CREATING LINE HINGES IN ADAPT-FLOOR PRO

INTRODUCTION

The purpose of this technical note is to show an illustrative example of how to successfully generate a line hinge within a floor slab in ADAPT-Floor Pro. Background and supporting information related to shell formulation and data architecture is necessary to understand the format by which shell edge degrees of freedom (DOF) are released for generating a line hinge.

FIGURE 1 shows the one-way slab and location, denoted by the black line, where the line hinge is to be located.

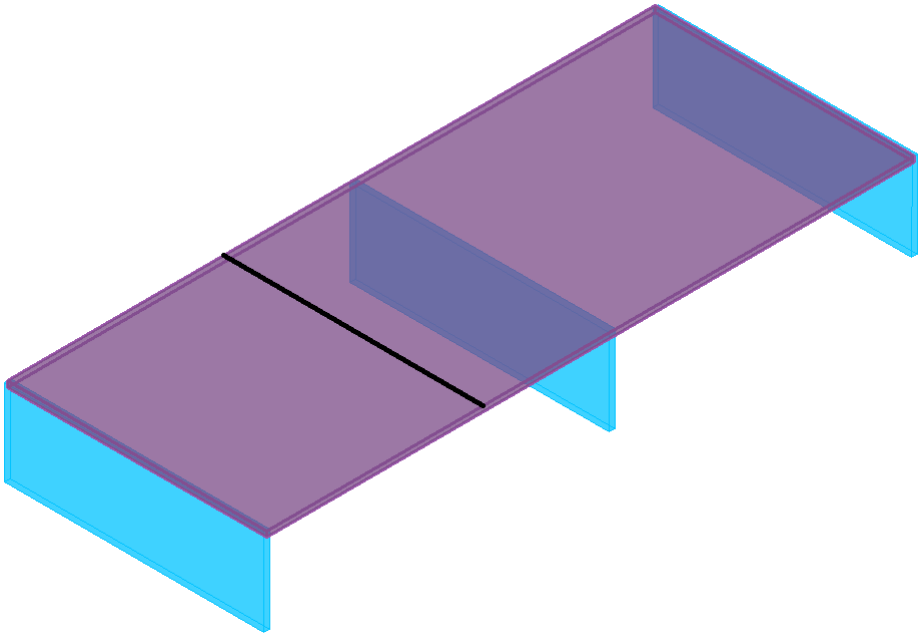


FIGURE 1 Concrete Slab with line hinge

FINITE ELEMENT ORIENTATION

The image shown in **FIGURE 2** shows the desired mechanism to be achieved by creation of the hinge from manipulating shell element releases along the hinge line. Shell elements in ADAPT-Floor Pro are comprised of nodes at adjoining corners. Unique numbers are assigned to represent shell nodes i, j, k and l. This process occurs at the time of analysis. These nodes represent the local orientation of each shell. **FIGURE 3** shows the shell element local and global axis orientation.

