SESAM EXAMPLE

Pushover Collapse Analysis of Jacket Using Usfos

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1 Introduction

This document is about pushover collapse analysis of a jacket using Usfos. The example is run as a job in Sesam Manager and is named Jacket4Leg_Collapse. Create a new job in Sesam Manager and import the ZIP file. The job is shown in **Figure 1-2** below. Note that this example requires the user to set up and run Usfos from GeniE.

The model is shown in **Figure 1-1**. Four mass points represent the deck and topside structures on top of the legs. Two versions of the model are analyzed, first with the model fixed at the bottom of the legs, and secondly with piles and soil.

For the benefit of Usfos the 'FEM analysis units' (set when creating an analysis activity) are SI units (N and m). The following programs and versions are used: GeniE 8.5.4, Wajac 7.9.0, Usfos 9.0.0, Splice 8.0.0 and Xtract 6.0.2.

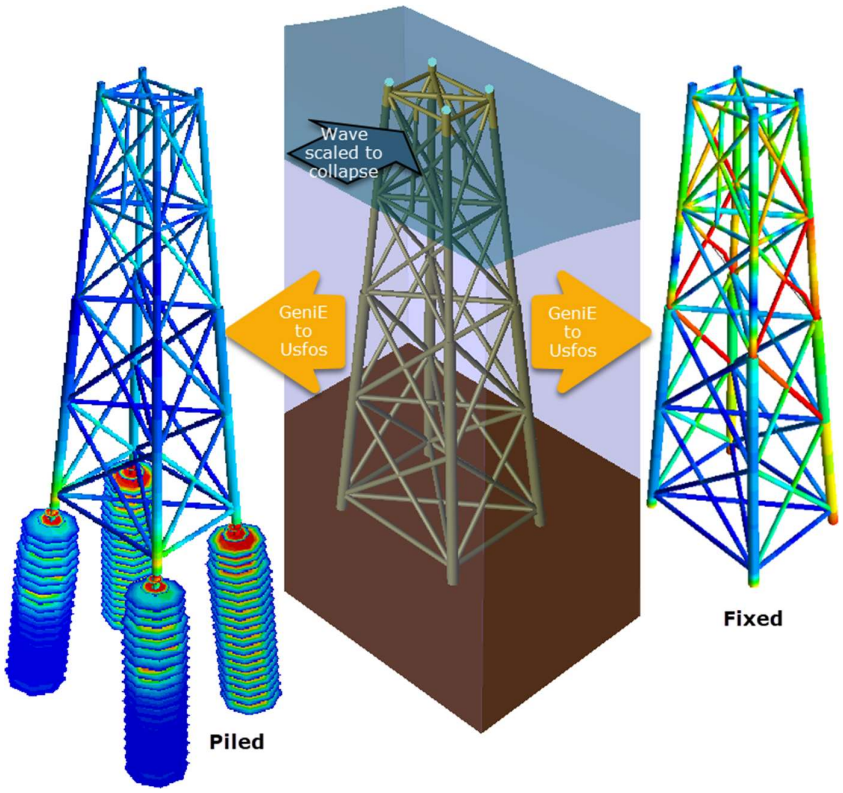

Figure 1-1 Jacket model created in GeniE and analysed in Usfos

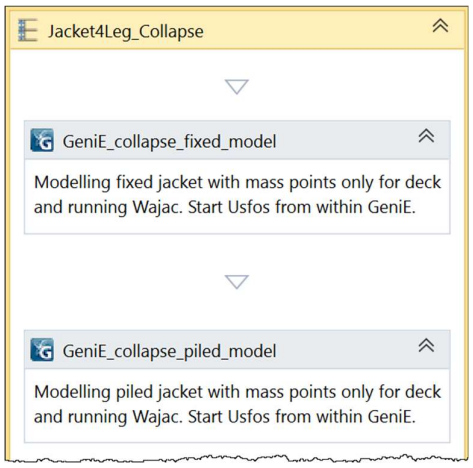

Figure 1-2 Sesam Manager workflow shown as 'Tree View'

2 Collapse Analysis of Fixed Model

The jacket model is created in GeniE by running the activity GeniE_collapse_fixed_model. The four mass points on top of the legs represent the deck and topsides. When collapse of the jacket is to be investigated simplified modelling of the deck and topsides is beneficial for two reasons:

1. The model for non-linear analysis in Usfos is smaller.
2. Potential problems that a fine mesh in the deck structure may cause in Usfos are eliminated.

