BESO2D Manual – Command Line Usage

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The command line usage of the BESO2D is suitable for higher level users. The BESO2D engine, i.e. the core executable file "BESO.exe" which performs FEA and optimization can be run in the command line as a standalone program independent from the *graphic user interface* (GUI). The command line usage is especially useful when a large model is dealt with since the engine only executes the necessary actions (mainly number crunching) without intermediate designs displayed in the GUI window. More importantly, it allows the user to import an initial design created by a third-party program which might be more powerful in generating meshes than the BESO2D GUI. The format of the model file accepted by the BESO2D engine is simple and easy to understand. After an optimization run is complete, the user can view the final optimal design in the BESO2D GUI window by importing the design model file into the program and view the evolution history data stored in a text file "Result.txt".

1. Calling the BESO2D engine

An example of calling the BESO2D engine is given below.

    C:\BESO2D>BESO Model.txt Parameters.txt

The BESO2D engine runs with two arguments, i.e. the names of two text files: the model file of the initial structure and the parameter file that contains the BESO parameters. Note that BESO.exe should locate in the same folder with the two text files.

2. The model file format accepted by the BESO2D engine

In order to explain the format of the model file, a typical sample file is introduced below for a coarsely meshed model shown in Figure 1.

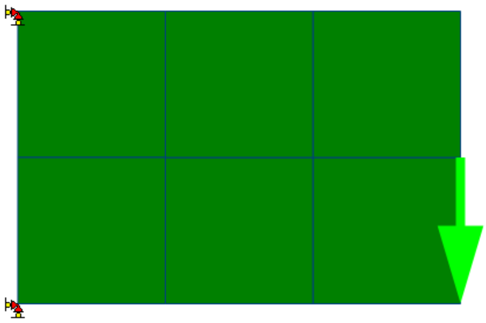

Figure 1 A coarsely meshed model for explaining the model file format.

```
-----Model file "Sample.txt" begins here-----
*model<Sample, 2, 1 >
*title< Sample model for manual >

*node< 1, 0, 3.5, 2.0, 0 >
*node< 2, 0, 4.0, 2.0, 0 >
*node< 3, 0, 4.5, 2.0, 0 >
*node< 4, 0, 5.0, 2.0, 0 >
*node< 5, 0, 3.5, 2.5, 0 >
*node< 6, 0, 4.0, 2.5, 0 >
*node< 7, 0, 4.5, 2.5, 0 >
*node< 8, 0, 5.0, 2.5, 0 >
*node< 9, 0, 3.5, 3.0, 0 >
*node< 10, 0, 4.0, 3.0, 0 >
*node< 11, 0, 4.5, 3.0, 0 >
*node< 12, 0, 5.0, 3.0, 0 >

*quad4< 1, 2, 2, 1, 2, 6, 5, 0 >
*quad4< 2, 2, 2, 2, 3, 7, 6, 0 >
*quad4< 3, 2, 2, 3, 4, 8, 7, 0 >
*quad4< 4, 2, 2, 5, 6, 10, 9, 0 >
*quad4< 5, 2, 2, 6, 7, 11, 10, 0 >
*quad4< 6, 2, 2, 7, 8, 12, 11, 0 >

*force< 1, 8, 0, 0, -100.0 >
*constraint< 1, 1, 0.0, 0.0 >
*constraint< 2, 9, 0.0, 0.0 >

*property<1, 210.0, 0.31, 7.8 >
*property<2, 210000000000.0, 0.31, 7800 >
*thickness<1.0 >
-----Model file "Sample.txt" ends here-----
```

In this model file, lines beginning with “*” are considered valid. Items in the model are expressed with specific tags that are identified by “*” followed by key words. The contents within “< >” that follows each tag are the accompanying parameters for the tags. Note that for tags with more than one parameter, the parameters are separated by “,”. The following eight tags are used for creating a complete model file.

- *model<model name, 1st reserved parameter (“2”), 2nd reserved parameter (“1”)>

  This tag provides the basic information of the model. The first parameter is the model name. The second and the third parameters are reserved and fixed as 2 and 1 as used in the above sample file.
- *title<title>

This tag gives further information about the model. The user may choose to input any text to describe the model.

- *node<node ID, coordinate system (“0”), X, Y, reserved parameter (“0”)>

  This tag defines a node. The first parameter is the node ID, the second parameter always takes the value of 0 indicating that the global coordinate system is used, the third and fourth parameters are the X and Y coordinates of this node. The last parameter is reserved as “0” and can be absent. Note that each node ID may only be used once and the IDs should be numbered with an increment of 1 for the whole model.

