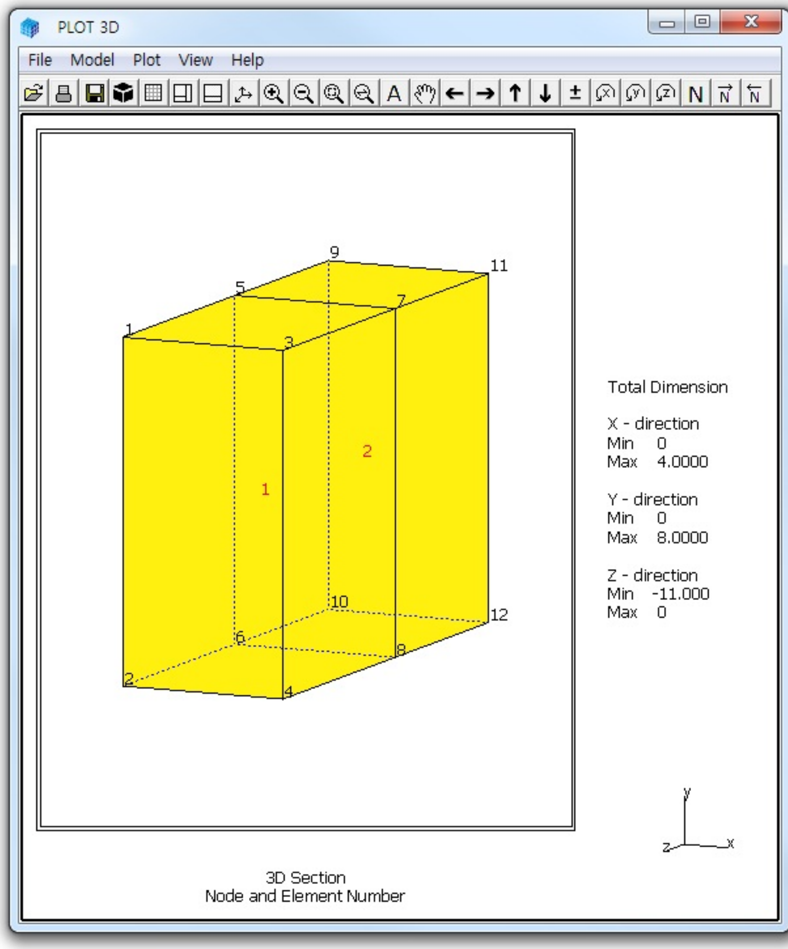


Figure 10.9 Finite element mesh for Example 1

Table 10.4 Listing of mesh input file Mesh3D.Mes for Example 1

```
3D Section
NUMNP    NCONT    NBEAM  NTRUS
  12       2      0       0
NODAL      BOUNDARY CONDITIONS      &            COORDINATES
NODE  ISX   ISY   ISZ   IFX   IFY   IFZ   IRX   IRY   IRZ XC    YC    ZC
  1     1     0     1     1     1     1     1     1     1  0.0  8.0  0.0
  2     0     0     1     1     1     1     1     1     0  0.0  0.0  0.0
  3     0     0     1     1     1     1     1     1     0  4.0  8.0  0.0
  4     0     0     1     1     1     1     1     1     0  4.0  0.0  0.0
  5     0     0     1     1     1     1     1     1     0  0.0  8.0 -6.0
  6     0     0     1     1     1     1     1     1     0  0.0  0.0 -6.0
  7     0     0     1     1     1     1     1     1     0  4.0  8.0 -6.0
  8     0     0     1     1     1     1     1     1     0  4.0  0.0 -6.0
  9     0     0     1     1     1     1     1     1     0  0.0  8.0 -11.0
 10     0     0     1     1     1     1     1     1     0  0.0  0.0 -11.0
 11     0     0     1     1     1     1     1     1     0  4.0  8.0 -11.0
 12     0     0     1     1     1     1     1     1     0  4.0  0.0 -11.0
             ELEMENT  INDEX
NEL    I1    I2    I3    I4    I5    I6    I7    I8   MATC  KS  KF  IR  IS  IT TBJWL
  1     3     1     2     4     7     5     6     8     4   0   1   2   2   2. 0E+0
  2     7     5     6     8    11     9    10    12     4   0   1   2   2   2. 0E+0
```

