

ANSYS PostProcessing: Full Graphics vs. PowerGraphics

Presented by:

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- Summary of Data Available on ANSYS Results File
- General PostProcessor Print/Plot Options
- Graphics Options – Full vs. Power
 - Summary of both methods
 - Nodal stress averaging
 - Effect of /EFACET
 - Effect of AVPRIN
 - Listing Results
 - Querying Results
 - Path, *GET Data
 - Section/Capped Plots
- Summary and General Guidelines

Summary of data available in the ANSYS results file:

- Displacements – component data for each node
- Element Solution Data (stress/strain)
 - Nodal data – stresses/strains at the corner nodes of the elements
 - extrapolated from integration points if no plasticity/creep using element shape functions (Sect 13.6 in theory manual)
 - **ERESX** command can be used to copy rather than extrapolate
 - copied from nearest integration point if any of the element's integration points undergoes active plasticity/creep
 - Integration point data (Element Table)
 - Surface stress/strain data (Element Table)
- Element data is stored in the element coordinate system for each element. Nodal DOF data is stored in the nodal coordinate system for each node.
- Data is transformed into current results CS for plotting and listing.
 - Default is **RSYS,0** – Global Cartesian

Plot/Print Options

- Nodal Solution (**PLNSOL**, **PRNSOL**)
 - Displacements, Averaged Nodal stresses/strains
 - Invariants computed based on averaged components by default. Use **AVPRIN** to change this.
- Element Nodal Solution (**PLESOL**, **PRESOL**)
 - Unaveraged Nodal stresses/strains
- Element Table Items (**PLET**, **PRET**) Note: some quantities are affected by **RSYS**, others are not.
 - Nodal stresses/strains
 - Surface stresses/strains
 - Centroidal stresses/strains

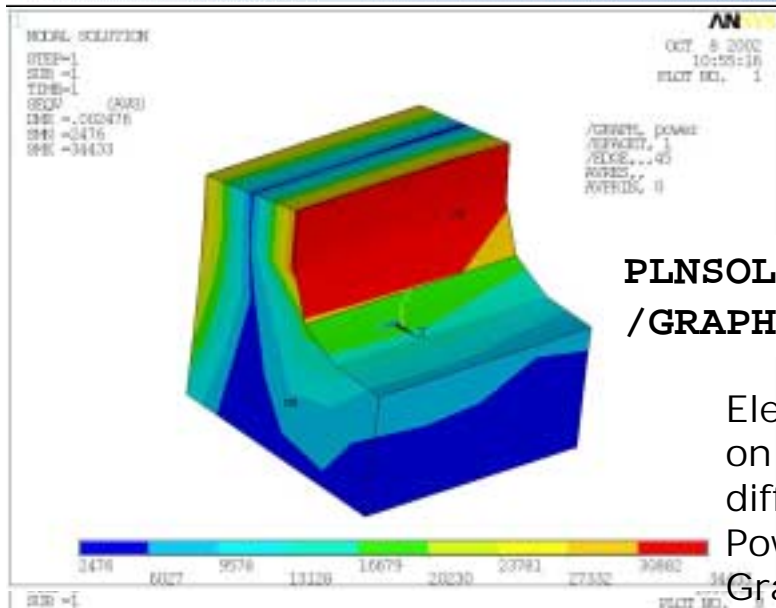
Full Graphics Summary – must be selected; not the default

- All selected elements are included in the results plot/printout.
- Only selected nodes are included in the averaging process.
 - No results plotted/printed at unselected nodes.
- Displacement data plotted/printed at corner and mid-side nodes.
- Stress/Strain data only at corner nodes.
- If average nodal solution is requested, data is averaged regardless of material, real constant, geometric discontinuities.
- Contours are determined via linear interpolation within each element based on the nodal values (averaged or non-averaged).
- Printout and graphics results are identical. Unique set of data at each node.

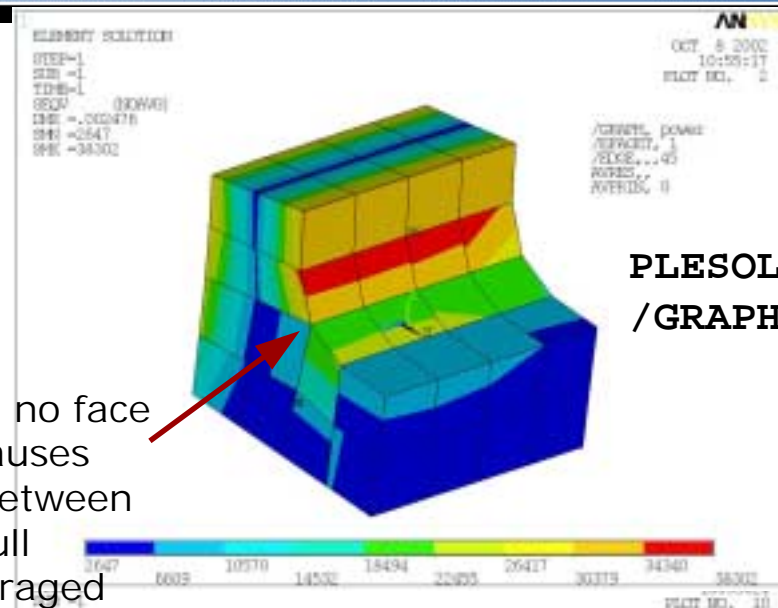
PowerGraphics Summary – default graphics setting

- Only selected elements with a face on the surface are included in the results plot/printout.
 - Can be modified by the **AVRES** command
- All nodes are included in plots/printout if they belong to the selected set of elements, regardless of whether or not they are selected.
- Displacement data plotted/printed at corner and sub-grid locations, depending on setting of **/EFACET**
- If average nodal solution is requested, data is NOT averaged across material and geometric discontinuities by default.
 - Geometric discontinuity is determined by **/EDGE**. Default setting is 45 degrees.
 - Can change averaging across material/real constant discontinuities using the **AVRES** command.
- Contours are determined via linear interpolation between each sub-grid (**/EFACET**) value (averaged or non-averaged).
- Printout and graphics results may be different at discontinuities.

Power vs Full Graphics PLNSOL and PLESOL

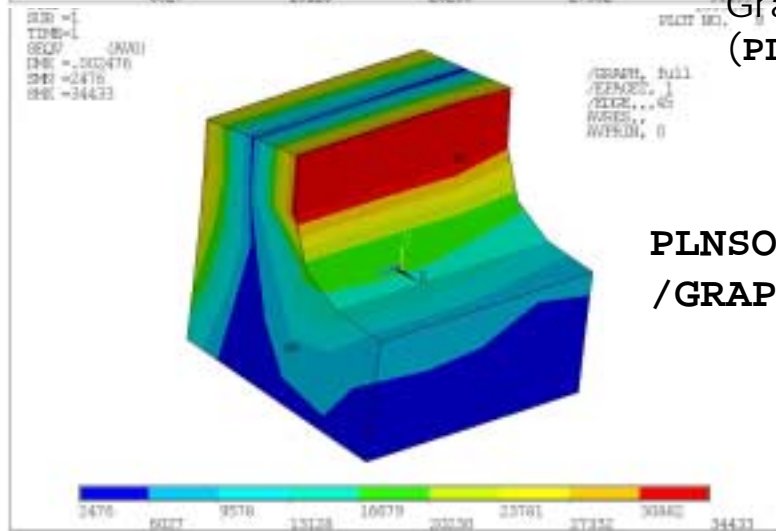


PLNSOL
/GRAPH, POWER

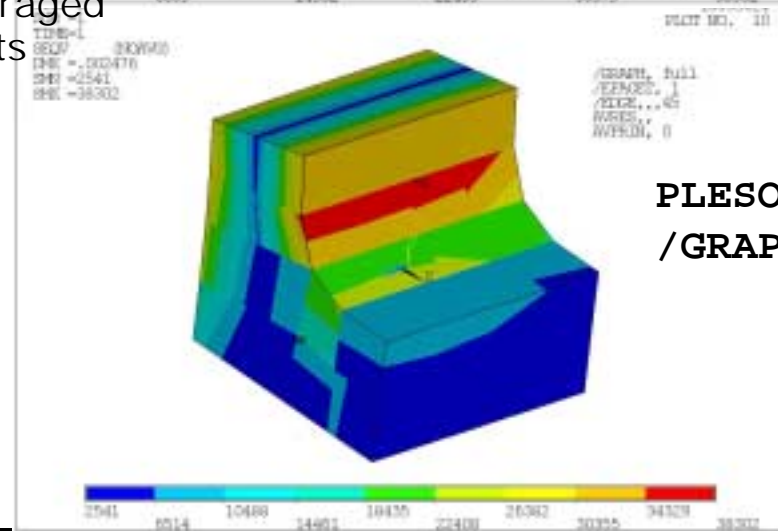


PLESOL
/GRAPH, POWER

Element with no face
on surface causes
differences between
Power and Full
Graphics averaged
(PLNSOL) plots

