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REMOVE RIGID BODY MOTION

1. INTRODUCTION

The scope of this document is to explain how to load a model with enforced displacements obtained from other model.

In the first chapter, some generic topics of the SPCD are going to be discussed as well as how to use them correctly.

Finally, to summarize and understand how to remove the rigid body movement, an example is used. The process will consist on obtaining the displacements from one model, and applying them to another one.

2. SPCD AND THEIR USE

The SPCD defines an enforced displacement in the defined DOF. The SPCD must be selected by the LOAD Case Control command. Also the DOF used in the SPCD must be referenced in a SPC or SPC1.
An example of an SPCD card is displayed below.

```
SPCD    1       6015997 3       0.02217
```

In the previous example, a displacement of 0.02217 is imposed in the DOF 3 of the node 6015997.

Usually, SPCD are used in order to load a structure with the displacements obtained from another structure. This is quite normal when there are GFEM (Global FEM) and DFEM (Detailed FEM). For example, the GFEM can represent a whole aircraft while the DFEM can represent only a component of the aircraft such as a rib or any other component.

Since the displacements are obtained from the GFEM and used to load the DFEM, there will be a part of the displacement that it is not really necessary. That is, a displacement due to a rigid body movement. However that displacement is not useful to obtain stresses and therefore, it is not useful for the analysis process.
But apart from not being useful, this kind of displacement can lead to low quality results. To see it, please, see the following figure.

Figure 1: Enforced displacement example

In the previous figure, the displacements can be quite similar due to the rigid body motion. The previous component has approximately 1000 mm of rigid body motion which can imply, as a consequence, a lack of accuracy losing some important digits due to truncation of results if eight characters are used on the fields of the NASTRAN cards. This process is complex if the rigid body movement contains rigid body rotations.

Due to all the previous reasons, it is important to remove this kind of displacement before loading a structure.

3. PATRAN UTILITY AND EXAMPLE

The best way to see how to remove the rigid body movement is with an example.
In this example, the GFEM is a fuselage as the one shown below:

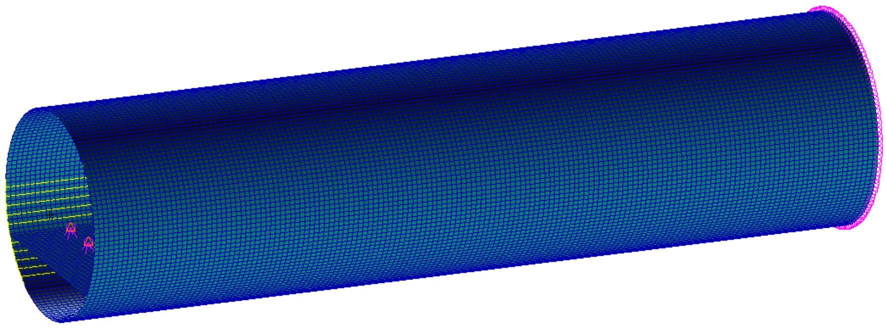

Figure 2: GFEM fuselage

And the DFEM which has to be loaded with enforced displacements is displayed in the following figure. It is a panel of the fuselage.

REMOVE RIGID BODY MOTION

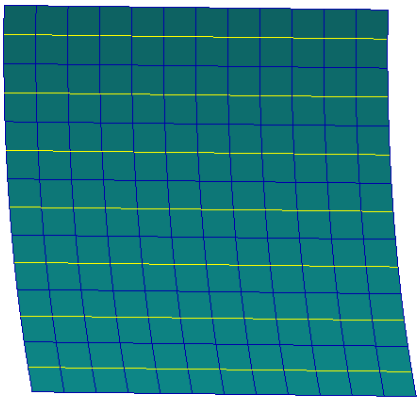

Figure 3: DFEM model

The position of the DFEM in the GFEM can be seen in the following figure in which both models are joined.

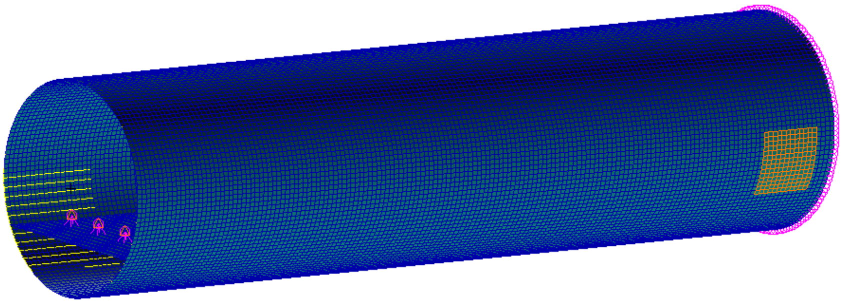

Figure 4: GFEM + DFEM model

The main subject of this analysis is to obtain the enforced displacements of the GFEM and apply them on the DFEM.

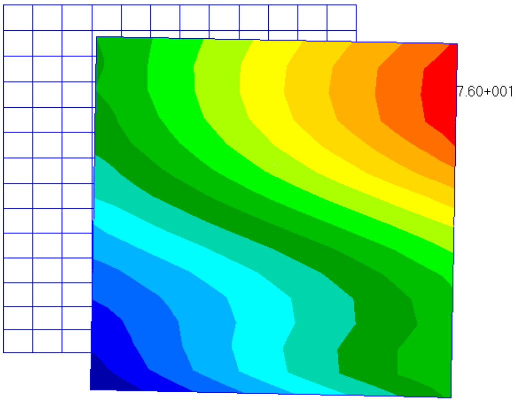

Figure 5: DFEM displacements with GFEM enforced displacements

The previous figure shows the displacements obtained in the DFEM after loading the model with the displacements obtained from the GFEM. But one of the most important things to check is the stress. The stress in the DFEM must be the same with and without the rigid body displacement. In this case, the stresses for this model loaded with the enforced displacements coming from the GFEM are displayed below.