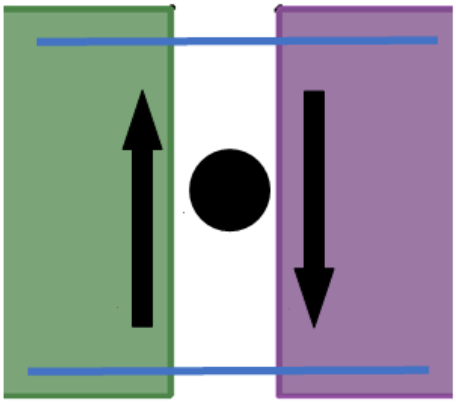


FIGURE 2 Slab hinge mechanism

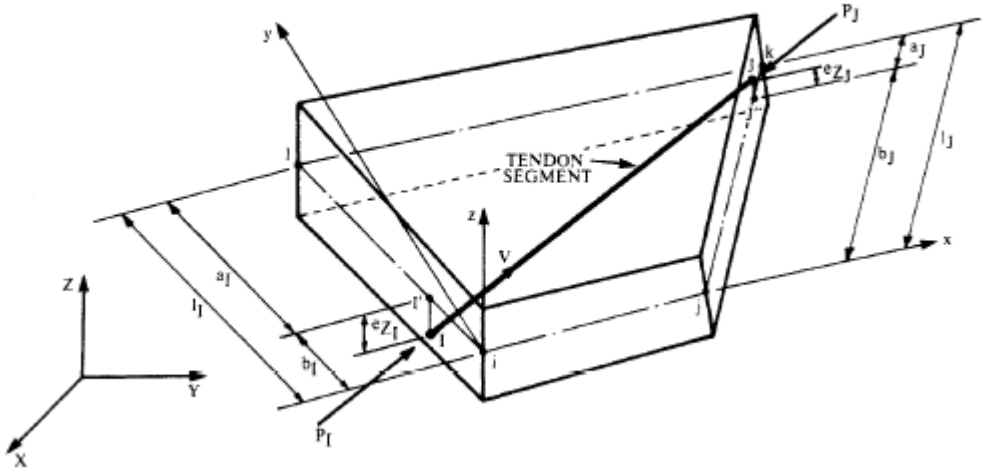


FIGURE 3 Finite Element shell with local and global coordinate system

SHELL DATA STRUCTURE

Prior to the general frame analysis in ADAPT-Floor Pro, a pre-processing step is carried out to establish shell local coordinate numbers. These node numbers are shown at each shell in **FIGURE 4.** Those shell elements aligned along the hinge line must be released for rotation to obtain the desired behavior. Specifically, only the edge of each shell located at the hinge line must be released.

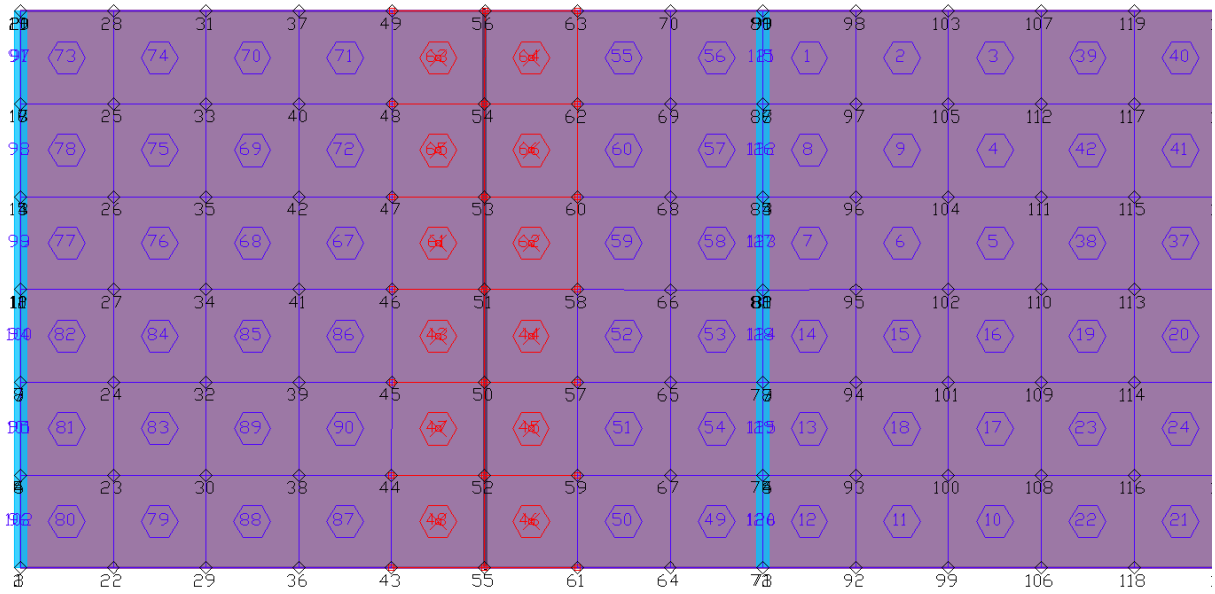


FIGURE 4 Finite Element shell and node numbers

In this example, the following shell elements and nodes corresponding to the edge aligned along the hinge are as follows:

Shells / Nodes

48, 46 / 55-52

47, 45 / 52-50

43, 44 / 50-51

61, 62 / 51-53

65, 66 / 53-54

63, 64 / 54-56

The edge releases for any shell can be accessed by opening the shell properties and selecting the "Release (FEM only)" tab. See **FIGURE 5** This tab lists edges 1-4 for the selected element. Each edge can be assigned Translation or Rotation releases along global X, Y and Z directions.