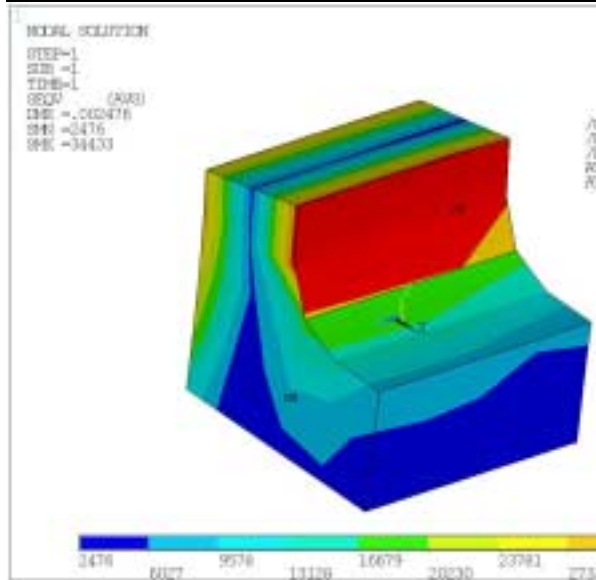


PLNSOL
/GRAPH, FULL



PLESOL
/GRAPH, FULL

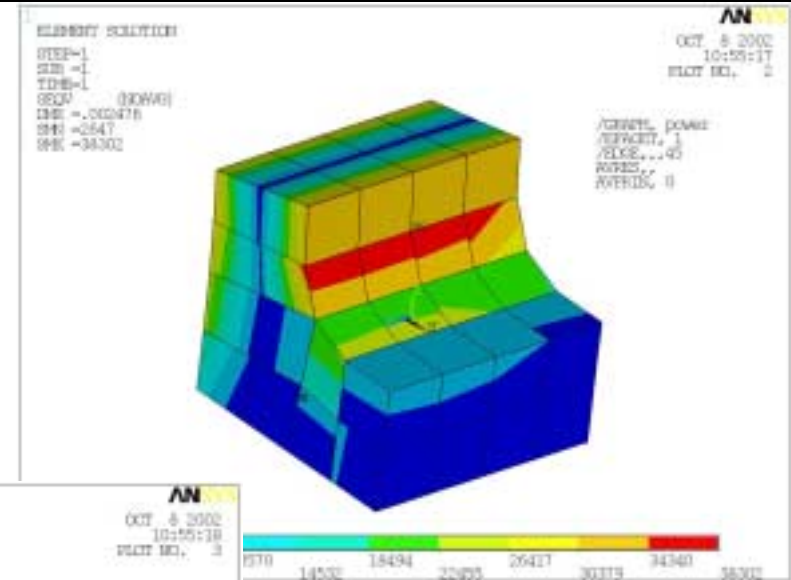
PowerGraphics Nodal Stress Averaging



AN
OCT 8 2002
10:58:16
PLOT NO. 1

/GRAPH, power
/EFACET, 1
/EDGE,,,45
/WRES,
/WPRIN, 0

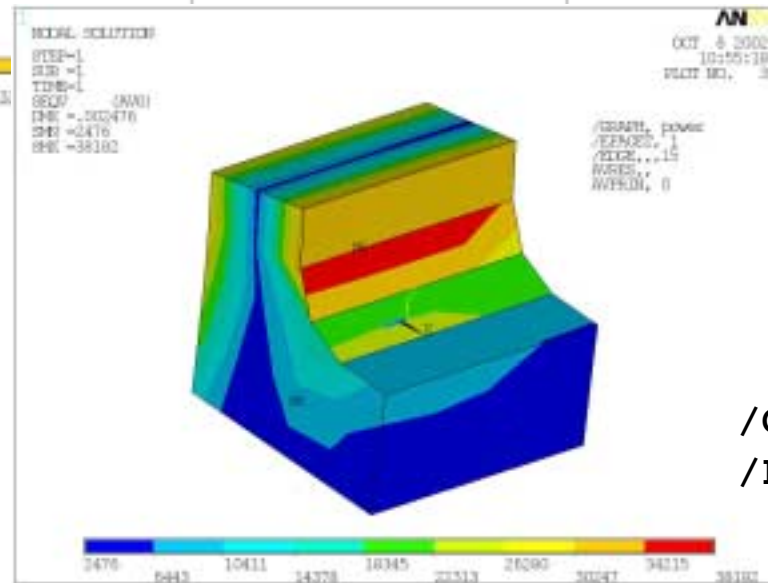
/GRAPH, POWER
/EDGE,,,45



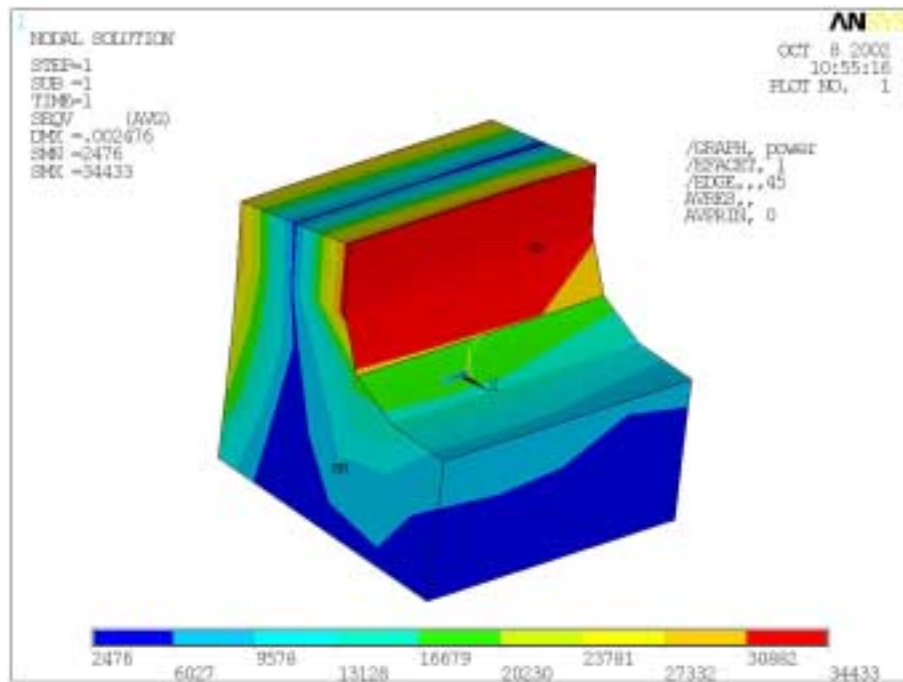
Unaveraged
(PLESOL)

PowerGraphics does not average across geometric discontinuities.

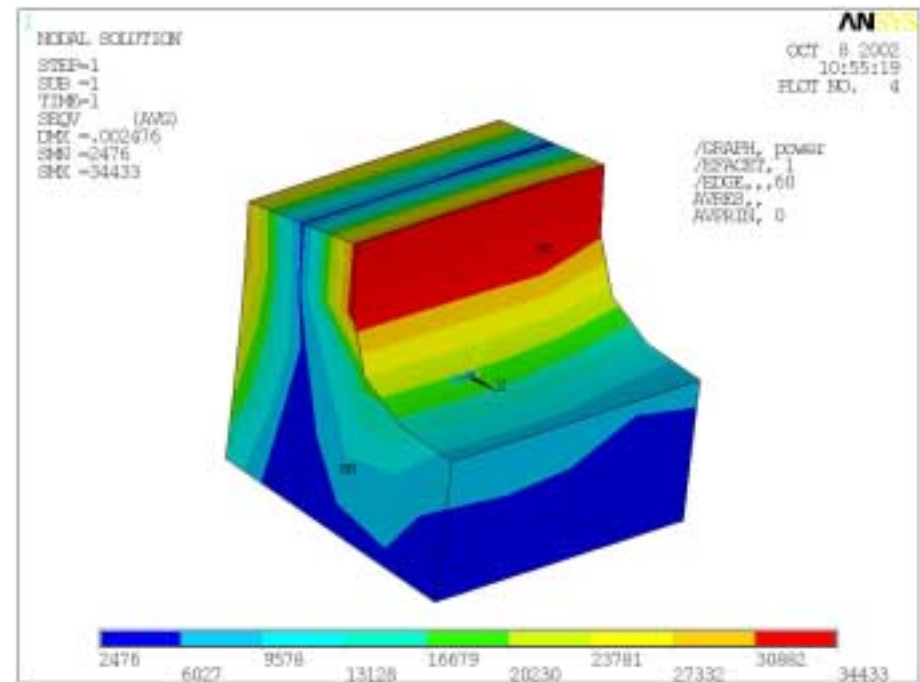
Geometric discontinuity is determined by **/EDGE** setting.