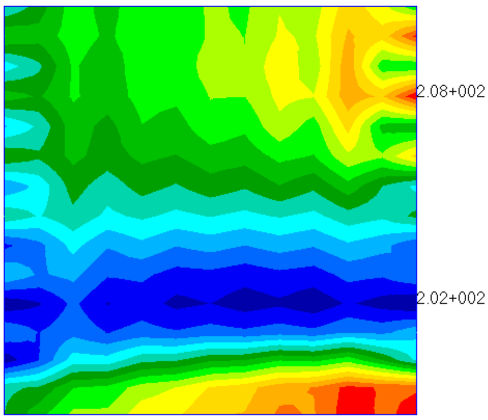

Figure 6: Von Mises stresses for DFEM

Now, let's see how to remove the rigid body displacement. In order to do it, there is a utility in Patran. It is under the menu Utilities/Results/Rel. Displacement ...

On the third menu, it is possible to choose between Simple Subtraction and Remove Rigid Body Motion. The description of both options can be seen in the help shown below.

This PCL creates new results which represent the relative displacement of the model with respect to some reference.

o Simple Subtraction: Calculates the relative displacement with respect to a single node or a group of nodes. This is done by taking the deformation at a single node or the average deformation at a group of nodes and subtracting this from the deformation for all of the selected nodes.o Remove Rigid Body Motion: Calculates the relative displacement with respect to a reference plane. The rigid body motion of the plane is subtracting from all selected nodes. Note that the method used is only valid for small deformations.

There are two important topics that must be clarified:

- The first one is that the results must be obtained in a rectangular coordinate system (grid analysis coordinate system → rectangular). Otherwise the computation of the displacements will not be correct because Patran does not perform the transformations.
- The second aspect that must be clarified is that the 'Remove Rigid Body Motion' option should only be used with a non deformable plane. Otherwise, the utility will remove real deformation of the structure which will lead to erroneous results. The user has to choose the nodes for this option in such a way that the selected nodes movement represents a rigid body movement (the rigid body movement to be removed). The movement of three nodes could also represent a deformable body movement, and this deformation will be subtracted from the displacements used to load the DFEM.

So, using the Simple Subtraction option for the previous example, it is possible to obtain the following displacements depending on the node chosen to remove the displacement.

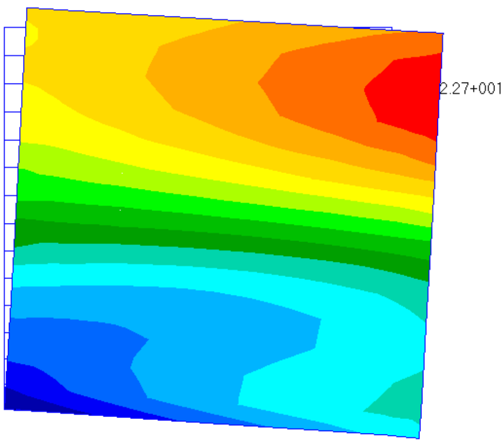

Figure 7: DFEM displacements for displacements removed with the bottom left node.

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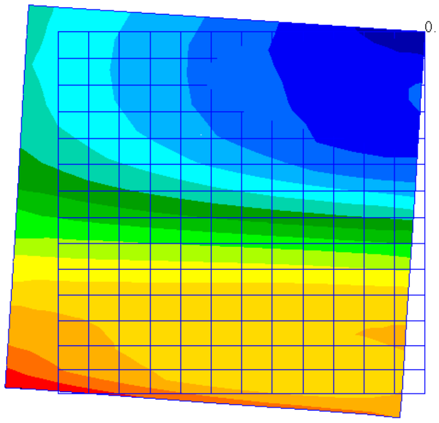

Figure 8: DFEM displacements for displacements removed with the top right node.

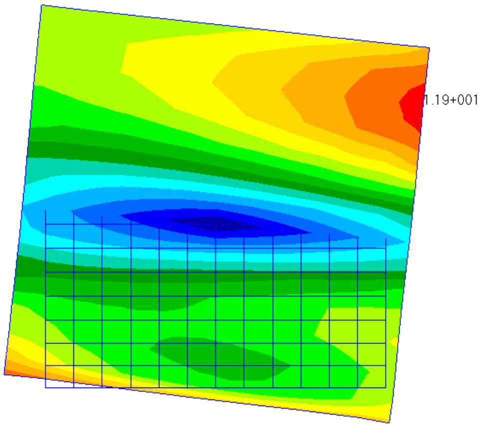

Figure 9: DFEM displacements for displacements removed with the centre node.

And as it was expected, for all these previous configurations, the stresses are equal to the ones obtained without removing any displacement.

Obviously, the second option ‘Remove Rigid Body Motion’ is more powerful since it allows removing the rigid body rotations. But the user has to ensure that the nodes selected are the correct ones (they really move as a rigid body = their relative distances remain constant on the deformed state). One useful trick is to select dependent nodes of RBE2 if they exist, or to create dummy free nodes connected by a dummy RBE2 to a single node of the structure which contains the rigid body movement (translation and rotations) to be removed.