July 2, 2009

Here is some communication with a colleague from NASA concerning:
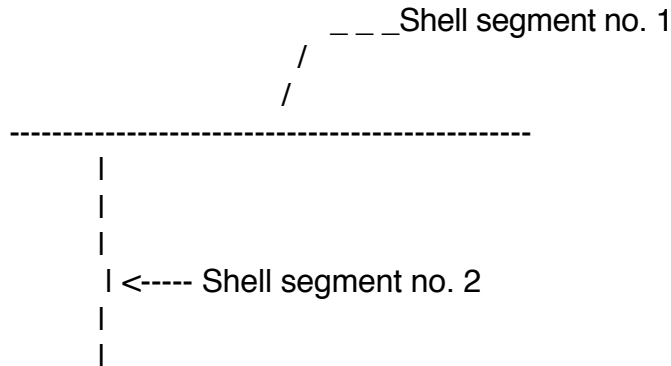**1. shell segment input for BOSOR4, BIGBOSOR4, and BOSOR5, and**
2. varying nodal point spacing within a given shell segment
3. very short shell segments with too many nodal points.

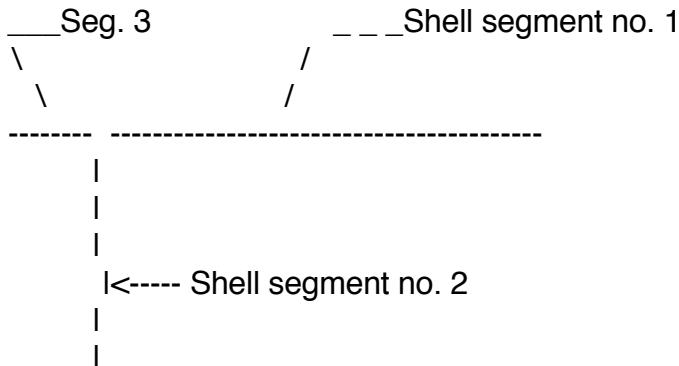This communication resulted from a BOSOR5 case that bombed.

ITEM 1: Shell segments in a BOSOR4 or BIGBOSOR4 or BOSOR5 model

Dear Colleague,

Here's a suggestion: Suppose you originally have two shell segments that meet at some internal nodal point of one of the segments. See the sketch:

```
                     _ _ _Shell segment no. 1
                 /
               /
----------------------------------------------
        |
        |
        |
        | <----- Shell segment no. 2
        |
        |
```

Segment 2 is joined to an internal point in Segment 1. You can always get the correct location of the connection of Shell segment no. 2 to Shell segment no. 1 if, instead of using two shell segments, you divide the same geometry into three shell segments, as in the sketch below:

```
   ___Seg. 3                _ _ _Shell segment no. 1
   \                     /
     \                 /
    --------  -----------------------------------------
          |
          |
          |
          |<----- Shell segment no. 2
          |
          |
```

ITEM 2: Varying nodal point spacing within a BOSOR4 or BIGBOSOR4 or BOSOR5 shell segment:

While I was investigating the case, I discovered that many of the segments in your case have variable nodal point spacing along the shell segment meridian. The way in which the variable mesh point spacing was done in your case is not recommended. If you want to vary the nodal point spacing within a shell segment, you should always do it as illustrated next.

Suppose you have a shell segment with 51 nodal points (NMESH = 51). Suppose you want to concentrate nodal points near one or the other end of that shell segment. Then you would provide the following input data, for example:

NTYPEH = 1
NHVALU = 4
IHVALU(1) = 1
IHVALU(2) = 25
IHVALU(3) = 26
IHVALU(4) = 50
HVALU(1) = 1.
HVALU(2) = 1.
HVALU(3) = 0.3
HVALU(4) = 0.3

or

NTYPEH = 1
NHVALU = 4
IHVALU(1) = 1
IHVALU(2) = 25
IHVALU(3) = 26
IHVALU(4) = 50
HVALU(1) = 0.3
HVALU(2) = 0.3
HVALU(3) = 1.0
HVALU(4) = 1.0

The following comments apply to the BOSOR4, BIGBOSOR4 and BOSOR5 input data just listed:

a. The nodal point spacing is at one constant level between nodal station 1 and 25 (including 25) and at another very different constant level between nodal station 26 and nodal station 50 (including nodal station 50, that is, the spacing between node point 50 and node point 51).

