APPENDIX A

USER MANUAL FOR DELAUNDO

DELAUNDO has two input files. First one is a control file with ".CTR" extension, which includes parameters that control orientation and number of unstructured grids. Second one is the geometry file with ".PTS" extension, and it includes the geometry data, i.e. coordinates of boundary points. These two files must be in the same directory with "DELAUNDO.exe".

A.1 Control File (CTR file)

A control file determines how DELAUNDO will treat the nodes read from the PTS file. In a CTR file, information is addressed by six-letter capitalized keywords. First, keyword is written and then in the next line its value is entered. DELAUNDO uses default values for parameters that are not included in control file. Keywords and their options are:

HELPME

The help menu will be called up at the beginning of program execution.

XAMPLE

The example menu will be called up and allows user to choose one of the examples.

RELEAS

It gives information about the current release.

VERBOS

This sets the verbosity. '0' gives no output at all, except for warnings and fatal error messages, '5' will give all important data in the progress of grid generation. Some of these are, time spent for each part of the triangulation process, number of elements of triangulation and etc. Default value is 3.

ALLPAR

If it is set to 't' or 'y', user will be prompted for all parameters that apply to current selections. Default is 'n' or 'f'.

INFILE

File name of the PTS file. The default is 'delaundo.pts'.

INFORM

The input file can be formatted by setting INFORM to 'y' or 't'; and unformatted by setting INFORM to 'n' or 'f'. Default is 't'.

NODEUS

Can be set to 't' or 'y'; this will make DELAUNDO use a given set of internal nodes. Note that only either of *NODEUS* or *NODECO* may be specified due to coding constraints. Default is 'f' or 'n'.

NODECO

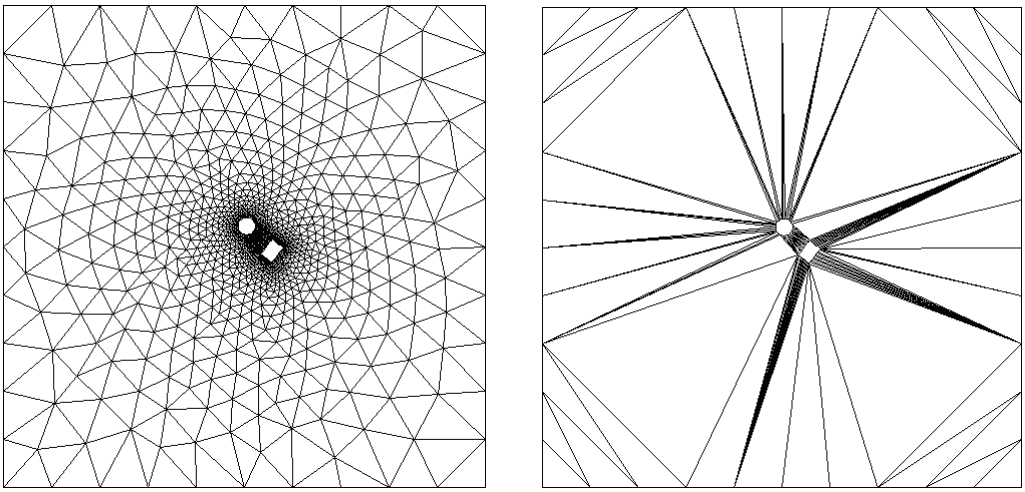
Can be set to 't' or 'y'; this will make DELAUNDO construct a set of internal nodes with the Frontal Delaunay method (Fig.A.1). Default is 't' or 'y'.

ASKROW

Can be set to 't' or 'y'; this will make DELAUNDO prompt the user for more rows to be constructed, once the current counts have been exceeded. Otherwise, the process will output the grid at the current stage. Default is 'f' or 'n'.

ANTICO

Can be set to 't' or 'y'; this will make DELAUNDO use the "anti-connectivity-information" specified in the PTS file. Default is 'f' or 'n'.



(a) (b)

Fig. A.1 Preview of initial grid by *NODECO,* a) *NODECO* off, b) *NODECO* on.