PowerGraphics Nodal Stress Averaging



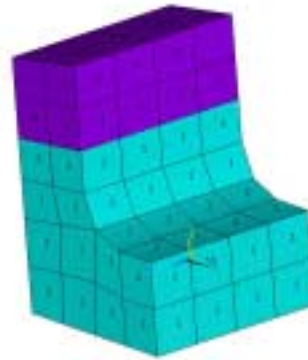
/EDGE,,,45



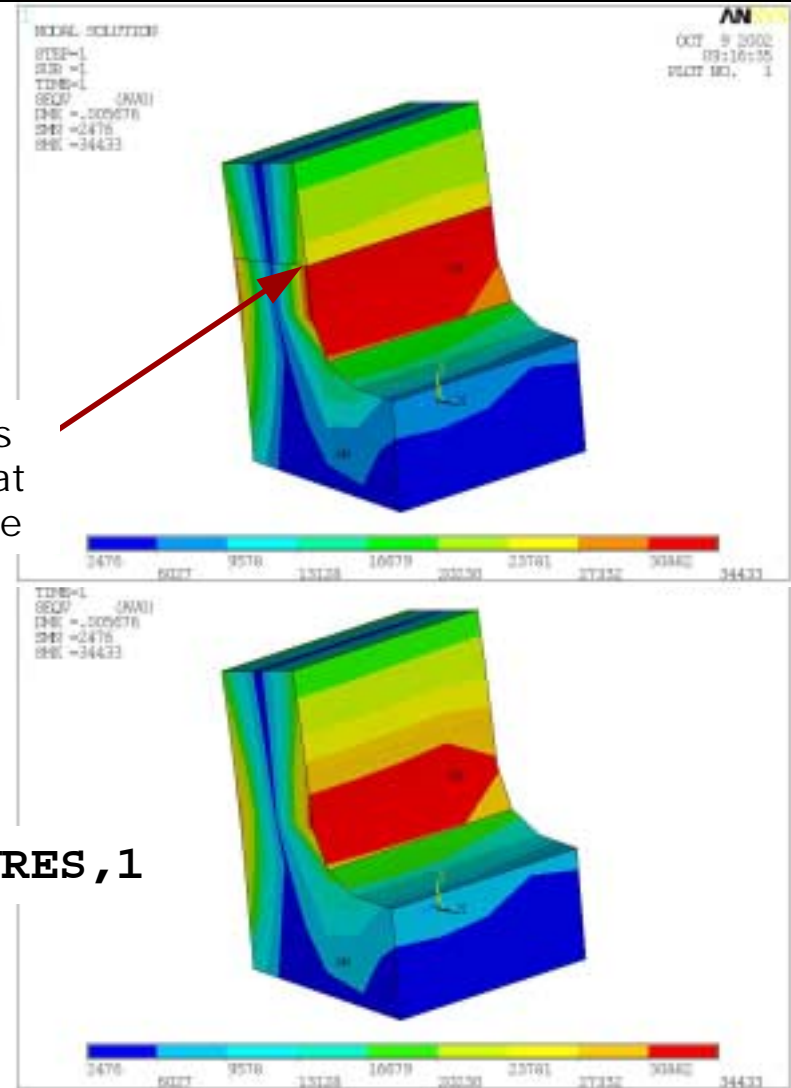
/EDGE,,,60

Max stress unchanged but contours near discontinuity change

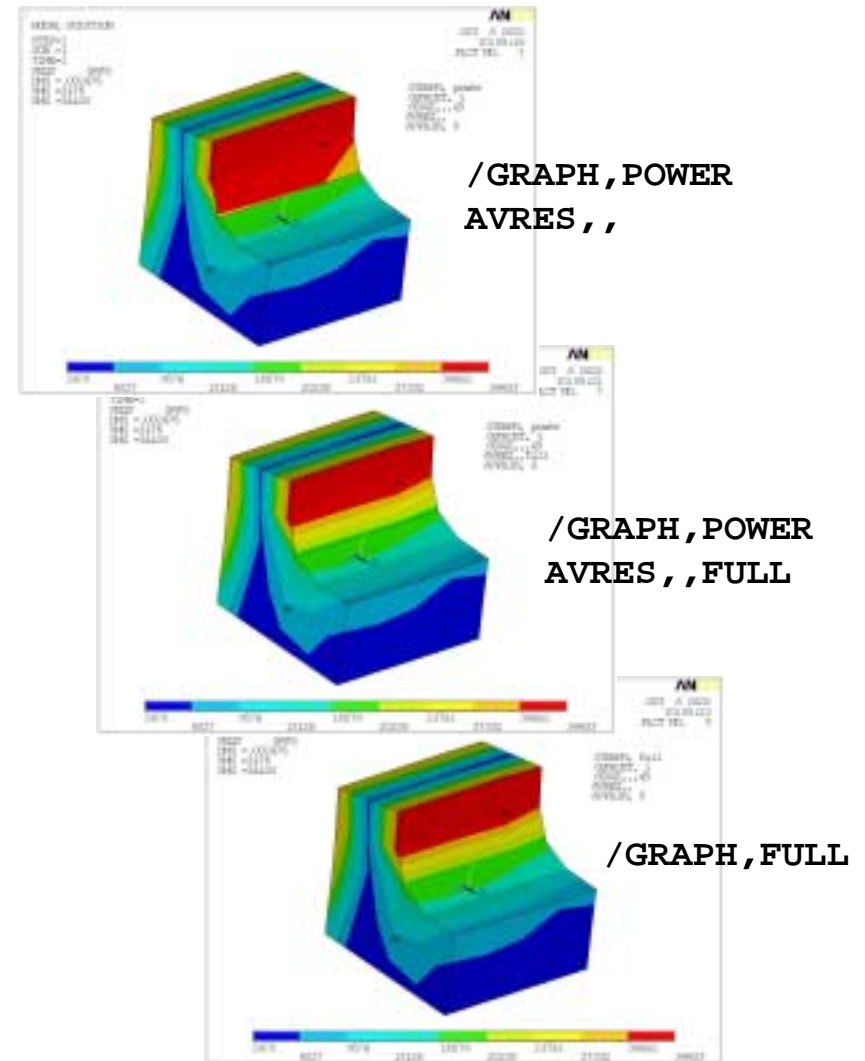
- By default, PowerGraphics does not average results across material discontinuities
- The **AVRES** command can be used to force averages across material and real constant discontinuities



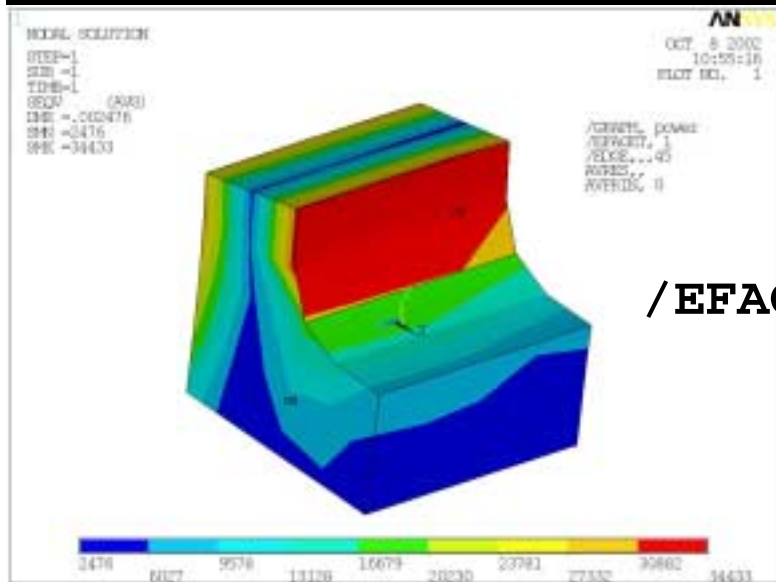
Stress contours discontinuous at material change



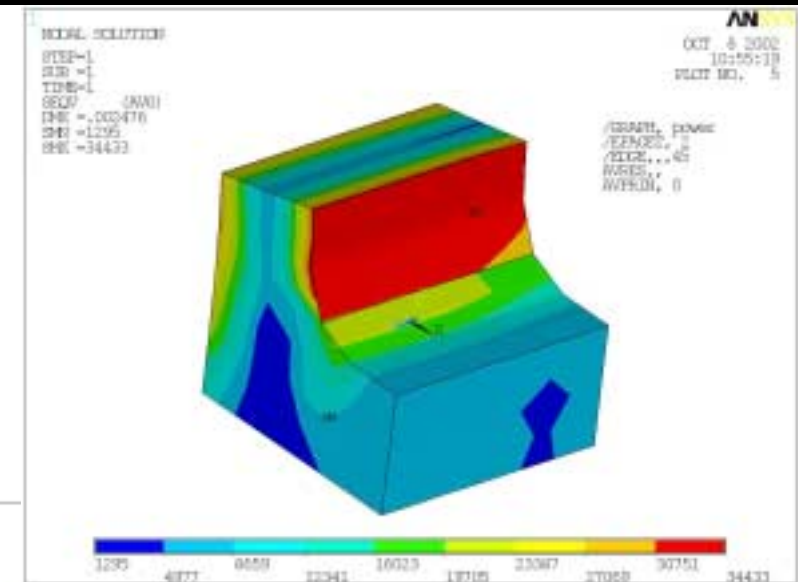
- The **AVRES** command can also be used to force PowerGraphics plots to use all of the elements rather than just the ones with faces on the surface for averaging.
(**AVRES** , , **FULL**)
- Averaging across material/real constants still controlled by first field of **AVRES**.
- **AVRES** , , **FULL** causes PowerGraphics to average across geometric discontinuities.