Table 10.5 Listing of load input file Load3D.Dat for Example 1

```
*
* LOAD-3D  INPUT
*
* CARD 1.1
* TITLE
  EXAMPLE 1  LOAD-3D Pressure [LDTYPE = 1]
* ========================================
* CARD 2.1
* NUMLS
   3
* ----------------------------------------
* CARD 2.2.1
* LSNO
   1
* CARD 2.2.2
* NUMNODE
   4
* CARD 2.2.3
* LISTING OF NODES
  12, 9, 10, 11
* ----------------------------------------
* CARD 2.2.1
* LSNO
   2
* CARD 2.2.2
* NUMNODE
   6
* CARD 2.2.3
* LISTING OF NODES
  11, 12, 3, 4, 7, 8
* ----------------------------------------
* CARD 2.2.1
* LSNO
   3
* CARD 2.2.2
* NUMNODE
   4
* CARD 2.2.3
* LISTING OF NODES
  5, 7, 11, 9
```

```
* =========================================
* CARD 3.1
* NUMLF
   3
* -----------------------------------------
* CARD 3.2.1
* LFNO   LPTYPE
   1      0
* CARD 3.2.2
* A-X0   A-XX   A-XY   A-XZ
  -1.,   0.0,   0.125, 0.0
* CARD 3.2.3
* A-Y0   A-YX   A-YY   A-YZ
  0.0,   0.0,   0.0,   0.0
* CARD 3.2.4
* A-Z0   A-ZX   A-ZY   A-ZZ
  0.0,   0.0,   0.0,   0.0
* CARD 3.2.5
* A-N0   A-NX   A-NY   A-NZ
  0.0,   0.0,   0.0,   0.0
* -----------------------------------------
* CARD 3.2.1
* LFNO   LPTYPE
   2      0
* CARD 3.2.2
* A-X0   A-XX   A-XY   A-XZ
  0.0,   0.0,   0.0,   0.0
* CARD 3.2.3
* A-Y0   A-YX   A-YY   A-YZ
 -0.5,   0.0,   0.0,   0.0
* CARD 3.2.4
* A-Z0   A-ZX   A-ZY   A-ZZ
  0.0,   0.0,   0.0,   0.0
* CARD 3.2.5
* A-N0   A-NX   A-NY   A-NZ
  0.0,   0.0,   0.0,   0.0
* -----------------------------------------
* CARD 3.2.1
* LFNO   LPTYPE
   3      1
```

```
* CARD 3.2.2
* A-X0   A-XX   A-XY   A-XZ
  0.0,   0.0,   0.0,   0.0
* CARD 3.2.3
* A-Y0   A-YX   A-YY   A-YZ
  0.0,   0.0,   0.0,   0.0
* CARD 3.2.4
* A-Z0   A-ZX   A-ZY   A-ZZ
  0.0,   0.0,   0.0,   0.0
* CARD 3.2.5
* A-N0   A-NX   A-NY   A-NZ
  1.0,   0.0,   0.0,   0.0
* =========================================
* CARD 4.1
* NUMLH
   3
* -----------------------------------------
* CARD 4.2.1
* LHNO
   1
* CARD 4.2.2
* NUMTP
   3
* CARD 4.2.3
* T1   T2   T3
  0.0  1.0  4.0
* CARD 4.2.4
* C1   C2   C3
  2.0  2.0  0.0
* -----------------------------------------
* CARD 4.2.1
* LHNO
   2
* CARD 4.2.2
* NUMTP
   4
* CARD 4.2.3
* T1   T2   T3   T4
  0.0  2.0  4.5  6.0
* CARD 4.2.4
* C1   C2   C3   C4
  0.0  4.0  3.0  0.0
```

```
* -----------------------------------------
* CARD 4.2.1
* LHNO
   3
* CARD 4.2.2
* NUMTP
   3
* CARD 4.2.3
* T1    T2    T3
  3.0   5.0   6.0
* CARD 4.2.4
* C1    C2    C3
  0.0   3.0   0.0
* =========================================
* CARD 5.1
* LSNO  LFNO  LHNO
   1,     3,     1
   2,     1,     3
   3,     2,     2
   0,     0,     0
* END OF INPUT DATA
```

The output file, Load3D.Out listed in Table 10.6, contains generated concentrated nodal forces and load time histories. Figure 10.10 shows time history curves for each load history number. The format of the generated load output is compatible to the format of Card Group 9 in SMAP-3D main input.