ALLDIS

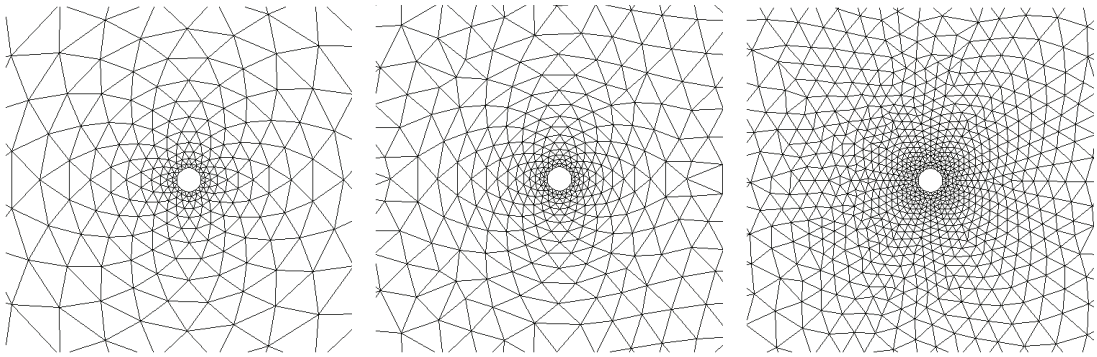
Can be set to 't' or 'y'; this will make DELAUNDO remove all edges in the background grid that connect non-consecutive boundary nodes, even if they reside on the same boundary segment. Use it with discretion as this might lead to many extra nodes needed for the disconnection of close surfaces.

SPCRAT

This floating point value specifies the ratio between the spacing gradients at the points of highest and lowest spacing Values higher than one will cause DELAUNDO to interpolate with a power law to extend the regions of fine spacing further into the domain (Fig.A.2). Default is 1.

DTOLER

This floating point value specifies the fraction of the background mesh size that is being used as a minimum distance between nodes. Default value is .65.



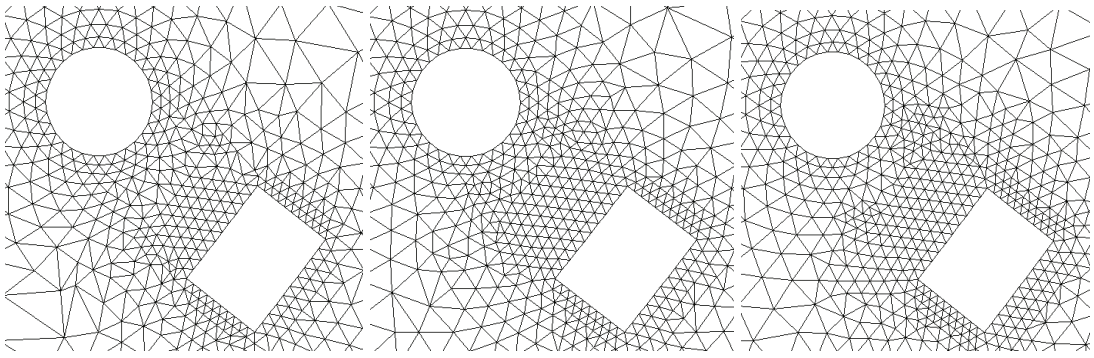
(a) (b) (c)

Fig. A.2 Effect of *SPCRAT* on unstructured grid generation. a) *SPCRAT* = 0.4, 373 nodes, b) *SPCRAT* = 1, 516 nodes, c) *SPCRAT* = 4.0, 1029 nodes.

QTOLER

This floating point value specifies the minimum fraction of the maximum side length that the smaller sides must have in order to make the triangle acceptable. Default value is .65

This parameter is another critical parameter that influences the grid quality. By setting different values to *QTOLER* between 0.5 and 1.0, different grid systems can be obtained (Fig.A.3). The result is more obvious at the mid-sections of different inner boundaries.



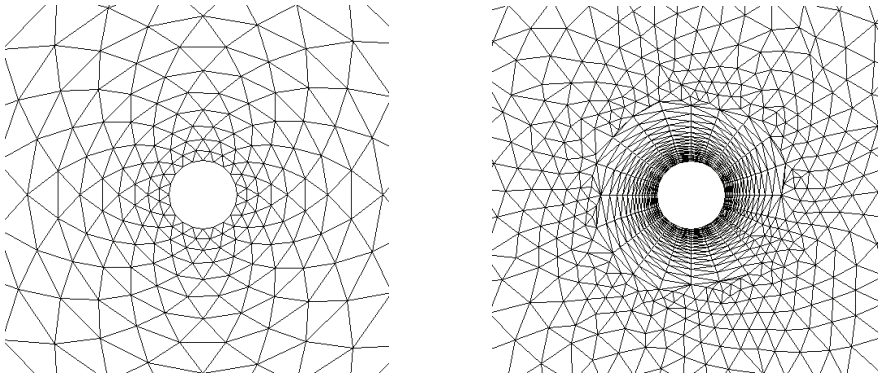
(a) (b) (c)

Fig. A.3 Effect of *QTOLER* on unstructured grid generation. a) *QTOLER* = 0.5, b) *QTOLER* = 0.80, c) *QTOLER* = 0.95.