There are three load cases created in GeniE and by Wajac (run under control by GeniE):

1. Gravity (FEM Loadcase 1)
2. Extreme wave towards north (FEM Loadcase 2)
3. Buoyancy (FEM Loadcase 3)

These are combined as follows:

- GravPlusBuoy (FEM Loadcase 5) = Gravity factored by 1.2 + Buoyancy factored by 1
- Combined (FEM Loadcase 4) = GravPlusBuoy factored by 1 + Extreme wave towards north factored by 1

The purpose of the combination Combined is only to identify the two loads (load sequences in Usfos) to be analyzed in Usfos, namely first GravPlusBuoy and then the extreme wave. The FEM Loadcases to analyze in Usfos are, therefore, 5 and 2. (The combination Combined itself will not be analyzed.)

2.1 Export fixed model and data to Usfos

The model with loads is exported to Usfos format by File | Export | Usfos file. This opens the Export to Usfos dialog shown in **Figure 2-1**, the Output tab of the dialog selected. The GeniE analysis activity WaveAnalysis and the load combination Combined should be selected. Otherwise, the default settings in the dialog are suitable.

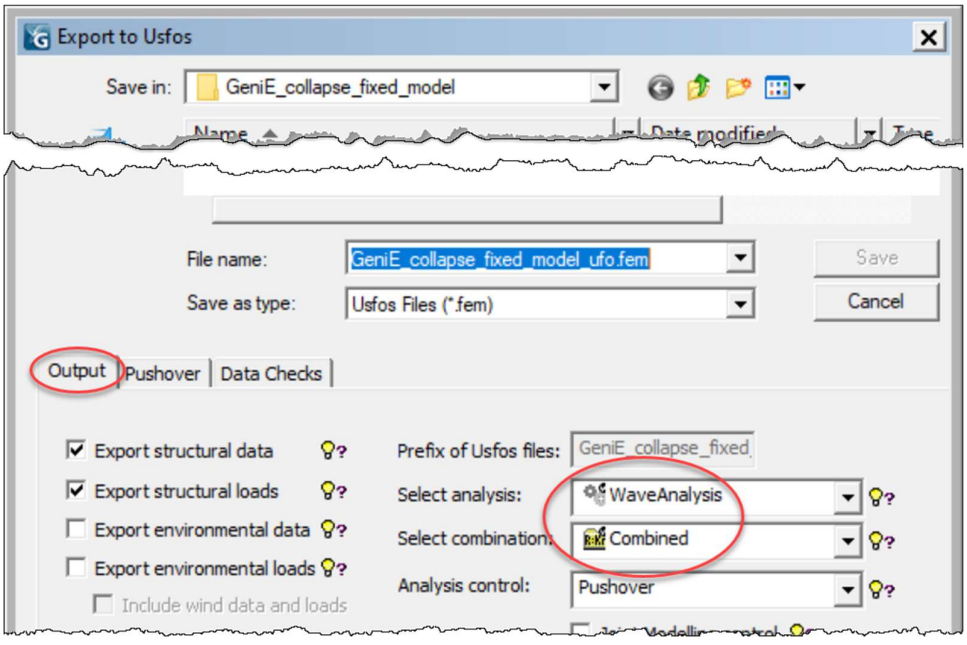

Figure 2-1 The 'Export to Usfos' dialog, Output tab

In the Pushover tab of the dialog, see **Figure 2-2**, select the node at End2 (top end) of Leg1 to be monitored in the Usfos collapse analysis. The other default settings of the tab are suitable.