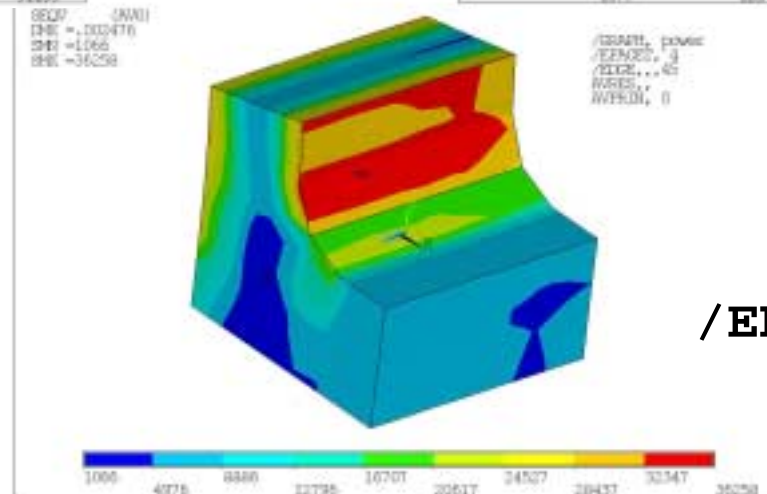
- **AVRES,1,FULL** will produce plots similar to Full Graphics for nodal solution:
 - Only difference is that results will be affected by **/EFACET** setting.
 - Setting **AVRES,1,FULL** and **/EFACET,1** will produce results identical to Full Graphics



/EFACET, 1



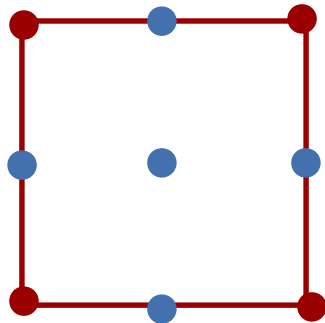
/EFACET, 2



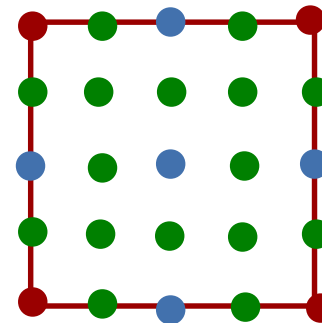
/EFACET, 4

- **/EFACET** can be used to plot results at “sub grid” points as well as the corners
- Only available for use with PowerGraphics

- **/EFACET, 2** will use the corner nodes and the mid points of each edge and face as sub-grid points at which to plot stresses. If it exists the mid-side node will be used as the sub-grid location. However, stress/strain results are just the average of the 2 corner nodes.
- **/EFACET, 4** will use the corners plus the mid and quarter points.



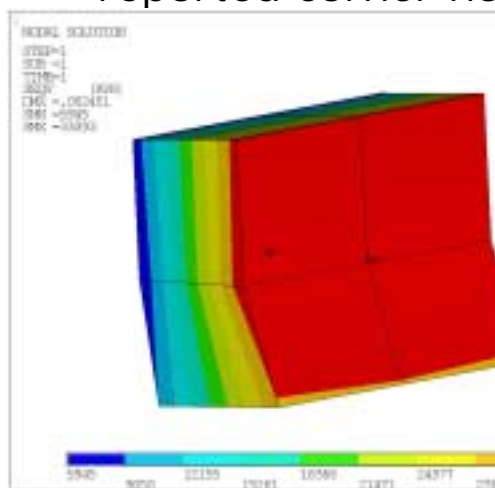
/EFACET, 2 sub grid points



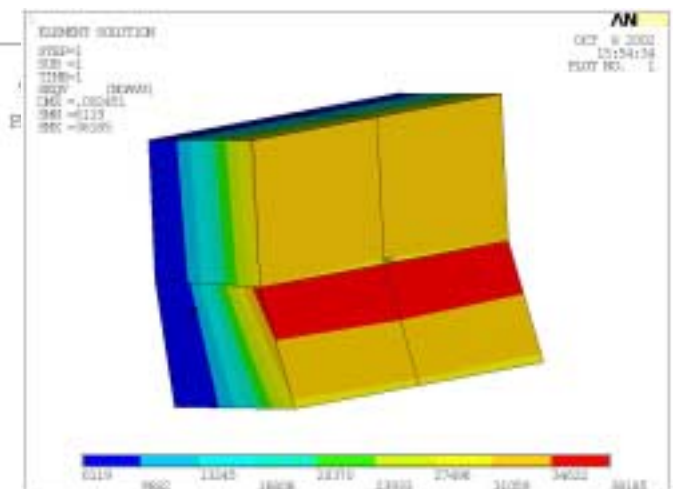
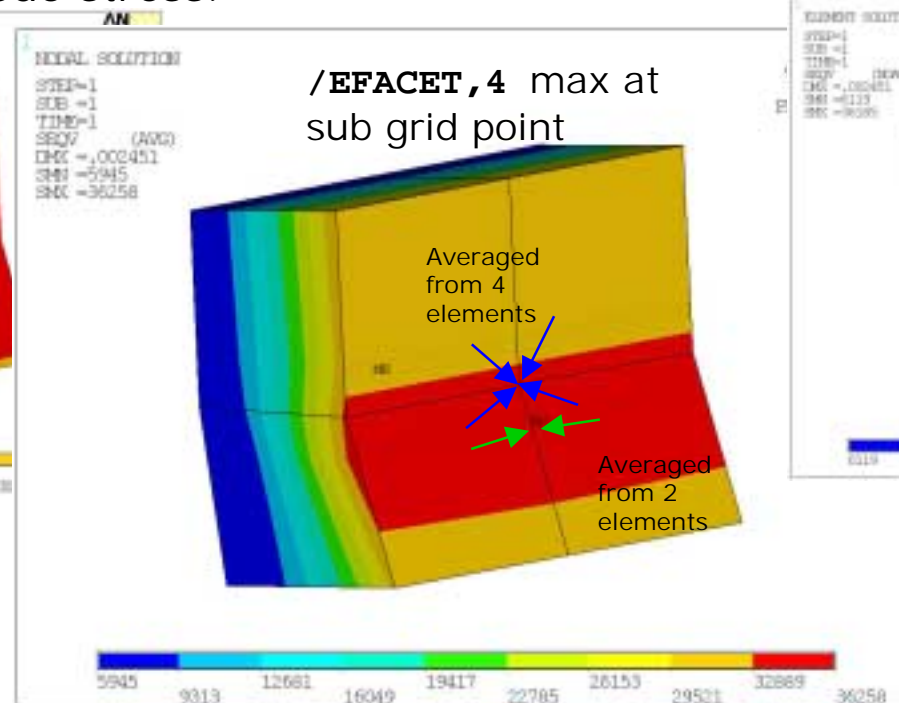
/EFACET, 4 sub grid points

Q: How can mid-nodes have higher stress than corners? Shouldn't it be a linear interpolation between the corner nodes?

A: It has to do with the nodal averaging. In this case the corner node results are the average of 4 adjacent elements. But the sub grid points are averaged from just 2 adjacent elements. Including the additional elements in the average may lower the reported corner node stress.

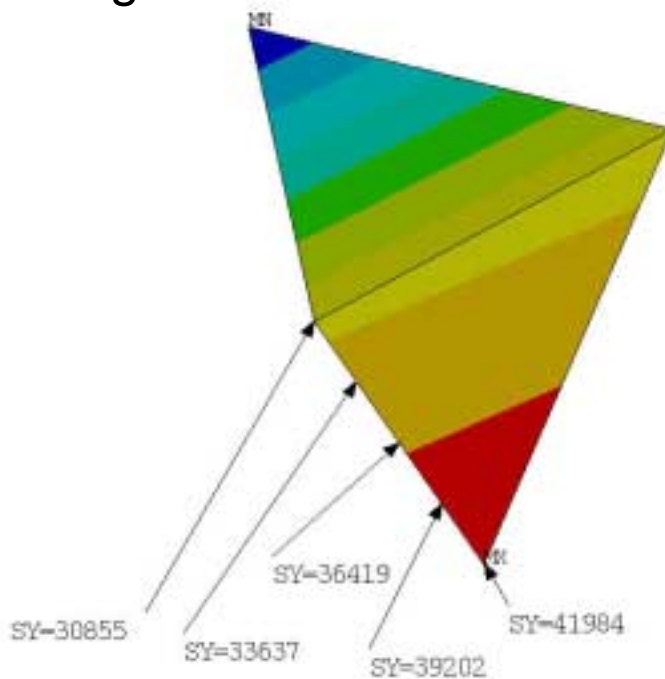


/EFACET,1 max at corner



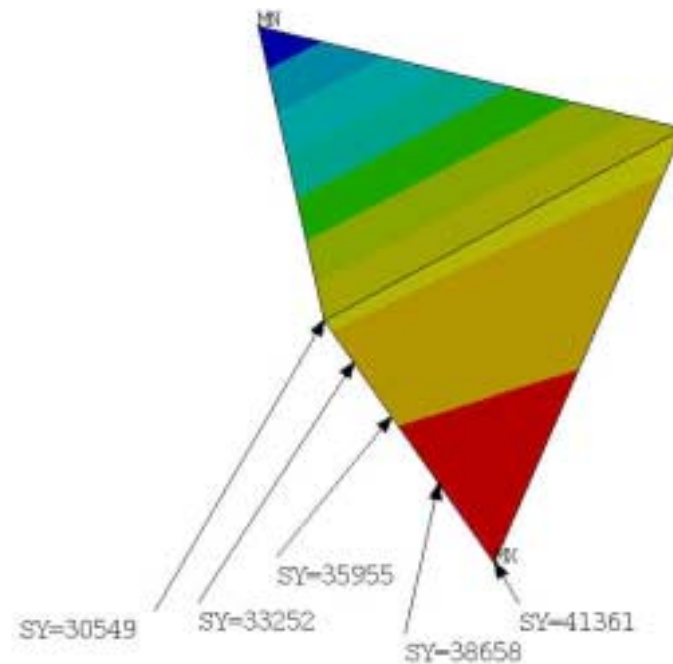
Unaveraged

- Stresses at sub-grid points are always the average of the 2 corner nodes, regardless of the mid-side node location. Quarter grid points are the average of the mid and corner points