STRETC

Can be set to 't' or 'y'; this will make DELAUNDO construct a layer of wedge type stretched triangles in form of rectangular boxes around frontal surfaces. Default is 'f' or 'n'.

Actually, this option enables to form a structured grid region around the inner boundaries, but the grids are still triangular. Using this option creates hybrid grid systems made up of both structured and unstructured triangular grids can be generated (Fig.A.4). Setting a stretched layer around the inner boundary can be useful in order to demonstrate a viscous region where smaller grid is required in order to achieve a better solution.



(a) (b)

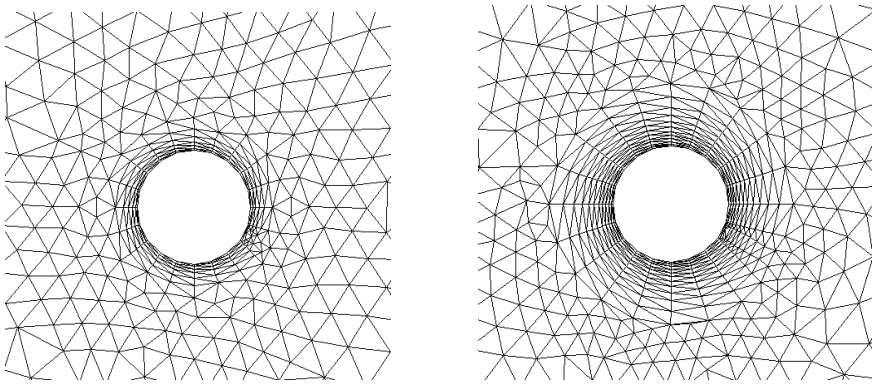
Fig. A.4 Effect of *STRECT* on unstructured grid generation,
a) *STRECT* off, b) *STRECT* on.

BTOLER

This floating point value specifies the minimum fraction of the background mesh size that is being used as a minimum distance between nodes in the background grid. Default value is 2.

DELTAS

This floating point value specifies the thickness of the stretched layer in the scale of the other points (Fig.A.5). IF *STRETC* is specified as 't' or 'y', this parameter is required.

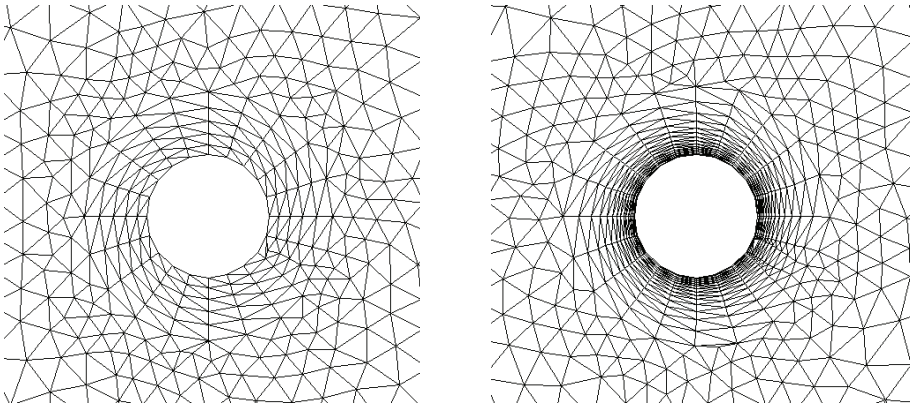


(a) (b)

Fig. A.5 Effect of *DELTAS* on unstructured grid generation,
a) *DELTAS* = 0.1, b) *DELTAS* = 0.2.

MAXASP

This floating point value specifies the maximum aspect ratio in the stretched layer. IF *STRETC* is specified as 't' or 'y', this parameter is required. Difference between the *DELTAS* and the Aspect Ratio is that *DELTAS* specifies the width of the stretched region, but the aspect ratio is the ratio between the width and the height of the triangles that forms the stretched region (Fig.A.6). In order to have a good grid quality, triangles must not have small angles at the corners. From the grid quality point of view, it may be necessary to use a smaller aspect ratio. But decreasing it results in less grid points inside the stretched region.