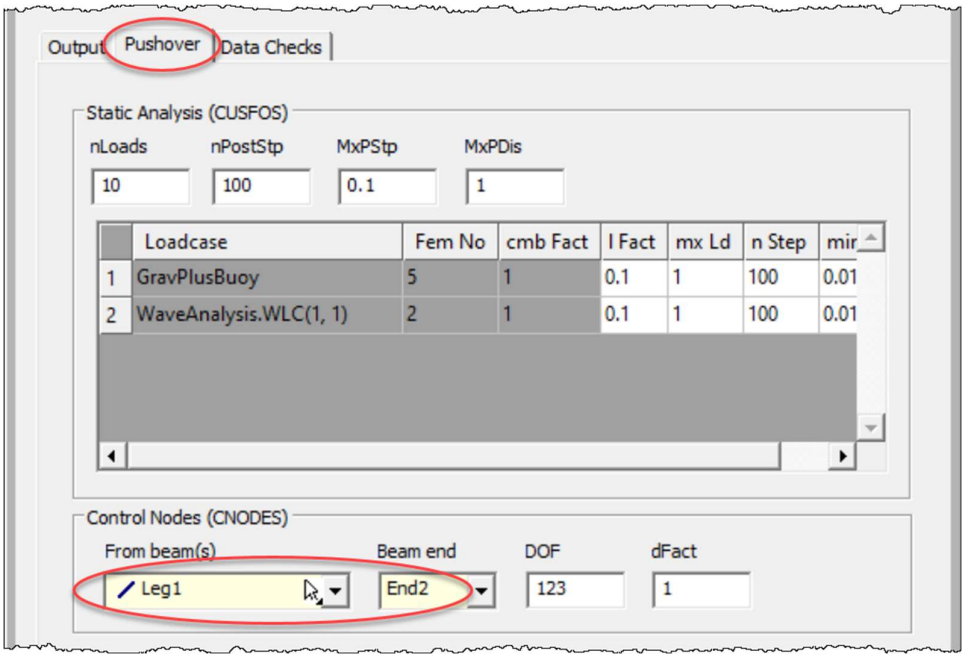

Figure 2-2 The 'Export to Usfos' dialog, Pushover tab

In the Data Checks tab of the dialog, see **Figure 2-3**, keep default settings.

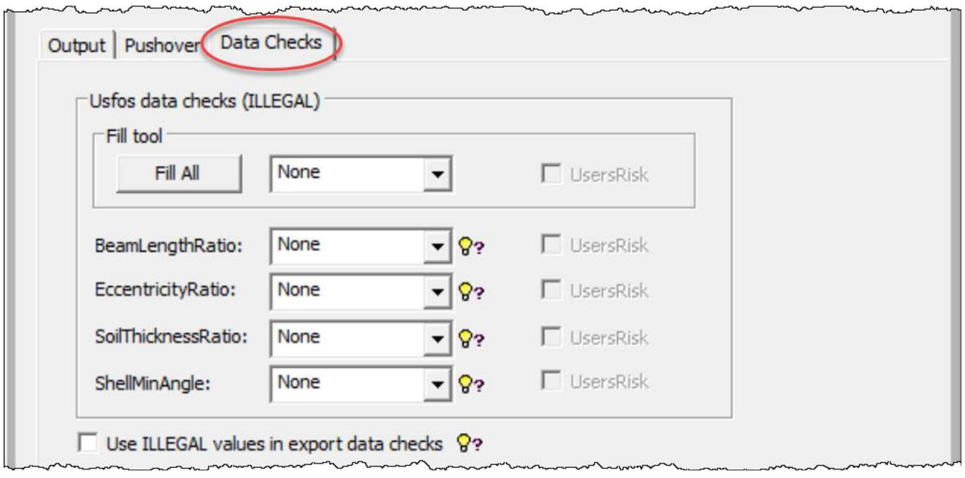

Figure 2-3 The 'Export to Usfos' dialog, Data Checks tab

Click Save in the Export to Usfos dialog.

The export to Usfos creates the files:

- GeniE_collapse_fixed_model_ufo.fem – contains model in Usfos input format (Usfos commands HEAD, NODE, BEAM, UNITVEC, PIPE, etc.)
- GeniE_collapse_fixed_model_control.fem – contains control data (Usfos commands HEAD, CUSFOS, CNODES, etc.)

- Notice that the CUSFOS command refers to load case IDs 5 (GravPlusBuoy) and 2 (extreme wave). These are applied in the collapse analysis in this order.

- GeniE_collapse_fixed_model_ufo_load.fem – contains wave loads computed by Wajac (Usfos commands HEAD, GRAVITY, NODELOAD and BEAMLOAD)

2.2 Usfos analysis of fixed model

Usfos is started from GeniE by the command Mesh & Analysis | Non-linear Analysis (Usfos).

In the Usfos window opening up:

- Use File | Open USFOS Model File to select the file GeniE_collapse_fixed_model_ufo.fem and see the model appear in the Usfos window (seen from above). Click the corner of the Navigation Cube to see the model in isometric view as shown in **Figure 2-4**.