Generated load vectors for concentrated forces can be plotted graphically. Refer to the step by step procedure in the file Running LOAD-3D.pdf.

Table 10.6 Listing of load output file Load3D.Out for Example 1

```
* CARD 9.2.1
* NUMLP
   14
* LOAD HISTORY NO:  1
* CARD 9.2.2
* NODE   IDOF   LHNO   CINT
    9      3      1    .80000E+01
   10      3      1    .80000E+01
   11      3      1    .80000E+01
   12      3      1    .80000E+01
* LOAD HISTORY NO:  2
* CARD 9.2.2
* NODE   IDOF   LHNO   CINT
    5      2      2   -.25000E+01
    7      2      2   -.25000E+01
    9      2      2   -.25000E+01
   11      2      2   -.25000E+01
* LOAD HISTORY NO:  3
* CARD 9.2.2
* NODE   IDOF   LHNO   CINT
    3      1      3   -.40000E+01
    4      1      3   -.80000E+01
    7      1      3   -.73333E+01
    8      1      3   -.14667E+02
   11      1      3   -.33333E+01
   12      1      3   -.66667E+01
* END OF LOAD HISTORY
* CARD 9.2.3.1
* NTFUN  NUMLH
    0      3
```

```
* CARD 9.2.3.2
* NUMTP  NTYPE   DTXX
    8      1    .00000E+00
* CARD 9.2.3.3
* LISTING OF TIME POINTS
  .00000E+00  .10000E+01  .20000E+01  .30000E+01  .40000E+01
  .45000E+01  .50000E+01  .60000E+01
* CARD 9.2.3.4
* LISTING OF LOAD FOR HISTORY NO:  1
  .20000E+01  .20000E+01  .13333E+01  .66667E+00 -.59605E-07
  .00000E+00  .00000E+00  .00000E+00
* CARD 9.2.3.4
* LISTING OF LOAD FOR HISTORY NO:  2
  .00000E+00  .20000E+01  .40000E+01  .36000E+01  .32000E+01
  .30000E+01  .20000E+01  .00000E+00
* CARD 9.2.3.4
* LISTING OF LOAD FOR HISTORY NO:  3
  .00000E+00  .00000E+00  .00000E+00  .00000E+00  .15000E+01
  .22500E+01  .30000E+01  .00000E+00
* END OF CONCENTRATED LOAD DATA
```

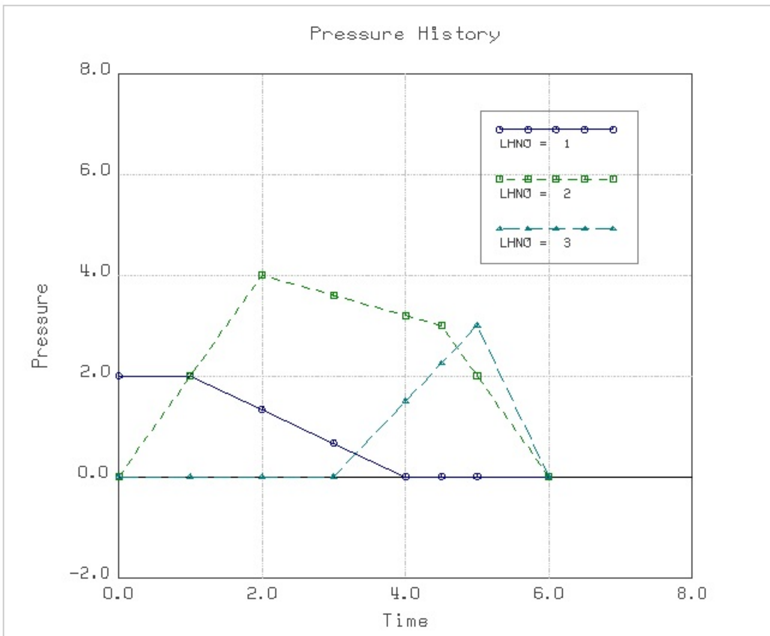


Figure 10.10 Generated load time histories for Example 1

XY Graph
Example Problem

XY Graph is a two-dimensional graph consisting of lines connecting each pair of data points, which can be plotted by PLOT XY or EXCEL. XY Graph User's Manual describes all the basic functions associated with XY graph creation and modifications.