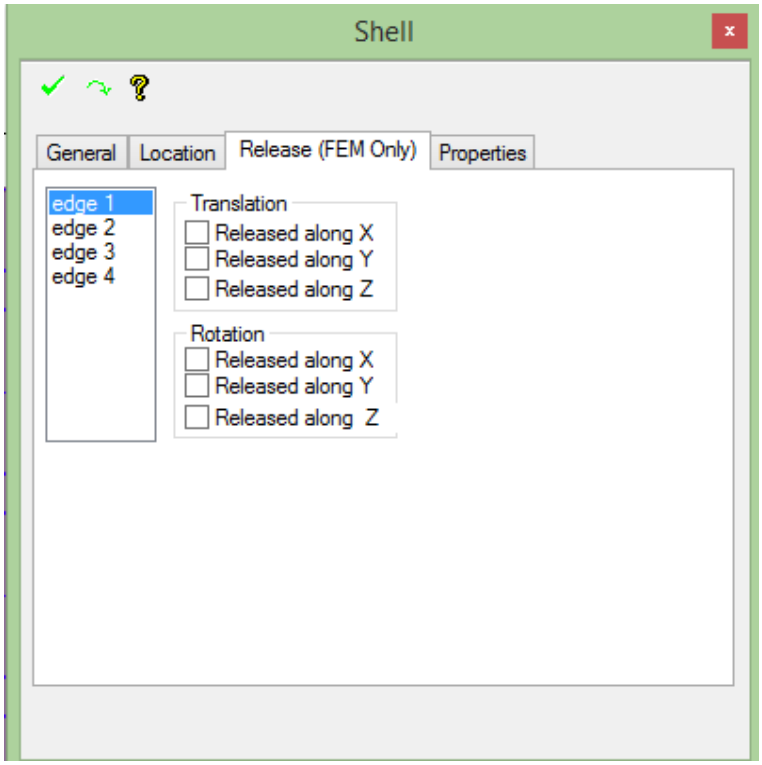


FIGURE 5 Shell release assignments

For the listed shell elements and nodes that define the edge along the hinge line, the dialogue window shown above does not describe which nodes define edges 1-4. In order to map node assignments to the edges, the .INP data file must be accessed. This file is located in the model folder\databases\NAME_OF_FILE.INP. The general structure of the "SHELL ELEMENTS" data block is shown in **FIGURE 7.** The first line reports the shell element number with the i, j, k and l nodes. For example, for Element No. 46 in **FIGURE 4**, the text line is as follows:

```
44,51,58,57,50 T=203.202471,203.202471,203.202471,203.202471 D=28 F=1 M=1 V=1.000
45,52,50,57,59 T=203.202471,203.202471,203.202471,203.202471 D=28 F=1 M=1 V=1.000
46,59,61,55,52 T=203.202471,203.202471,203.202471,203.202471 D=28 F=1 M=1 V=1.000
47,44,45,50,52 T=203.202471,203.202471,203.202471,203.202471 D=28 F=1 M=1 V=1.000
48,52,55,43,44 T=203.202471,203.202471,203.202471,203.202471 D=28 F=1 M=1 V=1.000
```

The local coordinate nodes i, j, k and l are: 59, 61, 55, 52. The positive local x direction is defined by the vector between the 59 and 61 nodes. The local y direction is perpendicular to this direction and defined by the vector between nodes 61 and 55. Using the nodes defined in this file, the edges are:

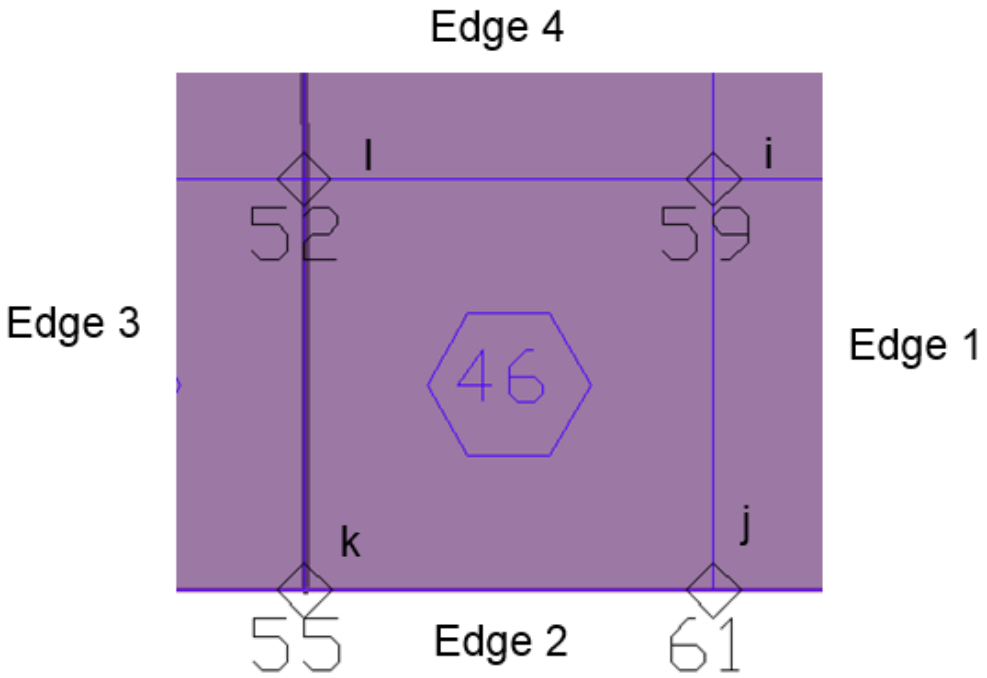
Edge 1 – 59, 61

Edge 2 – 61, 55

Edge 3 – 55, 52

Edge 4 – 52, 59

.



For this example, each of the shell elements are required to have the rotational releases along X and Y directions assigned. Based on the information shown below and taken from the .INP follow and mapping this data to shell and node numbers shown in **FIGURE 6,** the edges aligned along the hinge are established and shown in RED.

```
42,115,111,112,.
43,50,45,46,51
44,51,58,57,50
45,52,50,57,59
46,59,61,55,52
47,44,45,50,52
48,52,55,43,44

61,51,46,47,53
62,53,60,58,51
63,54,48,49,56
64,56,63,62,54
65,53,47,48,54
66,54,62,60,53
```