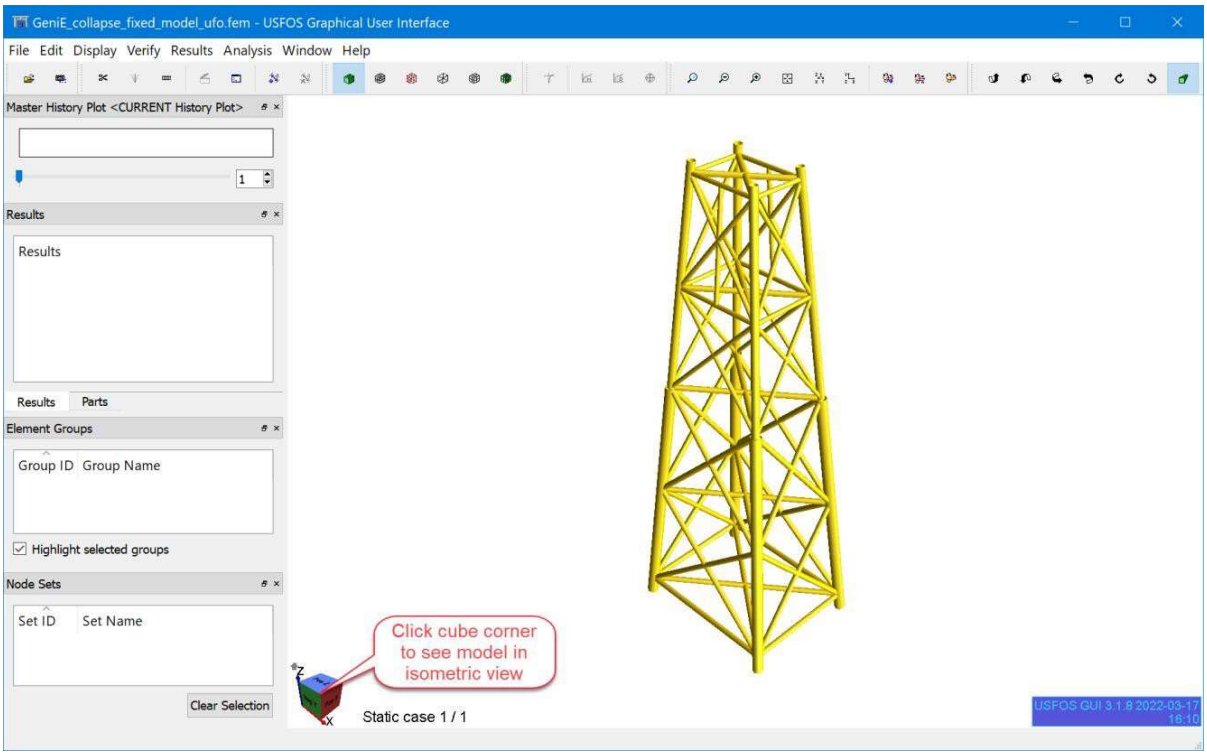

Figure 2-4 The Usfos window displaying the model

- Use Analysis | USFOS Analysis Control to select the Control file:

  GeniE_collapse_fixed_model_control.fem

  and Optional file:

  GeniE_collapse_fixed_model_ufo_load.fem

- Edit the Control file by clicking its Edit button:

  - Values 1 for the second and third parameters of the CSAVE command involve storing and printing of every load step.

  - Change mxLd on the CUSFOS command for the wave (load case id 2) to 8 as shown in **Figure 2-5**. This somewhat unrealistic factor for the wave load is set high to force collapse.

- Click the Save button to save the edits.

- The output files from Usfos are automatically set to res.out and res.raf, the former is a print file, and the latter is the binary results file.