Two example problems are presented:

1. New Graph
   Shows step by step procedure to create and modify XY graph.
   Main actions:
   - Access XY graph
   - Edit initial Draft XY
   - Modify XY graph by Edit dialog
   - Open XY graph on Excel Spreadsheet

2. SMAP Result
   Plots SMAP results specified in Card Group 12 in SMAP Post File.
   Main actions:
   - Execute SMAP-3D example
   - Access SMAP result
   - Access PLOT XY in Plot menu
   - Modify XY graph by Edit dialog
   - Open XY graph on Excel Spreadsheet

11.1 New Graph

The main objective of this first example is to show the step by step procedure to create and modify XY graph.

This example consists of the following main actions:

- Access XY graph
- Edit initial Draft XY
- Modify XY graph by Edit dialog
- Open XY graph on Excel Spreadsheet

Step 1: Access XY Graph (New)

Access XY Graph by selecting following items in SMAP (Figure 11.1):
Plot → XY → PLOT XY → New

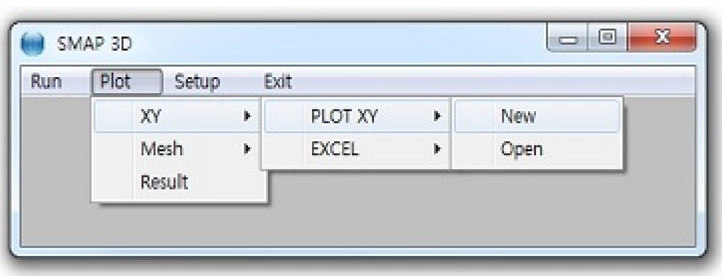


Figure 11.1 Accessing XY graph (New)

Step 2: Edit Initial Draft XY

Once selected, initial default file XY.dat will be opened by Notepad as listed in Table 11.1.

Edit the first plot in this default file as listed in Table 11.2.
And then save and exit.

Modified graph will be displayed on PLOT XY drawing board as shown in Figure 11.2.

Table 11.1 Draft XY Data (Initial Default File XY.dat)

```
Plot No. 1
Sub Title 1
XLabel-1
YLabel-1
 0          10
 100        20
 .000000E+00  .123456E+06
Curve 1
Legend
10,         20
90,         30
 .000000E+00  .123456E+06
Curve 2
Legend
 .000000E+00  .987654E+06
Plot No. 2
Sub Title 2
XLabel-2
YLabel-2
0           100
1000        200
 .000000E+00  .123456E+06
Curve 1
Legend
100         200
900         300
.000000E+00  .123456E+06
Curve 2
Legend
.000000E+00  .987654E+06
Plot No. 3
Sub Title 3
XLabel-3
YLabel-3
0            100
1000         200
.000000E+00  .123456E+06
Curve 1
Legend
200,        200
900,        300
.000000E+00  .123456E+06
Curve 2
Legend
.000000E+00  .987654E
```

Table 11.2 Modified Draft XY Data (File XY.dat)

```
Example 1
Stress History
Time (Sec)
Stress (MPa)
 0          10
 100        20
 .000000E+00   .123456E+06
Vertical
Stress
0           20
100         30
 .000000E+00   .123456E+06
Horizontal
Stress
 .000000E+00   .987654E+06
Plot No. 2
Sub Title 2
XLabel-2
YLabel-2
0           100
1000        200
 .000000E+00   .123456E+06
Curve 1
Legend
100         200
900         300
.000000E+00   .123456E+06
Curve 2
Legend
.000000E+00   .987654E+06
Plot No. 3
Sub Title 3
XLabel-3
YLabel-3
0           100
1000        200
.000000E+00   .123456E+06
Curve 1
Legend
200,        200
900,        300
.000000E+00   .123456E+06
Curve 2
Legend
.000000E+00   .987654E
```