- *quad4< element ID, PID, reserved parameter (“2”), node 1, node 2, node 3, node 4, designability >

  This tag defines an element. The first parameter is the element ID. Similar to the node IDs, the element IDs must be defined sequentially with an increment of 1. The second parameter is the property ID, designating the material used (see the description for “*property” below). The third parameter is reserved and always takes the value of 2 as shown in the sample file. The next four parameters are the IDs of the four nodes of this element. The last parameter determines the design ability of the element, namely 0 for being designable and 1 for being non-designable. Note that the IDs of the four nodes in each element should be given in a counter-clockwise order, as shown in Figure 2.

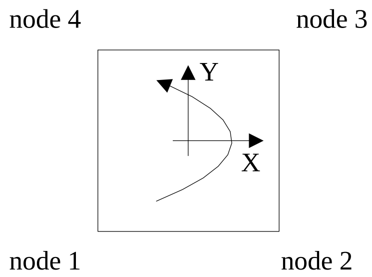

Figure 2 The order of nodes in each element.

- *force< force ID, node, coordinate system (“0”), X component, Y component >

  This tag defines a force. The first parameter is the force ID, the second parameter is the ID of the node where the force is applied. The third parameter always takes the value of 0 indicating the global coordinate system. The last two parameters are the X and Y components of the force.

- *constraint< constraint ID, node, X freedom, Y freedom >

  This tag defines a constraint. The first parameter is the constraint ID, the second parameter is the ID of the node where the constraint is applied. The last two parameters are the specified displacements in the X and Y directions. In two extreme cases where the specified displacement is “0.0” and “free”, it defines a fixed degree of freedom and a free degree of freedom, respectively.

- *property<PID, E, u, rho >

  This tag defines a material. The first parameter is the material ID (also known as property ID). The next three parameters are Young’s modulus, Poisson’s ratio and the mass density, respectively.

- *thickness< thickness >

  As plane stress conditions are assumed in BESO2D, this tag defines the thickness of the structure. Unit thickness will be assumed if this tag is absent.

Note that such a model file can also be exported by BESO2D GUI. Simply create a model in BESO2D GUI and then select the menu item “File → Export Model” to save the created model to a model file.

3. Format of BESO parameter file

A typical parameter file is given below.

-----Parameter file “Parameters.txt” begins here-----
*Model<Test>
*EvoVolRatio<0.02>
*FilterRadius<0.3>
*ConvTolerance<0.001>
*MaxIter<200>
*ObjVolFraction <0.6>
-----Parameter file “Parameters.txt” ends here-----

- *Model< model name >

  This tag specifies the model name of the structure to be optimized. The intermediate designs will be stored in files whose names are composed of the model name and a three-digit iteration number, e.g. the intermediate design of iteration 38 will be stored in a file named Test038.txt, if the model name of “Test” is specified.

- *EvoVolRatio< *ER* >

  This tag defines the evolutionary volume ratio. A typical value is 0.02 (i.e. 2.0%).

- *FilterRadius< $r_{\min}$ >

  This tag defines the filter radius. A typical value is two to three times of an element size.

- *ConvTolerance< τ >

  This tag defines the allowable tolerance error for convergence. A typical value is 0.001 (i.e. 0.10%).

- *MaxIter< maximum iteration number >

  This tag defines the maximum number of iterations.

- *ObjVolFraction < volume fraction >

  This tag defines the objective volume fraction of the final optimal design. Its value is between 0 and 1, e.g. 0.6 for 60% volume fraction.

4. Result file of an optimization run

After the optimization run is finished, a text file named “Result.txt” can be found in the folder where the BESO2D engine is. The sample result file is given below.

```
-----Result file “Result.txt” begins here-----
Bi-directional Evolutionary Structural Optimization:  BESO2D Version 1.0
Model: Test    Objective: Maximizing stiffness
Starting Date: 12/25/09   Time: 18:00:00
---------------------------------------------------------------

  Iter     VolFrac       mean Compliance         Time
  Start                                        18:00:00
     0    1.000000        2.058341E-007        18:00:02
     1    0.979620        2.058365E-007        18:00:03
     2    0.959640        2.058699E-007        18:00:05
     3    0.939660        2.059636E-007        18:00:07
     4    0.920080        2.061125E-007        18:00:08
     5    0.900899        2.063617E-007        18:00:10
    ……
    ……
-----Result file “Result.txt” ends here-----
```

The header before the separation line contains information such as the version of BESO2D engine, model name and the date etc. In this sample result file, the results of the first six iterations are presented below the header. Totally four columns of data are recorded: the iteration number, the volume fraction, the mean compliance and the finishing time. Each row records the above four data for one iteration.

If the user has any difficulties in obtaining or using BESO2D, or has queries about updates of the program, please contact us by email at the following address:

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