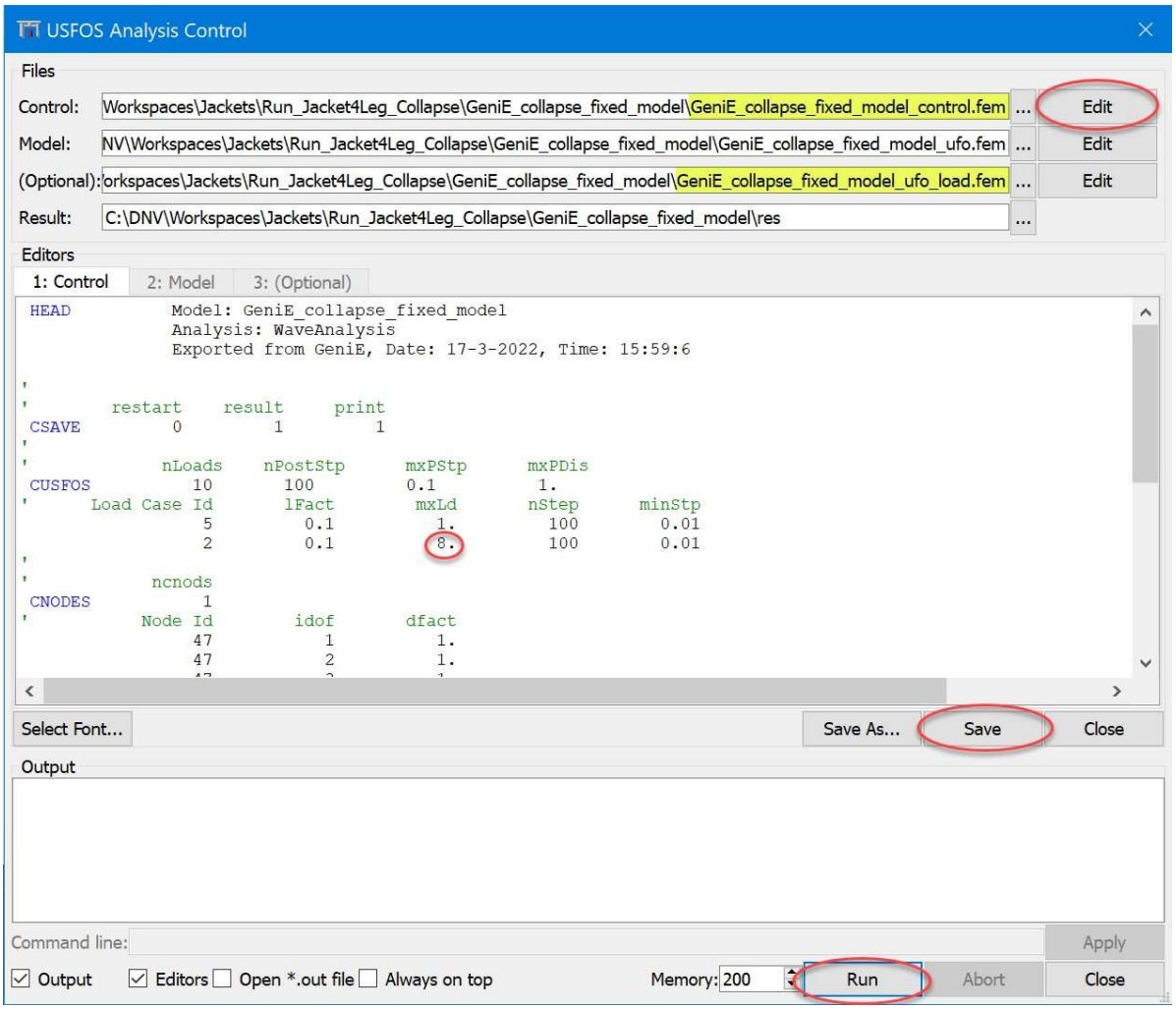

Figure 2-5 Select files and increase the wave load factor to force collapse

- Click the Run button to run the Usfos analysis and see that output control data fills the Output pane. When the run finishes, verify that the text 'Analysis process terminated normally' appears.

- Close the USFOS Analysis Control dialog.

2.3 View Usfos results for the fixed model

The results may be examined in Usfos as exemplified in **Figure 2-6**. The vertical Global load axis in the graph shows that collapse of the jacket starts at approximately 5.8 times the wave load. From that point the load carrying capacity of the jacket is reduced while the displacements increase.

The plastic utilization of the members is shown by selecting GLOBAL > ELEMENT > Plastic Utilization. Grab the red cross in the graph and drag it beyond the maximum load level (or use the spin button beneath the graph). Plastic deformation can barely be seen for one of the members. Note that the model deformation is not scaled.