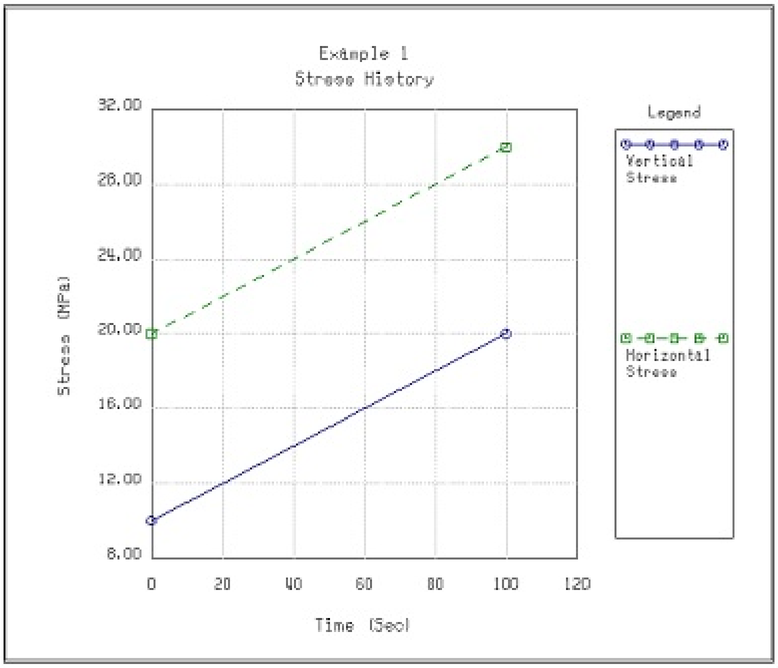


Figure 11.2 Modified graph on PLOT XY

Step 3: Modify XY Graph by Edit Dialog

Access Edit dialog by clicking the Edit menu in PLOT XY (Figure 11.3):

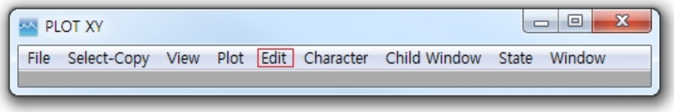


Figure 11.3 Edit menu in PLOT XY

Edit dialog will be displayed as shown in Figure 11.4.

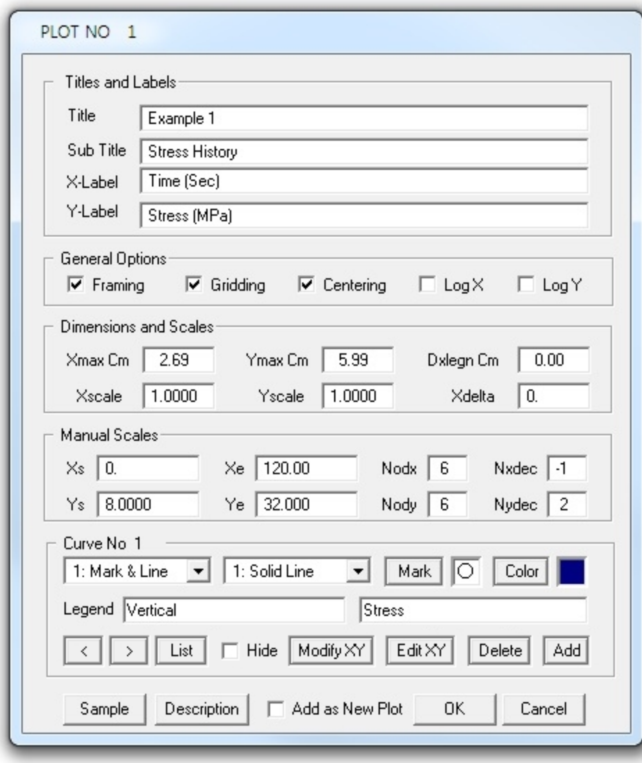


Figure 11.4 Edit dialog

There are many different options available for changing view of XY graphas described in detail in Section 12.3 in XY Graph User's Manual.

Here, change the color of the first curve into Red.
Click Color button and select Red from Color Palette dialog.
Then Red color will be updated for first curve as shown in Figure 11.5.

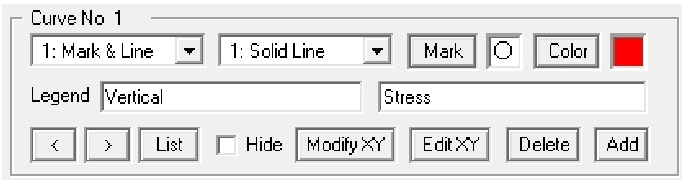


Figure 11.5 Updated red color in Edit dialog

Click OK button in Edit dialog.
Then updated plot will be displayed on PLOT XY as in Figure 11.6.