Mid-node at mid point

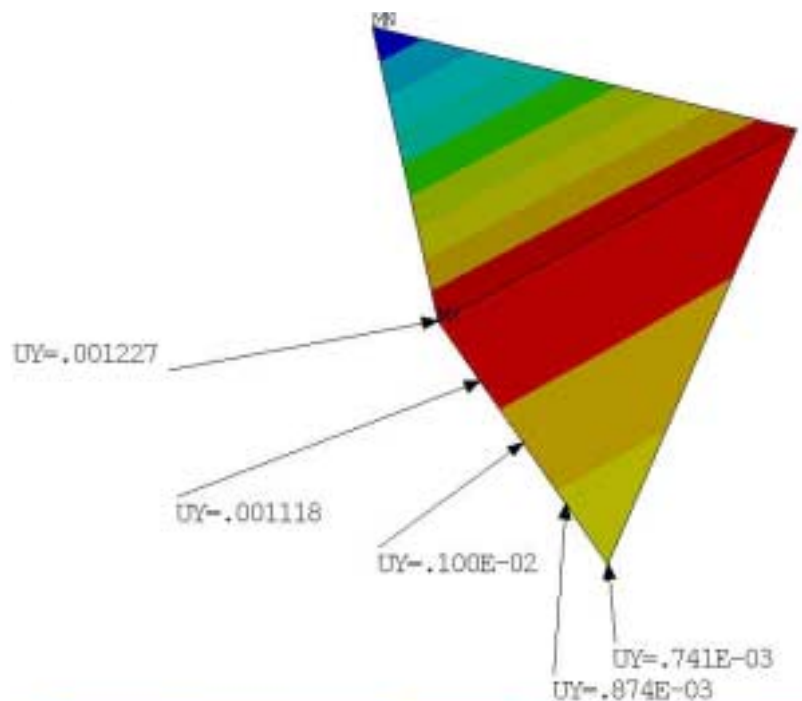
$$(41984 + 30855)/2 = 36419$$



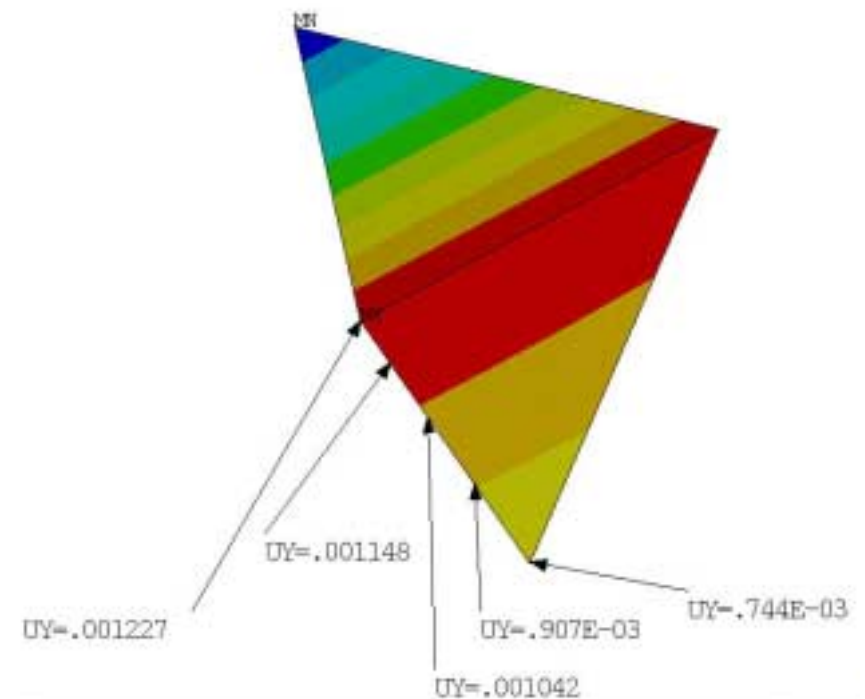
Mid-node shifted to 60% point

$$(41361 + 30549)/2 = 35955$$

- Displacements at middle sub-grid points use actual mid-side node displacements from the results file. Quarter sub-grid points use shape functions to calculate values



Mid-node at mid point



Mid-node shifted to 60% point

- The sub-grid (middle or quarter point) stress values are averaged from the corner values. This averaging is done in the global Cartesian system. Then the results are transformed into the coordinate system specified with RSYS.

- **AVPRIN** controls how the nodal averaged Stress/Strain invariants (S1, S2, S3, SEQV, etc) are calculated in Full Graphics mode.
- By default the stress/strain components are averaged at the nodes and then the invariants are recalculated from these averaged component values.
- **AVPRIN,1** forces ANSYS to average the invariants directly.
- The setting of **AVPRIN** only affects FULL Graphics. It does not affect PowerGraphics.

Full and Power Graphics AVPRIN setting

SEQV Plot

FULL Graphics

Max = 34433

Max = 35145

PowerGraphics

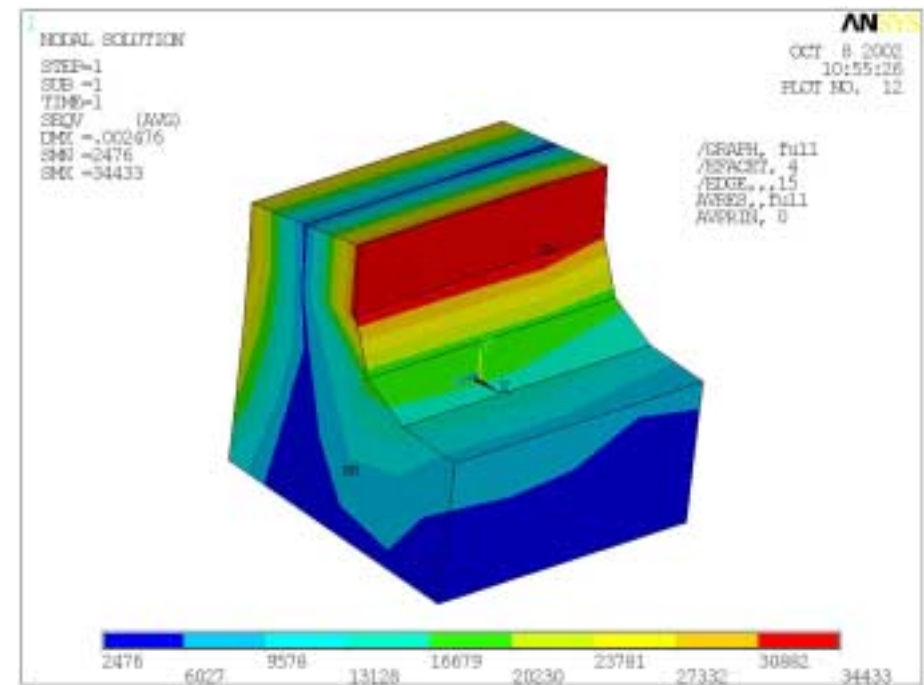
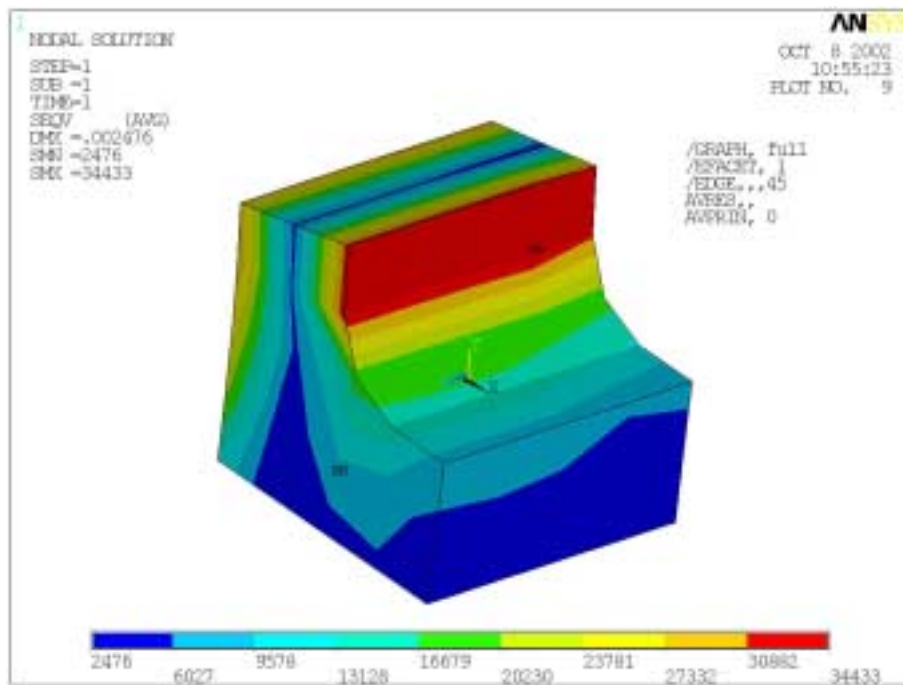
No effect