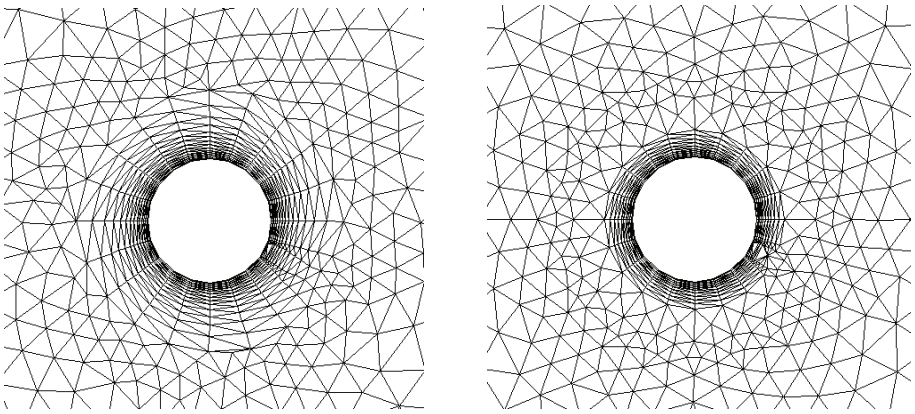
(a) (b)

Fig. A.6 Effect of *MAXASP* on unstructured grid generation,
a) *MAXASP* = 2.0, b) *MAXASP* = 20.

MVISRO

This integer value specifies how many stretched, viscous rows are to be built (Fig.A.7). If *ASKROW* is set to 't' or 'y', the user will be prompted for more rows. (Limiting the number of rows is to be considered a debugging tool.) Default is 30000.

It is important not to define a value for this parameter in order for the number of rows to conform to the stretched layer thickness defined by *DELTAS*.



(a) (b)

Fig. A.7 Effect of *MVISRO* on unstructured grid generation, a) *MVISRO* = (Default) 30,000, b) *MVISRO* = (Default) 10.

ISMOOT

This integer value specifies how many stretched rows of cells will be opened for isotropic re-triangulation once the stretched process has terminated. 0 does not allow any re-triangulation,

a) **1:** allows re-triangulation of the outermost cells,
b) **2:** allows re-triangulation of the neighbors of the outermost cells as well.

Note that whenever stretched layers from different geometry segments impinge on each other, the "sew-up" becomes more gentle with *ISMOOT* = 2. Default is 2.

MISORO

This integer value specifies how many isotropic rows are to be built. If *ASKROW* is set to 't' or 'y', the user will be prompted for more rows. (Limiting the number of rows is to be considered a debugging tool.) Default is 30000.

LAPLAC

If set to 't' or 'y', a Laplacian filter is applied to smoothen the mesh. Default is 'f'. Note that the applying the Laplacian to a stretched mesh will most likely fail due to mesh overlap.

RSWEEP

This integer value specifies the number of relaxation sweeps for the Laplacian. Default is 10.

LPBETA

This floating-point value specifies how much the weight of the grid points increases with increasing vertex degree. 0 means fixed weights, 1 is maximum variance. Default is 5.

RELFAC

This floating point value specifies the relaxation factor for the Laplacian. The stability limits are [0,1], default is 0.75

MLEVEL

This integer value specifies the number of multi-grid levels that are to be produced. The maximum permissible depth is 10, default is 1.

FLATSW

Set to 't' or 'y', this will make DELAUNDO swap diagonals in the final mesh in order to minimize the maximum angles. (Note that although the implementation is rather

efficient to prevent any N^2 worst case, it is supposed to be used only to correct cases where the stretched process has stopped before reaching isotropy and the isotropic process created flat cells.) Default is 'f','n'.

ANGMAX

This floating point value specifies the maximum tolerable cell angle before *FLATSW* kicks in (Fig.A.8). Note that this does not guarantee that all angles are below that value. A diagonal switch is not carried out if the maximum angle in the quadrilateral were to increase. So the optimum value must be found by trial and error. Default is 120.