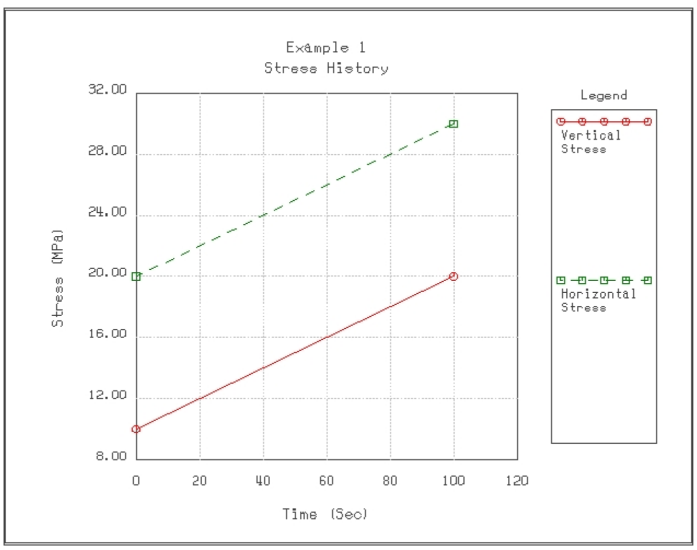


Figure 11.6 Updated first curve on PLOT XY

Step 4: Open XY Graph on Excel Spreadsheet

Access XY Graph by selecting following items in SMAP (Figure 11.7):
Plot → XY → EXCEL → Open

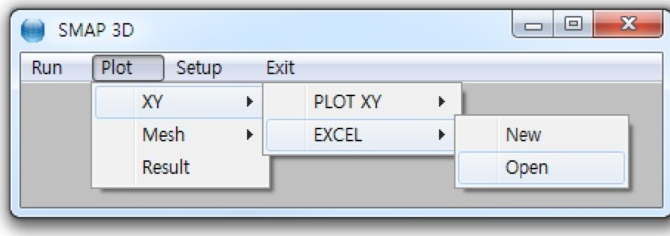


Figure 11.7 Accessing XY graph on Excel (Open)

Open XY.dat in the current working directory.
XY graph will be displayed on Excel Spreadsheet as in Figure 11.8.

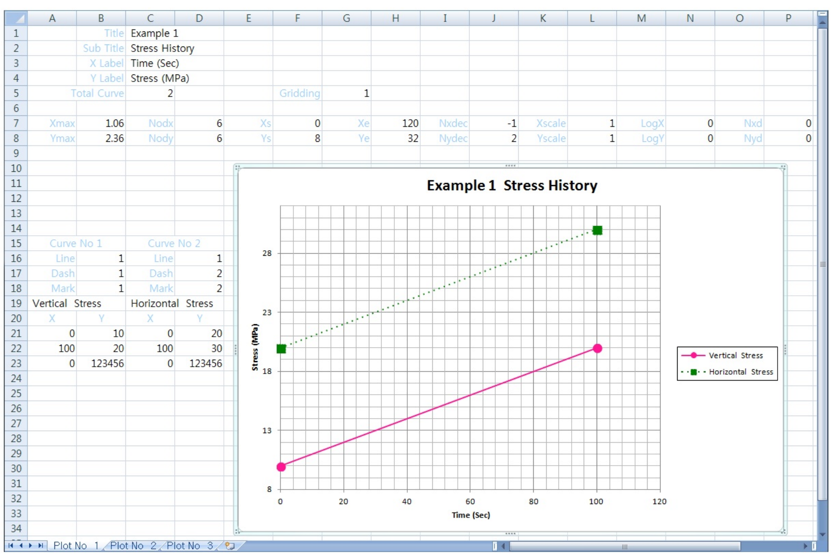


Figure 11.8 XY graph on Excel spreadsheet

11.2 SMAP Result

The main objective of this second example is to show the step by step procedure to plot SMAP results specified in Card Group 12 in SMAP Post File. This example involves SMAP-3D Example Problem 5 (Laminated Beam with Slip Interface).