AVPRIN, 0

AVPRIN, 1

FULL Graphics Other Settings

- The other settings discussed have no effect on FULL Graphics plots



/EDGE

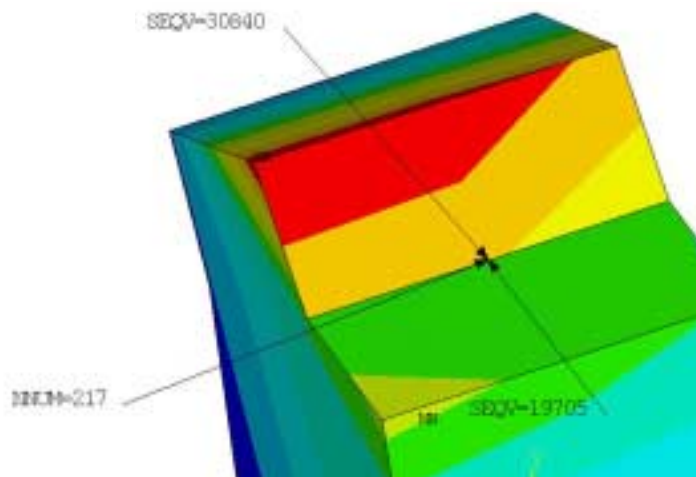
AVRES

/EFACET

No Effect on Full Graphics

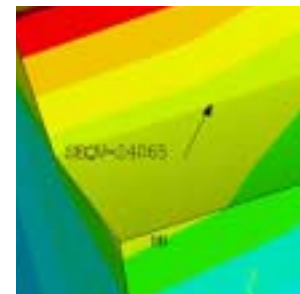
- Listing of results is also affected by the choice of Power vs. Full graphics as well as the other settings discussed.
- In general, nodal listings will list the stress/strains/displacements values the same way they appear in the plots.
- Exceptions are at geometric discontinuities with PowerGraphics
 - Since only one value can be listed per node, ANSYS will average the 2 or more values at a discontinuity and report the averaged value in a nodal listing.
 - Note: The invariants are averaged directly across the discontinuity (not recalculated). But parallel to the discontinuity the invariants are recalculated from the components.

NODE	S1	S2	S3	SINT	SEQV
216	30410.	8135.1	5720.6	24690.	23581.
217	31693.	8090.9	5104.2	26589.	25272.
218	24554.	4669.8	1956.0	22598.	21411.
290	5652.6	-1774.0	-6151.2	11804.	10335.



With geometric discontinuity
nodal stress at node 217 is listed
as $(19705 + 30840)/2 = 25272$

If geometric discontinuity
removed (/EDGE,,,60) then
SEQV=24065



Listing Results

- For material and real set discontinuities the listings contain a separate listing of results for each material

***** POST1 NODAL STRESS LISTING *****

PowerGraphics Is Currently Enabled

LOAD STEP= 1 SUBSTEP= 1
TIME= 1.0000 LOAD CASE= 0

NODAL RESULTS ARE FOR MATERIAL 1

NODE	S1	S2	S3	SINT	SEQV
1	2203.7	-579.66	-3784.9	5988.6	5190.6
2	2632.1	-214.96	-3599.9	6232.0	5403.8
3	892.74	-730.40	-4037.4	4930.2	4351.9
8	843.53	4.1223	-5524.9	6368.4	5993.0
9	10136.	483.56	-3439.0	13575.	12100.
10	6326.1	-768.30	-2919.8	9245.9	8379.9
11	4408.7	-455.19	-1553.0	5961.7	5495.7
70	35691.	6103.7	610.13	35081.	32682.
74	35452.	6037.3	352.54	35099.	32630.
78	35350.	5257.3	364.86	34985.	32814.
82	35342.	3668.8	741.13	34600.	33234.
83	32266.	2195.1	480.94	31785.	30964.

333 3555.3 87.600 -2540.4 6095.7 5295.7

***** POST1 NODAL STRESS LISTING *****

LOAD STEP= 1 SUBSTEP= 1

TIME= 1.0000 LOAD CASE= 0

NODAL RESULTS ARE FOR MATERIAL 2

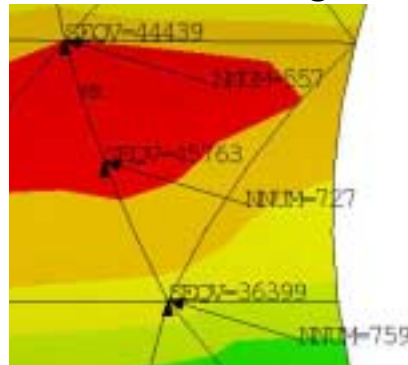
NODE	S1	S2	S3	SINT	SEQV
3	3030.8	297.95	-2519.4	5550.2	4806.8
4	2832.7	-106.63	-3278.9	6111.6	5294.1
5	3210.2	2.4382	-3398.2	6608.4	5723.9
68	19411.	1770.7	456.45	18954.	18333.
69	22709.	1979.9	-171.19	22880.	21884.
70	26149.	2811.8	-845.36	26994.	25364.
72	19356.	1752.1	384.85	18972.	18326.
73	22529.	1914.2	-343.77	22873.	21831.
74	25819.	2688.6	-1145.8	26965.	25267.
76	19371.	1649.0	440.76	18930.	18356.
77	22538.	1571.4	-295.37	22833.	21960.
78	25796.	1884.2	-1171.8	26968.	25577.
80	19320.	1444.0	532.07	18788.	18349.
81	22431.	851.35	-177.03	22608.	22112.
82	25498.	242.09	-1153.4	26651.	25981.
83	24772.	-257.29	-1207.4	25980.	25518.

Listing Results

- For Power Graphics, if **/EFACET** is set to 2 or 4 then the stresses/strains at the mid-side nodes are listed for higher order elements. No other sub-grid locations are listed.
- Stresses/Strains at mid-side nodes are never available with FULL Graphics.
- Nodal displacements are listed at mid-side nodes for both FULL and Power Graphics regardless of **/EFACET** setting.

```
/EFACET,4
/GRAPH,POWER
PRNSOL,S,PRIN
```

```
***** POST1 NODAL STRESS LISTING *****
PowerGraphics Is Currently Enabled
LOAD STEP=      1  SUBSTEP=      1
TIME=      1.0000  LOAD CASE=    0
NODAL RESULTS ARE FOR MATERIAL  1
```



NODE	S1	S2	S3	SINT	SEQV
556	45307.	3607.1	465.63	44842.	42256.
557	48164.	6355.4	1493.7	46670.	44439.
558	47474.	8561.4	3350.4	44123.	41762.
...					
726	44631.	8100.3	3852.0	40779.	38829.
727	52098.	8318.8	4581.2	47517.	45763.
...					
757	51270.	13427.	5319.5	45950.	42481.
758	48176.	10817.	5385.6	42791.	40350.
759	42334.	6212.5	5663.8	36671.	36399.
760	3.1012	-10.219	-85.122	88.223	82.375

```
/EFACET,4
/GRAPH,FULL
PRNSOL,S,PRIN
```

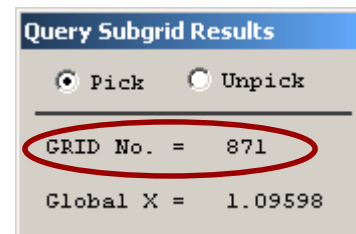
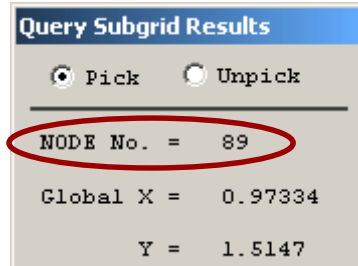
NOTE: node 727 not available in listing

```
***** POST1 NODAL STRESS LISTING *****
LOAD STEP=      1  SUBSTEP=      1
TIME=      1.0000  LOAD CASE=    0
```

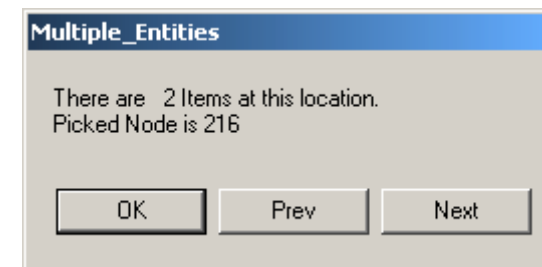
NODE	S1	S2	S3	SINT	SEQV
557	44593.	5348.6	1453.0	43140.	41330.
...					
721	13134.	-941.54	-2281.2	15415.	14791.
754	35395.	4673.2	3439.2	31956.	31357.
755	39958.	8053.5	4008.6	35949.	34107.
...					
758	40745.	8057.7	2681.7	38063.	25680.
759	34252.	3705.8	3231.5	31021.	30786.

- When performing a **NSORT** command. The data is always sorted (and listed) based on FULL graphics data. The **AVPRIN** setting is taken into account.
- After an **NSORT** command all subsequent **PRNSOL** listings will list FULL graphics data regardless of the **/GRAPH** setting until **NUSORT** is issued.

- The Query Results tool can be used to query the results by picking points on the model
- With PowerGraphics on, to query the nodal averaged results use the “Query Results > Subgrid Solu” option.
- Using /EFACET,2 or 4, all sub-grid points are available for querying. If the sub-grid point falls on a node, that node number is reported in the query box. If there is no node at the grid point then an arbitrary grid number is reported.