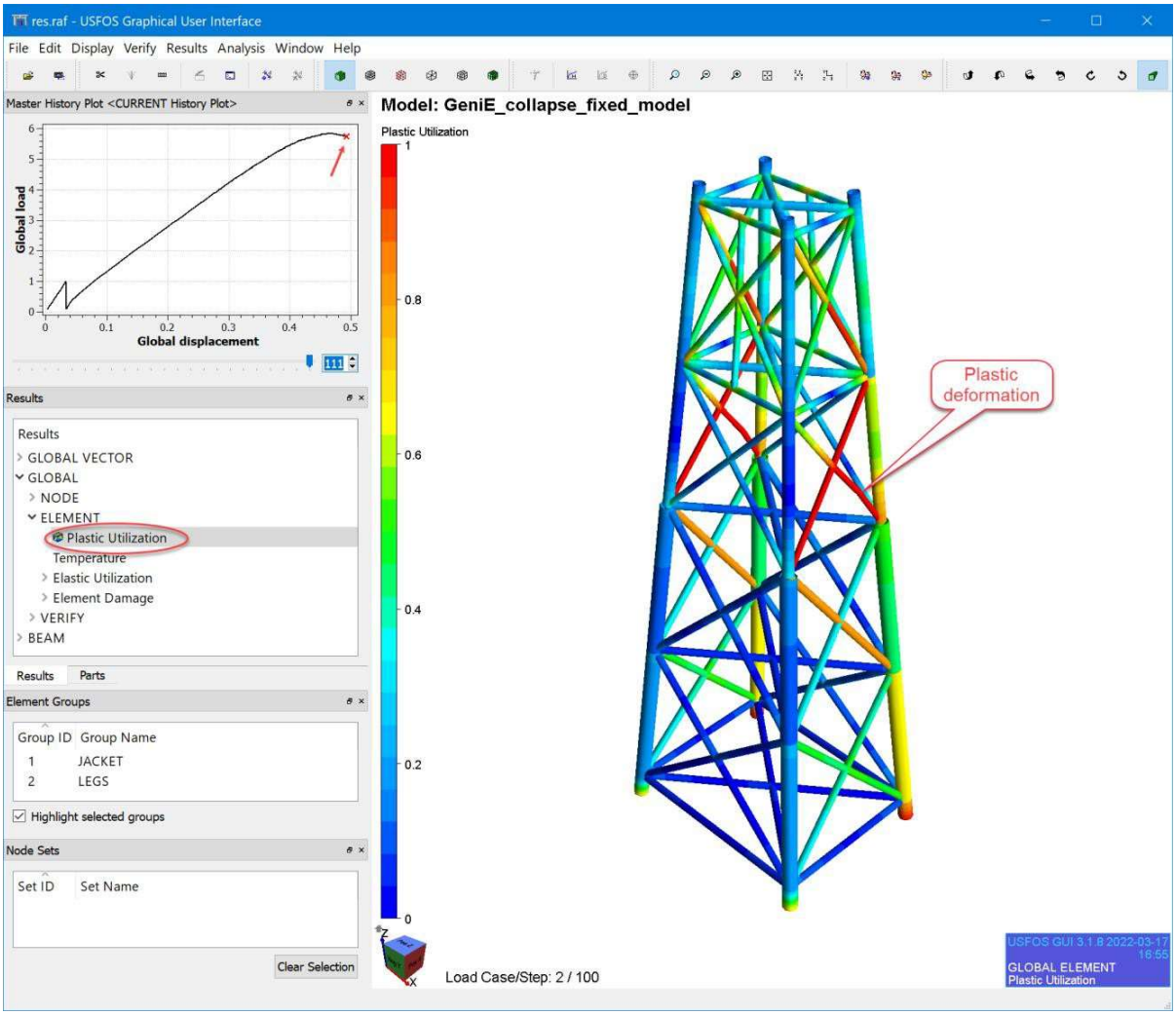

Figure 2-6 Examine analysis results for the fixed jacket

3 Collapse Analysis of Piled Model

In this version of the jacket model it has a pile-soil foundation rather than being fixed. Otherwise, the model and loads are the same.

A full structure-pile-soil analysis is run under control of GeniE. I.e. Wajac, Splice (including Gensod) and Sestra are run. In Sesam Manager, run GeniE_collapse_piled_model activity and this will automatically run the wave pile soil analysis.

3.1 Export piled model and data to Usfos

The model including pile-soil data and loads is exported to Usfos format by File | Export | Usfos file. This opens the Export to dialog shown in **Figure 3-1**, the Output tab of the dialog selected. In addition to selecting the analysis activity WaveAnalysis and the load combination Combined, make sure Export pile-soil data is checked. Otherwise, the default settings in the dialog are suitable.