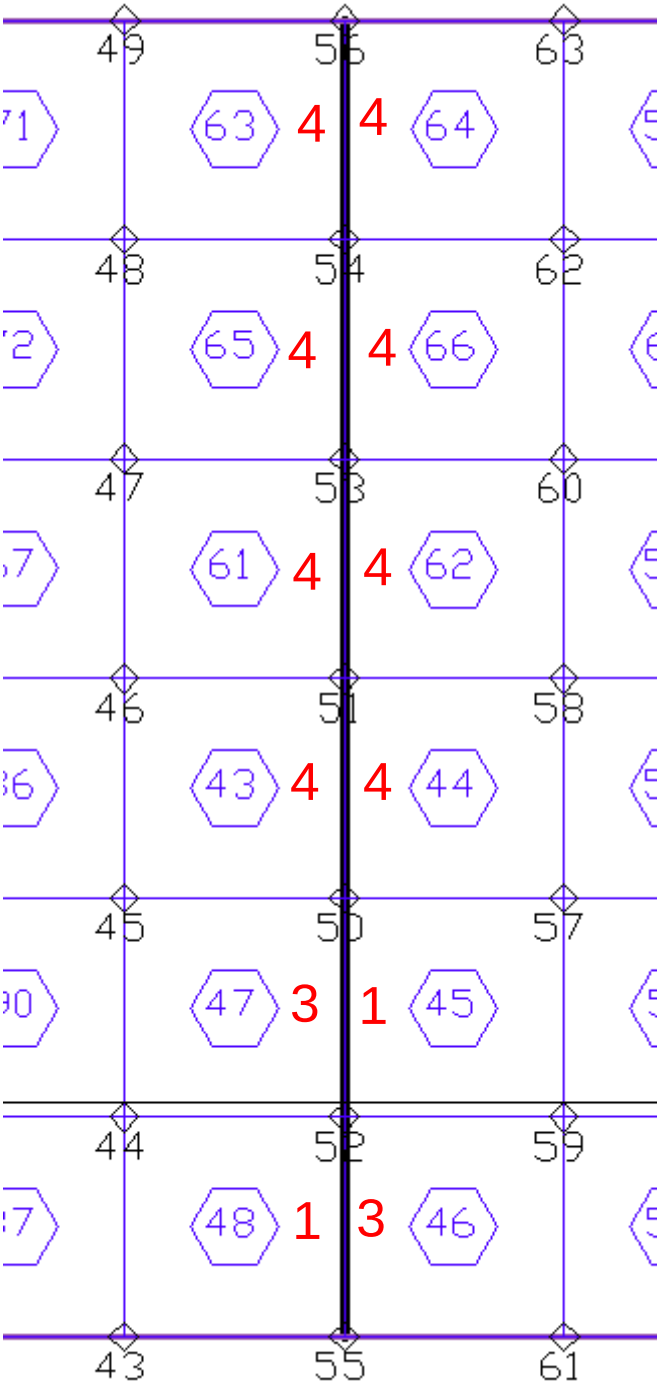
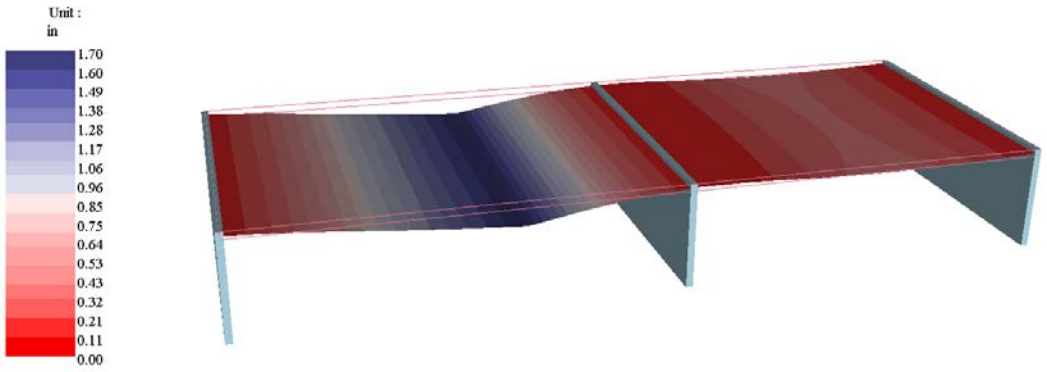
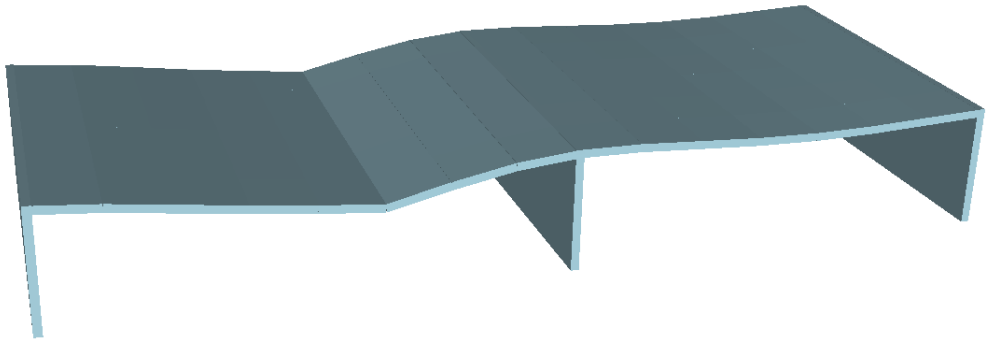
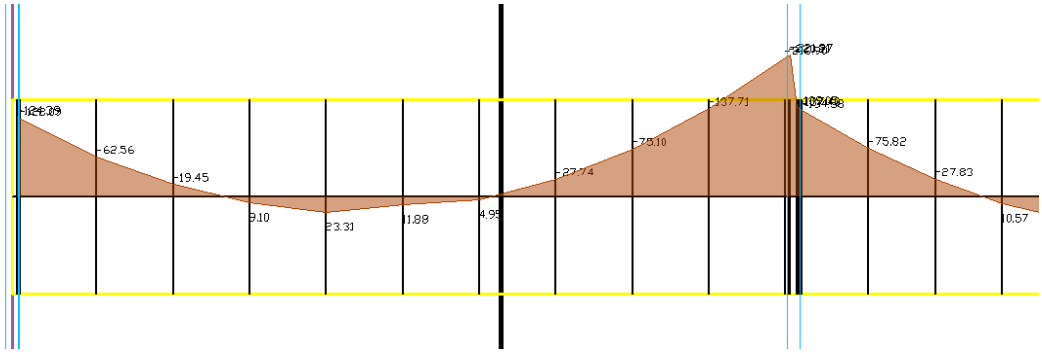