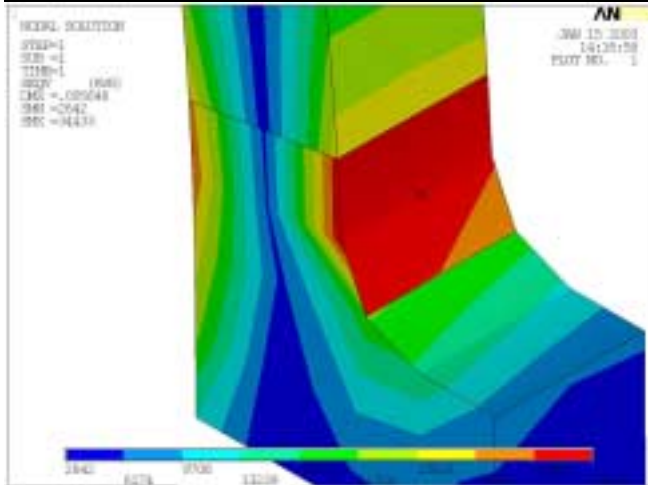
- When querying at a discontinuity an additional box pops up informing the user that multiple values exist for one point



- Both the PATH commands and the *GET and *VGET of nodal stresses (***GET,par,NODE,#,S,comp**) use the FULL graphics values.
 - *GET and *VGET will use the AVPRIN setting to calculate the invariant stresses
 - PATH commands calculate the invariants from the components regardless of the AVPRIN setting.
- *GET of the max value from the last plot (***GET,par,PLNSOL,,MAX**) will get the maximum value (**/EFACET** sub-grids included) from the last plot.
- **ETABLE** data is stored as one value per element so the **PLETAB** and **PRETAB** are unaffected by the **/GRAPHICS** settings.

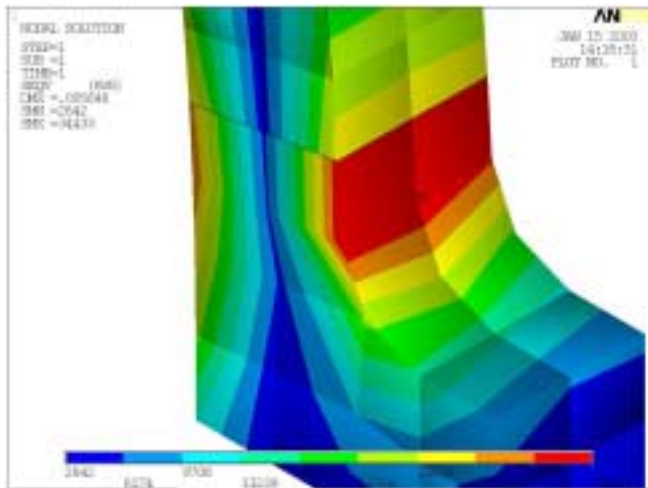
- Section type plots (Capped Z-Buffer, Q-Slice etc.) behave similarly to uncapped plots. Most of the time the results are the same unselecting the elements on one side of the slice
- One difference is in the `/EDGE,,,angle` which determines a geometric discontinuity.
 - After unselecting elements, if two adjacent elements have angle less than the `/EDGE` value then the results are averaged at the common nodes.
 - For a section plot the results are never averaged even if the slice is at an angle less than the `/EDGE` value.
- Another difference can be seen if `/EFACET` is greater than 1. Section plots use a slightly different average scheme than the non-section plots for the mid-side nodes.
 - Section plots average the unaveraged element data at each corner to get a mid-side node value for each element then these values are averaged together to get the final mid-side node value.
- Contour legends are always based on the whole model even if part is “sliced off” by the section plane. The contour legend may not correctly scale for the section plots (leaving gray areas) and therefore may need to be adjusted manually.

Section / Capped Plots

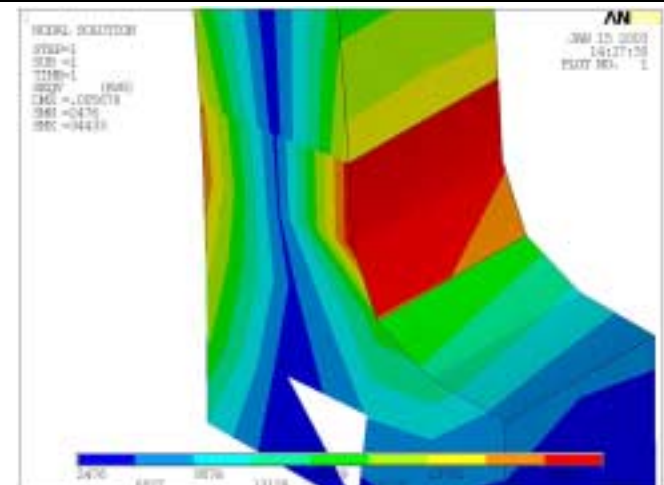


/EDGE,,,45

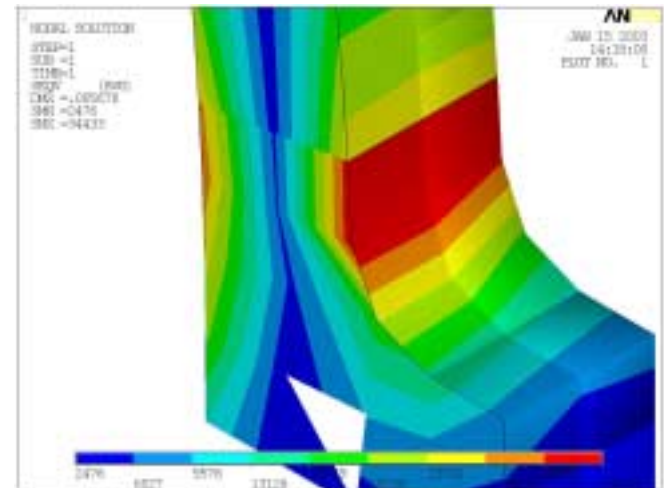
Z-Buffer plot (/TYPE,,6)
Elements on +Z side of WP unselected



/EDGE,,,91



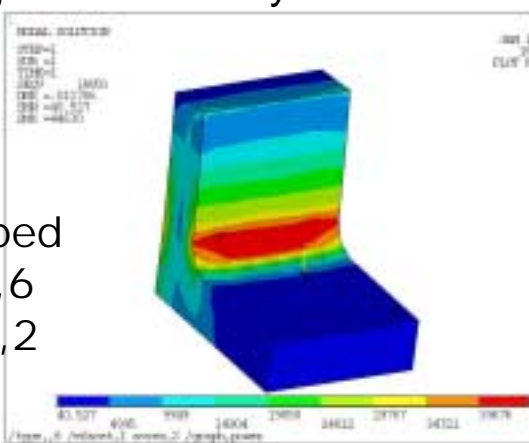
Capped Z-Buffer plot (/TYPE,,7)
All elements selected



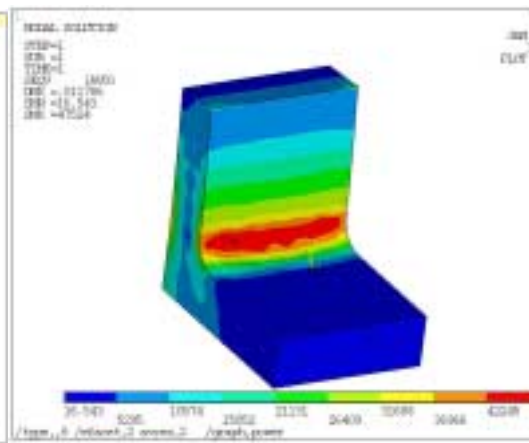
/TYPE,,6 vs /TYPE,,7 comparison

- Section plots with the Default AVRES settings produce the same plots as non-section plots, except the contour legend bands may not be calculated correctly and may need to be adjusted manually.