This example consists of the following main actions:

- Execute SMAP-3D example
- Access SMAP result
- Access PLOT XY in Plot menu
- Modify XY graph by Edit dialog
- Open XY graph on Excel Spreadsheet

Step 1: Execute SMAP-3D Example

Execute SMAP-3D by selecting the following menu items in SMAP (Figure 11.9): Run → Smap → Execute

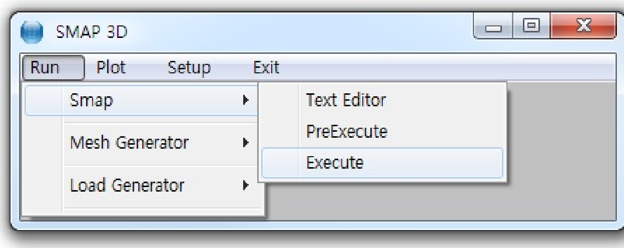


Figure 11.9 Execute SMAP-3D example problem

Note that SMAP-3D Example Problem 5 includes XY graph specified in Card Group 12 in SMAP Post File Vp5.Pos as listed in Table 11.3

Step 2: Access SMAP Result

Access SMAP Result by selecting the following menu items in SMAP : Plot → Result

Table 11.3 SMAP-3D post file (File Vp5.Pos)

```
* Card 11.1
* NPTYPE IHOR IVER
  0      0    0
* P L O T - X Y
* Card 12.1
* IPTYPE
  2
* Card 12.3.1
* IPLOT
  1
* Card 12.3.2
* NODE
  1
* LIST1,  LIST2,  ...
  4
* Card 12.3.4
* NDPQ
  1
* Card 12.3.5
* KX       KY
  1,       3
* Card 12.3.6
* TMFAC   SND    SNV   SNA   NC  ANGLE
  0.018  -100    1     1     0   0
* Card 12.3.7
* TITLE / X-LABEL / Y-LABEL
  Laminated Beam
  Applied Load (t)
  Displacement (Cm)
* Card 12.1
* IPTYPE
  0
* End of Data
```

Step 3: Access PLOT XY in Plot Menu

Select PLOT XY in Plot Menu dialog in Figure 11.10.

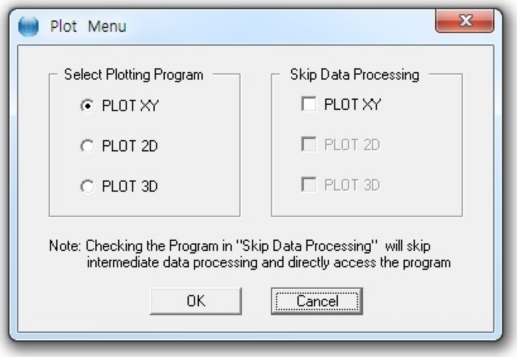


Figure 11.10 Plot menu dialog

Select PLOT XY in Select Plotting Program dialog in Figure 11.11.
Click OK button.

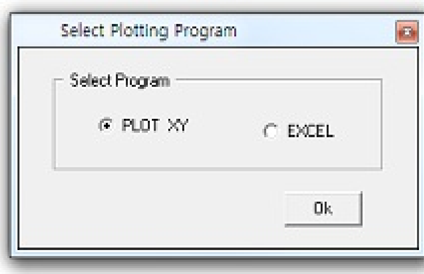


Figure 11.11 Select plotting program dialog

Step 4: Modify XY Graph by Edit Dialog

Once XY graph is displayed on PLOT XY, access Edit dialog by clicking the Edit menu in PLOT XY as shown in Figure 11.12

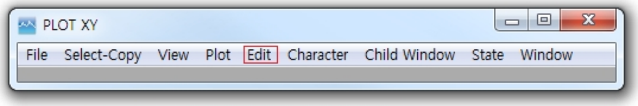


Figure 11.12 Edit menu in PLOT XY

Modify Edit dialog as shown in Figure 11.13.
The main modification is to plot the XY graph in log scales.
Click OK button in Edit dialog.