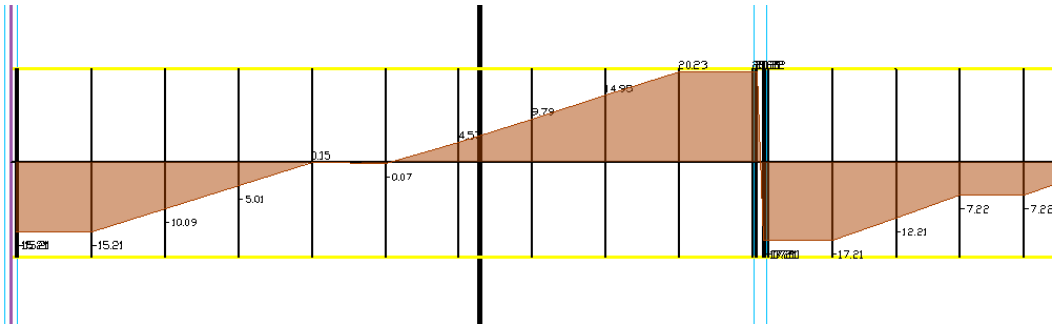
FIGURE 6 Shell edge numbers

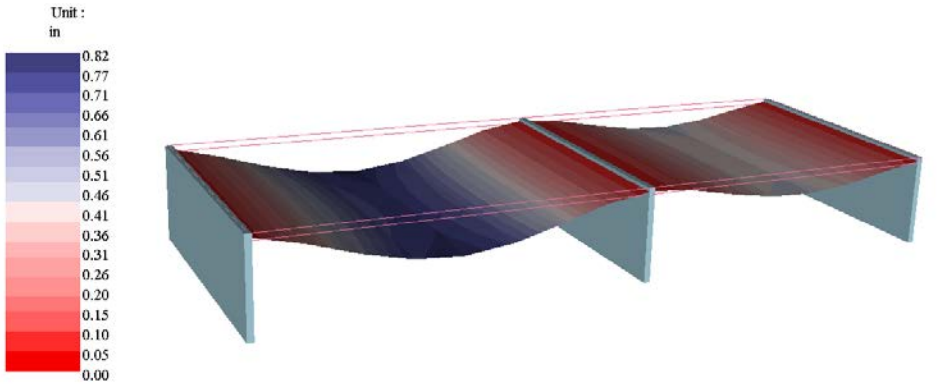
After making the modifications to shell edges and running the analysis, with and without the edge releases, the images below show the deformed shape and moment diagram along a strip through the slab hinge.