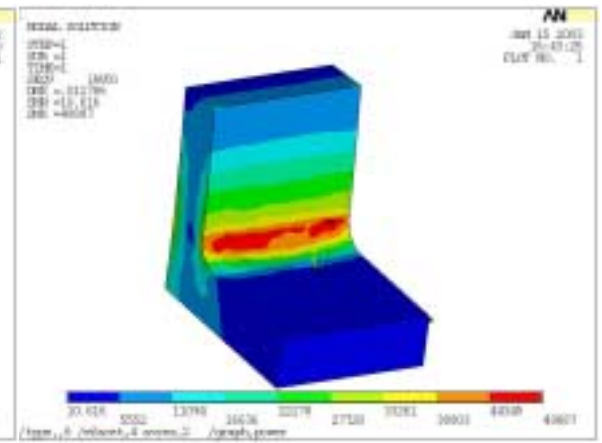
Uncapped
/TYPE,,6
AVRES,2



/EFACET,1

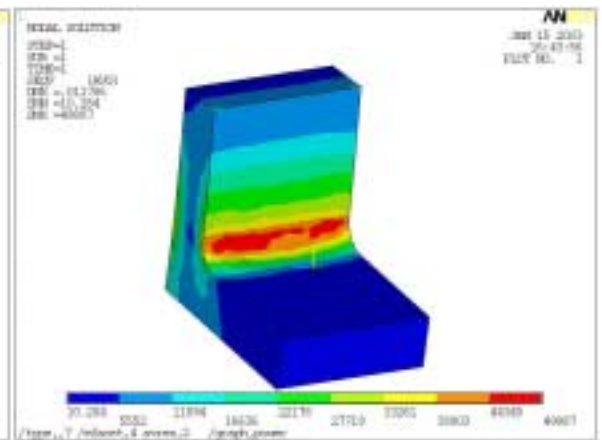
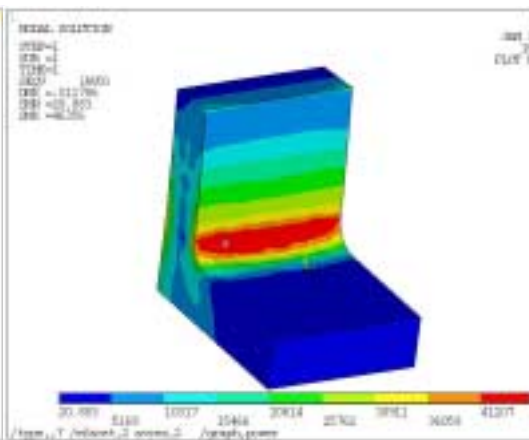
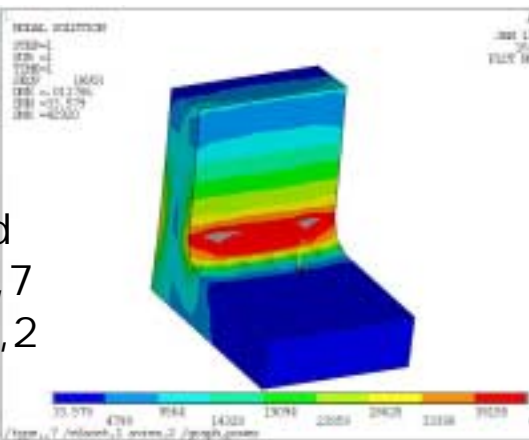


/EFACET,2



/EFACET,4

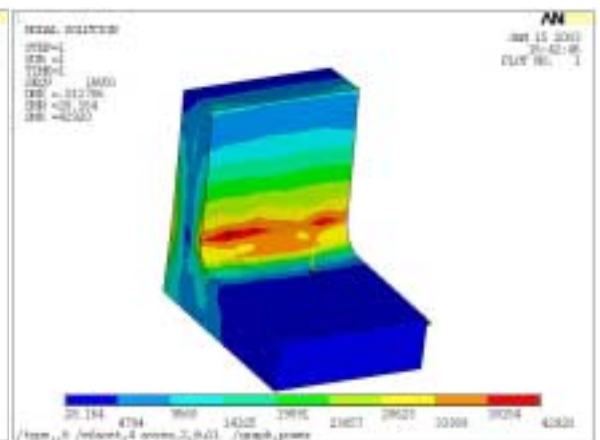
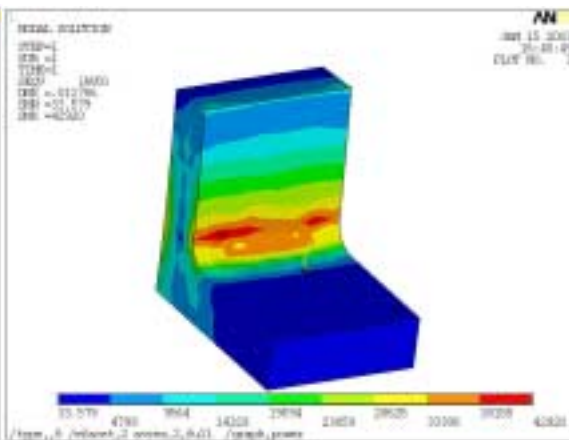
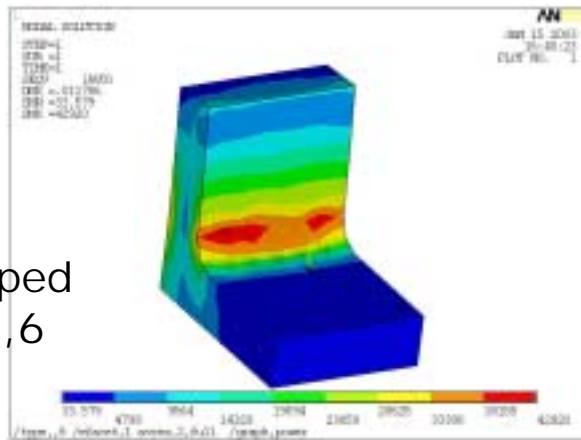
Capped
/TYPE,,7
AVRES,2



/TYPE,,6 vs /TYPE,,7 comparison

- Different averaging techniques cause differences in section vs. non-section plots with /EFACET set greater than 1

Uncapped
/TYPE,,6

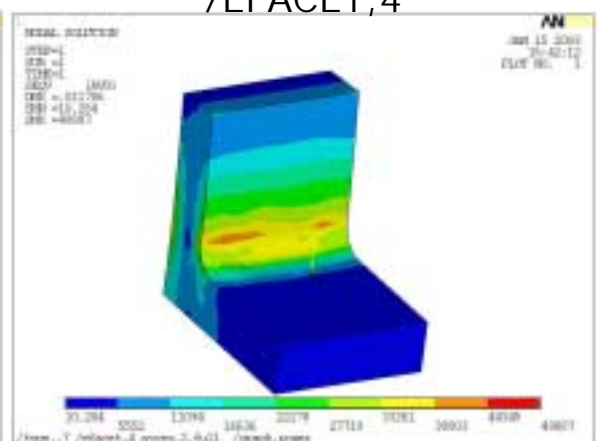
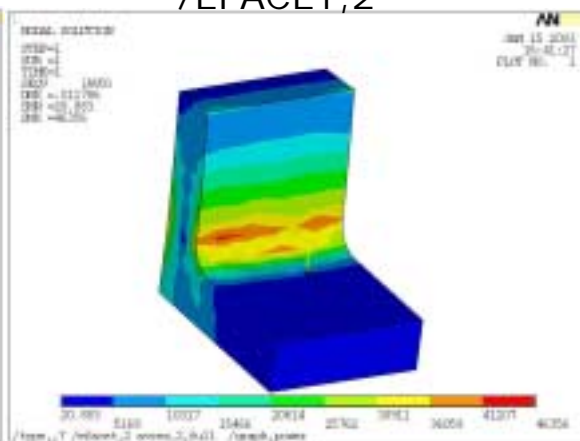
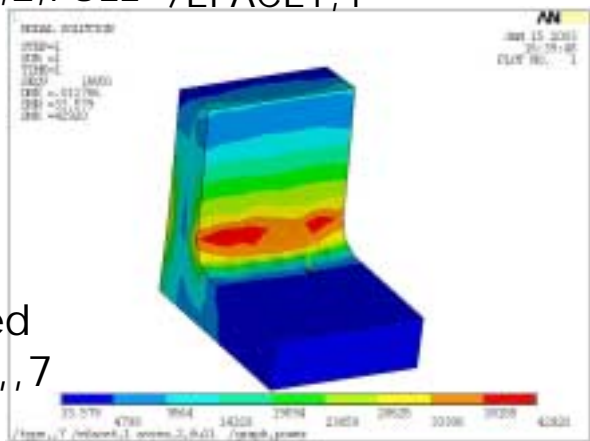


AVRES,2,FULL /EFACET,1

/EFACET,2

/EFACET,4

Capped
/TYPE,,7



- Unaveraged nodal stresses/strains (PLESOL) results will normally be unaffected by graphics setting. Exceptions are:
 - PowerGraphics will not produce PLESOL results for selected elements which do not have a face on the surface. Full Graphics always includes all selected elements. Effect of this is usually negligible as highest stresses usually occur on the surface.
 - You may see differences in PLESOL contour plots if /EFACET >0 and results are reviewed in a CS other than global Cartesian (RSYS,0). The reason for this is that the sub-grid results are first averaged in the global Cartesian coordinate system, and then the averaged results are transformed to the specified results coordinate system for plotting.

Settings Which May Affect Printed/Plotted Results

	AVPRIN	/EFACET	/EDGE	AVRES	NSORT
PowerGraphics		√	√	√	√
Full Graphics	√				

- Decision of which graphics option to use is not always clear
- PowerGraphics Advantages
 - Faster.
 - Plots quadratic surfaces.
 - Does not average across discontinuities .
 - Can plot shell top and bottom stresses simultaneously.
- Full Graphics Advantages
 - Affected by fewer settings. This means better repeatability from user-user.
 - Plotted results always match with printed results.
 - Results always match what is provided on the results file (no subgrid data interpolation).

- Generally speaking PowerGraphics will produce higher (more conservative) values than Full Graphics
 - Higher stresses are usually on the surface and PowerGraphics does not average in results from subsurface elements.
 - Does not average across discontinuities, which leads to more realistic plots (true discontinuities in stress and/or strain can exist at discontinuities).
- Choice of Full vs. PowerGraphics may also depend upon which results were used to correlate FEA results to test data for lifing/failure calculations.
- Large discrepancies between PowerGraphics, Full Graphics, or unaveraged nodal results in continuous regions indicates that the mesh is not fine enough. Neither value is likely correct.