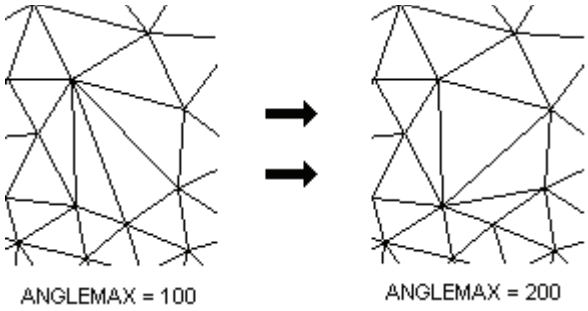


Fig. A.8 Effect of *ANGMAX* on the final grid connectivity.

MCYCSW

This integer value specifies how many swapping cycles will be executed. Default is 10.

OUTFIL

This string is the output file name. The default is 'delaundo.dpl'.

OUTTYP

This character determines the output type. Possible types are:

a) **'t':** the triangulation with the cells outside the domain removed.
b) **'q':** the triangulation of t, but with 6 nodes per triangle for quadratic elements.

c) **'h':** the convex hull with all the triangles. This is useful for creating a grid of scattered nodes for interpolation purposes or for debugging in case a boundary enforcement check fails.

d) **'b':** the background grid with the automatically added background nodes. Nodal values given are the node spacing as rho (1. state quantity) and the stretching magnitude multiplied by the spacing as rho*u (2. state quantity).

e) **'i':** the initial triangulation of the set of given nodes for debugging purposes. The default is 't'.

OUTFOR

This character determines the output format for special programs. It should be used only for DPLOT program; other programs are for other previous projects in which DELAUNDO was used recently. Possible formats are:

a) **'g':** a VKB .gri file with grid.

b) **'o':** a VKB .out file with grid and solution.

c) **'d':** a DPLOT file.

d) **'u':** a.ucd file.

The default is 'd'. Output of original DELAUNDO is modified so that besides the above mentioned output files, a TECPLOT file is also created, as described in Appendix B.

TITLE1,...,TITLE4

Here are the titles for the 'g' and 'o' output formats, as specified for *OUTFOR* parameter. Titles 2-4 apply only to 'o'. Default is ' '.

DOLOGF

Set to 't' or 'y', this will make DELAUNDO to write a log file. Default is 'f' or 'n'.

LOGFIL

This string is the name of the log file. Default is 'delaundo.log'.

ENDDAT

Any information after this keyword will be ignored.

A.2 Geometry Data File (PTS file)

A PTS file contains the geometry data, including the coordinates of initial boundary grid nodes. The geometry is split up in segments that are given by ordered sets of boundary nodes, preferably given with the domain to the left. Segments are connected to other segments at their ends, possibly themselves. The nodes where segments connect are listed for both segments.

The information in the formatted PTS files are read via, the familiar six-letter capitalized keywords. The information pertaining to a keyword follows the line[s] after the keyword.

The following keywords are known to DELAUNDO:

NEWBND

This opens a new boundary segment and closes the previous one (if there was). Any information pertaining to one boundary must be given before the next *NEWBND*, *INDEXY* or *ENDDAT* statement.

%

Comment sign. A line beginning with '%' is ignored.

NAMEBN

Each segment can receive a name which is an integer between 1 and 20. Segments are addressed with this name. If the name is omitted, the name defaults to the number of the boundary taken from the position in the PTS file, if this name is not yet taken. Otherwise, the first open name starting from 1 is selected. Note that, it is a bad practice to omit the name unless there are self-connected boundaries that carry no

anti connectivity information. In addition, user might run into trouble with a name that is chosen for a boundary that coincides with a name given by the program to a boundary that is listed earlier in the PTS file.

NRBNDE

The number of nodes found in the PTS file for this boundary is compared to this integer. A warning is issued if they do not coincide.

NFRSBN

The name of the boundary connected to the first node of this boundary. If *NFRSBN* is omitted, the boundary is supposed to be linked to itself. *NFRSBN* is a little tricky for wake-type boundaries that are connected to a solid surface. By convention, for a 'counter clockwise' wake, i.e. *ITYPBN* = +4, *NFRSBN* is the boundary to the left of the juncture, as viewed from the wake. In this case, *NLSTBN* = 0. Note that, for reasons of keeping a simple data structure, wake-type boundaries may not be connected to other wake-type boundaries. They may only be left open, *NFRSBN* = 0, or connected to a solid surface at a junction of boundary segments at one of their ends.