b. You don't have to supply the actual physical spacing values. Only the relative values are significant. BOSOR4 (BIGBOSOR4) and BOSOR5 figure out what the

actual physical nodal point spacings are later, once BOSOR4 or BOSOR5 knows what the arc length of the shell segment is. In the list above we have two sections of the shell segment. The nodal point spacing in the second section (with HVALU(3) and HVALU(4) = 0.3 in the topmost list) is three tenths the value of the nodal point spacing in the first section (with HVALU(1) and HALU(2) = 1.0). Whenever I have variable nodal point spacing (which I rarely do!) I always make the largest spacing equal to 1.0 and set the other smaller spacing relative to that largest spacing. Also, I **never allow the nodal point spacing to vary linearly over a range of nodal point numbers within a given shell segment**. In the two lists above the nodal point spacing abruptly changes from one value between nodal points 25 and 26 to another very different value between nodal points 26 and 27. The nodal point spacing remains constant elsewhere along the shell segment. This arrangement leads to favorable rates of convergence with increasing nodal point spacing.

c. What should never be done is the following, for example:

NTYPEH = 1
NHALU = 2
IHVALU(1) = 1
IHVALU(2) = 50
HVALU(1) = 1.
HVALU(2) = 0.3

The above input (which I should have made illegal) causes the nodal point spacing to vary linearly between the beginning and the end of the shell segment. The reason that this should never be done (or that the nodal point spacing should never be made to vary linearly over a range of nodal points within a given shell segment) is that it gives rise to **very** slow convergence of the results with respect to nodal point density in the shell segment. I notice that in your BOSOR5 case there are many nodal point spacings of the type listed under Item 3 above. Nodal point spacings of these types should be eliminated from your case and any other cases in which they occur. AS A GENERAL RULE, USE MORE SHELL SEGMENTS EACH WITH CONSTANT NODAL POINT SPACING RATHER THAN HAVE TO VARY THE NODAL POINT SPACING WITHIN A GIVEN SHELL SEGMENT.

ITEM 3. Very short shell segments with too many nodal points.

I plotted out your BOSOR5 model and noticed that there are many shell segments in it that are small, some of them very small indeed, compared to others. In many of these small segments you use more nodal points than is necessary, I think. If you expect displacements, strains, etc. to vary significantly over these very short shell segments, then thin shell theory may not apply and you may have to use solid finite elements rather than using BOSOR4 or

BIGBOSOR4 or BOSOR5 to solve the problem.

I'm not inclined to re-establish IFACT as an input quantity in either BOSOR4 or BOSOR5. (Note: IFACT used to be an input variable in very early versions of BOSOR4 and BOSOR5. IFACT had to do with the locations of the "extra" nodal points that BOSOR4, BIGBOSOR4, and BOSOR5 automatically add at each end of each shell segment.) I think you'll be okay in your use of BOSOR5 if you don't use too many nodal points in very short shell segments. As a guideline, don't use more nodal points than a number that corresponds to a nodal point spacing equal to about one-half the shell wall thickness. If you need more than that to obtain a converged result it means that thin shell theory is probably not good enough to solve your problem; you need to be using solid finite elements for that problem. The main reason I don't want to re-establish IFACT is that if I did, everyone's present input for BOSOR4 (BIGBOSOR4) and BOSOR5 would no longer work. Also, IFACT is kind of opaque. It isn't the kind of input datum an engineer or researcher should have to deal with.

Other comments about the same case

I eliminated the varying nodal point spacing everywhere (I think) and reran your case. I left the number of nodal points in each of the 24 shell segments, NMESH (i), i = 1,24, unchanged. The case then ran to completion, no "blowing up" of the solution. I didn't pin down exactly which of the shell segments caused the solution to "blow up". I suspect it was one of the very small segments, one which formerly had varying nodal point spacing. If you have a very small shell segment with quite a few nodal points, and over part of that shell segment the smallest nodal point spacing is much smaller than the largest nodal point spacing in that segment, and at the end of that very small segment an extra node is inserted by BOSOR4 (BIGBOSOR4) and BOSOR5 that is spaced 1/20th of the distance between the second-to-last and the last node, then you could, I suppose, run into numerical difficulty related to very, very small differences between large numbers. Something like this could have caused the "blow up". In addition to eliminating the variable nodal point spacing everywhere, I also changed the strain allowable, EPSALW (or whatever the spelling is) in each of the 24 shell segments and I changed WPRALL (the last line in the *.ALL file). I doubt if these last changes had anything to do with the modified case running successfully.

With best regards, Dave (Bushnell)