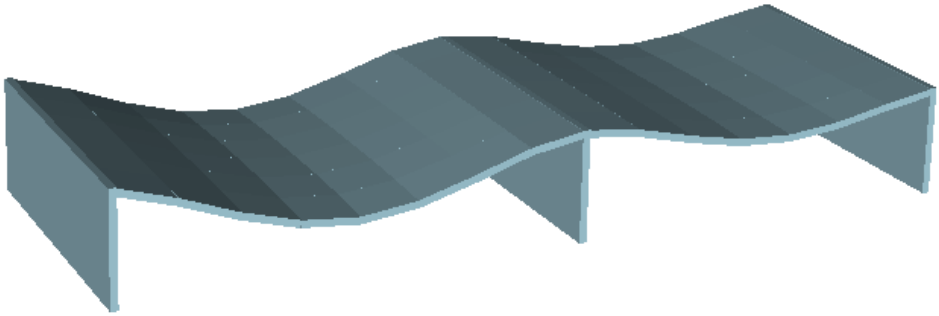


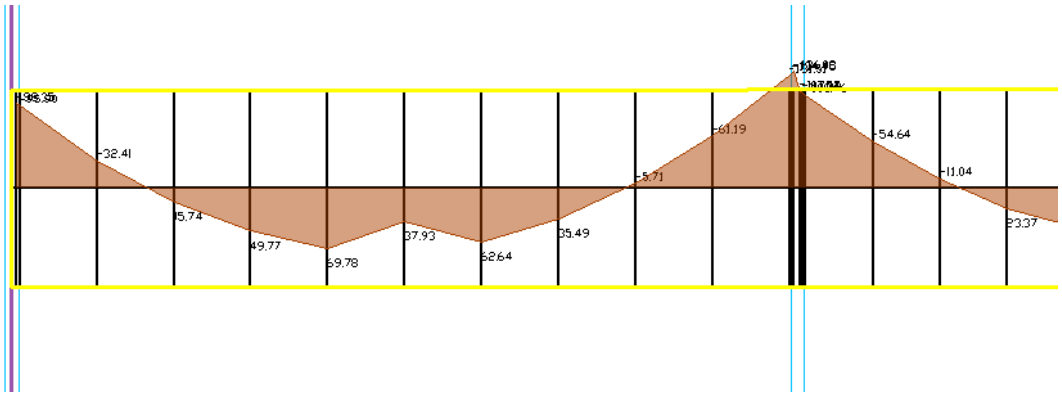


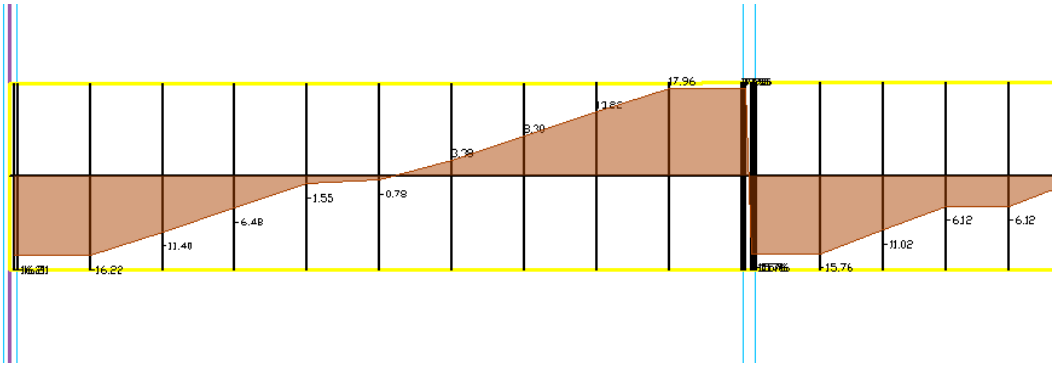





Unit :
in
0.82
0.77
0.71
0.66
0.61
0.56
0.51
0.46
0.41
0.36
0.31
0.26
0.20
0.15
0.10
0.05
0.00




32.41
15.74
49.77
69.78
37.93
82.64
35.49
5.71
61.19
54.64
11.04
23.37


16.22
11.48
6.48
1.55
0.78
3.39
11.82
17.96
15.76
11.02
6.12
6.12

```
SHELL ELEMENTS  N=num_shell

   n,ni,nj,nk,nl   T=ti,tj,tk,tl   M=matl   V=v3x,v3y,v3z   D=cd   F=if     \
             O=ofx1,ofy1,ofz1,ofx2,ofy2,ofz2,ofx3,ofy3,ofz3,ofx4,ofy4,ofz4  \
             G=n1,n2,…,n7

   num_shell = Total number of shell elements [1]
   n       = Shell element number
   ni      = Node number for node I
   nj      = Node number for node J
   nk      = Node number for node K
   nl      = Node number for node L
   ti      = Thickness at node I
   tj      = Thickness at node J
   tk      = Thickness at node K
   tl      = Thickness at node L
   matl    = Concrete property number
   v3x     = Global coordinate x of local vector for modulus of elascticity E1.
             Modulus of elasticity E2 is normal to E1.
   v3y     = Global coordinate y of local vector for modulus of elascticity E1.
             Modulus of elasticity E2 is normal to E1.
   v3z     = Global coordinate z of local vector for modulus of elascticity E1.
             Modulus of elasticity E2 is normal to E1.
   cd      = Casting date (days)
   if      = Creep integration type [3]
   ofx1    = Global coordinate x of offset of node I
   ofy1    = Global coordinate y of offset of node I
   ofz1    = Global coordinate z of offset of node I
   ofx2    = Global coordinate x of offset of node J
   ofy2    = Global coordinate y of offset of node J
   ofz2    = Global coordinate z of offset of node J
   ofx3    = Global coordinate x of offset of node K
   ofy3    = Global coordinate y of offset of node K
   ofz3    = Global coordinate z of offset of node K
   ofx4    = Global coordinate x of offset of node L
   ofy4    = Global coordinate y of offset of node L
   ofz4    = Global coordinate z of offset of node L
   n1      = First element in generation sequence
   n2      = Last element in generation sequence
   n3      = Shell element number increment
   n4      = Node i increment
   n5      = Node j increment
```

FIGURE 7 – Shell Element block data structure for .INP fle