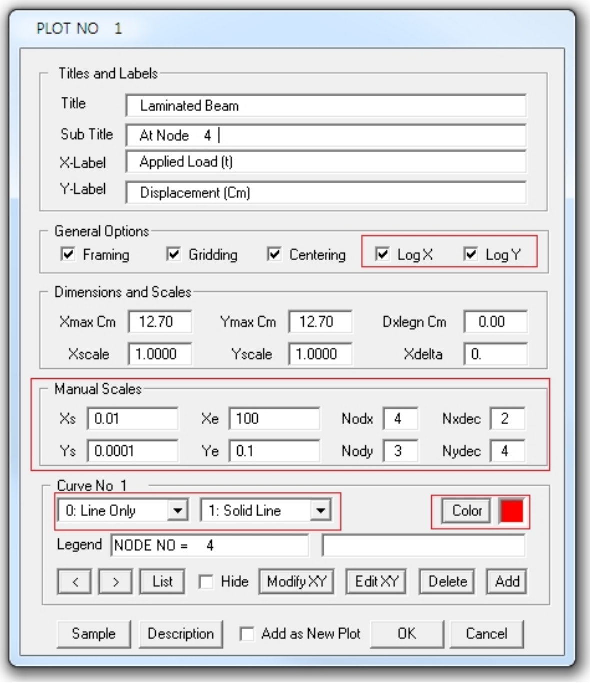


Figure 11.13 Edit dialog

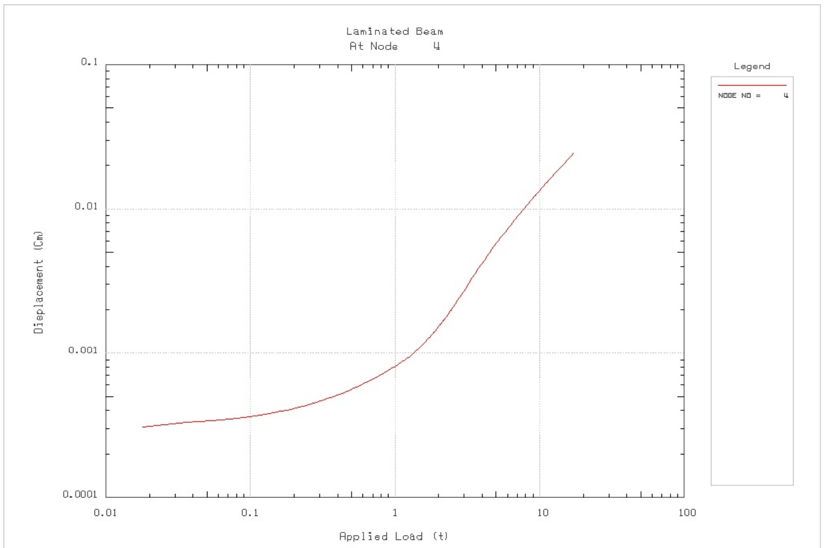


Figure 11.14 XY graph in log scales on PLOT XY

Refer to more samples in the following directory:
C:\Smap \Smap3D \Example \XY_Graph \PLOT XY Graph Sample.pdf

Step 5: Open XY Graph on Excel Spreadsheet

Access XY Graph by selecting following items in SMAP (Figure 11.15):
Plot → XY → EXCEL → Open

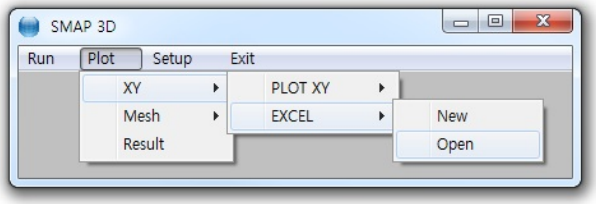


Figure 11.15 Accessing XY graph on Excel (Open)

Open PlotXy.dat in the current working directory.
XY graph will be displayed on Excel Spreadsheet as in Figure 11.16.

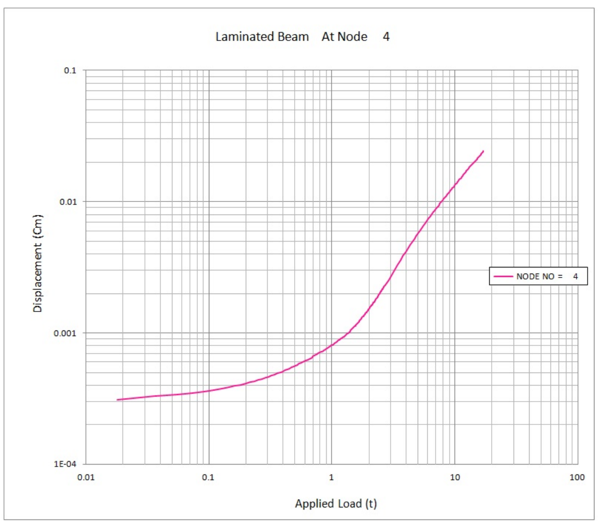


Figure 11.16 XY graph on Excel spreadsheet

Refer to more samples in the following directory:
C:\Smap \Smap3D \Example \XY_Graph \Excel XY Graph Sample.pdf