NLSTBN

The name of the boundary connected to the last node of this boundary. If *NLSTBN* is omitted, the boundary is supposed to be linked to itself. In the case of *ITYPBN* = -4, *NLSTBN* is the boundary to the left of the juncture, as viewed from the wake. The limitations on the connectivity of wake-type segments are unchanged, naturally.

ITYPBN

It is an integer specifying the type of the boundary (Fig.A.9). Possible types are:

a) **1:** a frontal, enforced boundary. (wall boundary)
b) **2:** a non-frontal, enforced boundary. (outer boundary.)

c) **3:** a non-frontal, non-enforced set of nodes. (a set of interior nodes to be used when also constructing interior nodes. Note that as there is no nodal overlap due to connected segments, all nodes are used.)
d) **4:** a frontal, non-enforced boundary. (a wake. Note that as there is no nodal overlap due to connected segments, all nodes are used.)
e) **'9':** a boundary in the background grid. (can be used to change the spacing distribution.)

All boundaries with positive type have the domain to the left, the ones with negative type to the right. Default is 1.

MINRES

The minimum required resolution for this segment. The segment will not be coarser beyond this value. Default is 2.

ANTICO

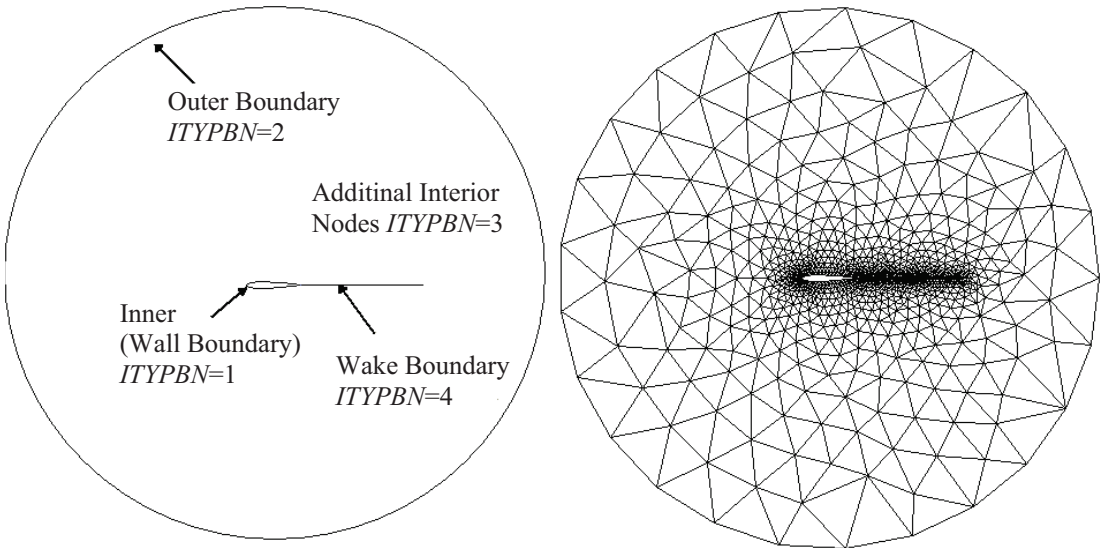
It sets the set of names of segments this one must not be connected to. Connection between mutual *ANTICO* boundaries will be removed by insertion of nodes with a spacing value extrapolated from the surfaces with an average gradient. This information is used only if *ANTICO* is set in the CTR file.

BNDEXY

The set of boundary nodes as *x,y* pairs.

NRINDE

The number of internal nodes found in the PTS file is compared to this integer. A warning is issued if they do not coincide. Note that *NRINDE* and *NRBNDE* are equivalent.



(a) (b)

Fig. A.9 Basic Boundary types defined by *ITYPBN*, a) Boundaries of the domain, b) Unstructured grid for flow around an airfoil and the wake behind it.

INDEXY

The set of boundary nodes as *x,y* pairs. An *INDEXY* statement opens a type 3 boundary that is a set of non-enforced foreground vertices. It is equivalent to specifying *ITYPBN* = 3 or *NFRSBN* = 0 or NLSTBN = 0. Every new *INDEXY* statement will open a new type 3 segment. The fact that all arrays pertaining to boundary vertices are only dimensioned for a small subset of all the vertices, which should not cause any trouble since these arrays are only invoked for the frontal process. That is, if there is large number of internal vertices, user should list them at the end after the boundaries with frontal character.

ENDDAT

Anything after an *ENDDAT* statement will be ignored.