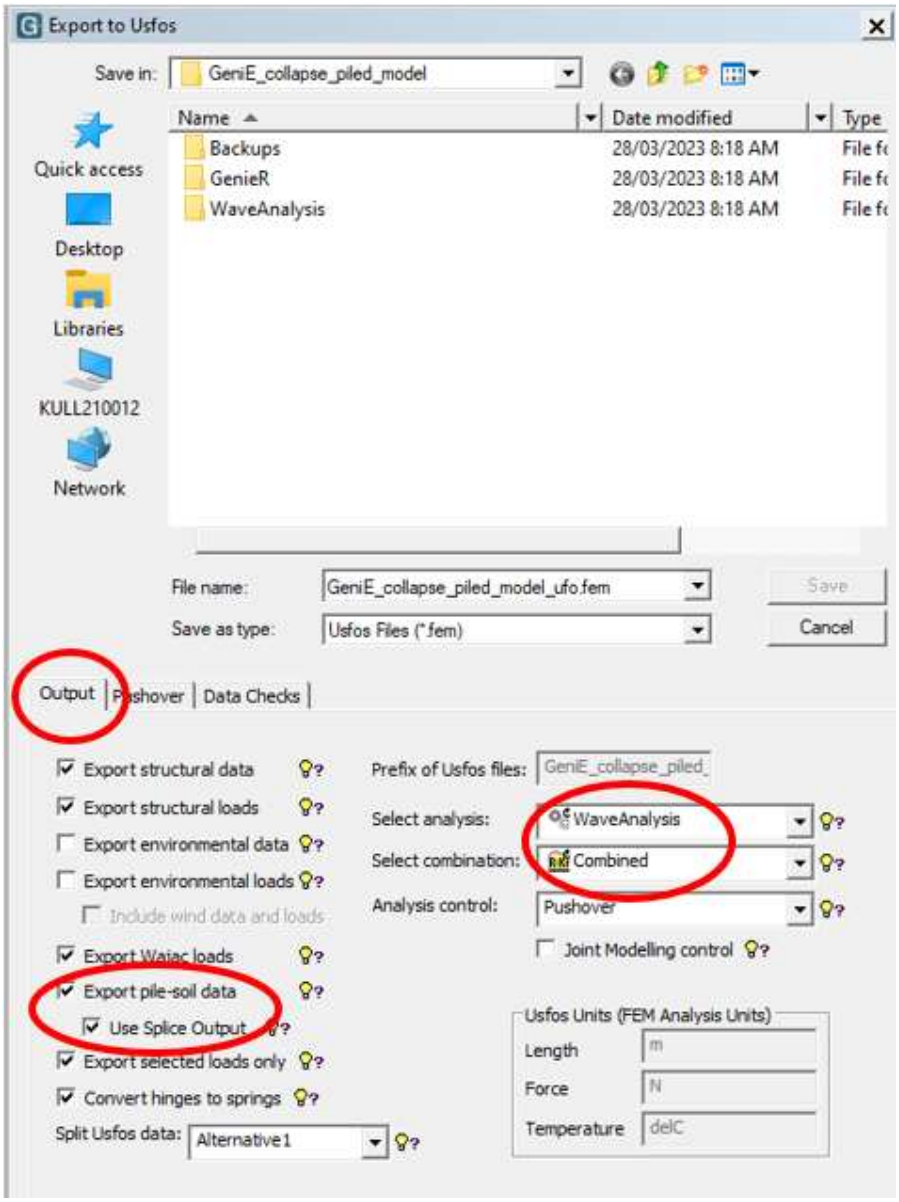

Figure 3-1 The 'Export to Usfos' dialog, Output tab

In the Pushover tab of the dialog select, as for the fixed model, see **Figure 2-2**, the node at End2 (top end) of Leg1 to be monitored in the Usfos collapse analysis. The other default settings of the tab are suitable.

In the Data Checks tab of the dialog all default settings are OK.

Click Save in the Export to Usfos dialog.

3.2 Usfos analysis of piled model

Start Usfos from GeniE by the command Mesh & Analysis | Non-linear Analysis (Usfos). In the Usfos window opening, go to File | Open USFOS Model File and select the file GeniE_collapse_piled_model_ufo.fem.

- Use Analysis | USFOS Analysis Control to select the Control file:
  GeniE_collapse_piled_model_control.fem
  and Optional file:
  GeniE_collapse_piled_model_ufo_load.fem
- Edit the Control file by clicking its Edit button:
  - Add the LITER command to increase number of iterations per load step to 10 (default 1).
  - Change mxLd on the CUSFOS command for the wave (load case id 2) to 8 as shown in **Figure 3-2**. This somewhat unrealistic factor for the wave load is set high to force collapse. You can also set this to 0 to force collapse.
  - Click the Save button to save the edits.
- The output files from Usfos are automatically set to res.out and res.raf.

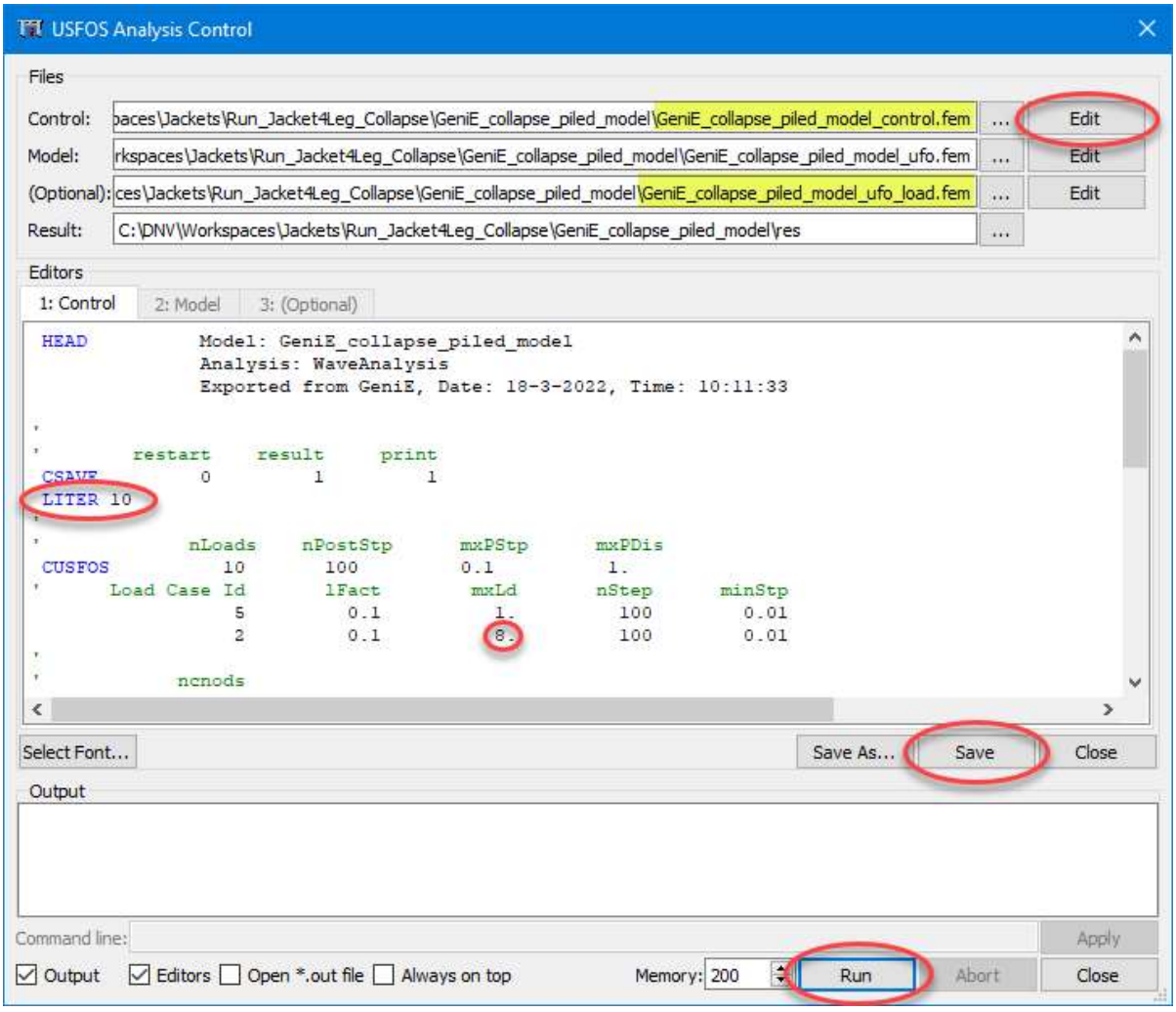

Figure 3-2 Select files and increase the wave load factor to force collapse

- Click the Run button to run the Usfos analysis and see that output control data fills the Output pane. When the run finishes, verify that the text 'Analysis process terminated normally' appears.
- Close the USFOS Analysis Control dialog.

3.3 View Usfos results for the piled model

The results may be examined in Usfos as exemplified in **Figure 3-3**. The collapse of the jacket starts at approximately 2.85 times the wave load. From that point the load carrying capacity of the jacket is reduced while the displacements increase. The results show that plasticity of the pile and soil occur with no plasticity in the jacket itself. This is consistent with the analysis of the fixed jacket that showed that collapse of the jacket occurs at 5.8 times the wave load.

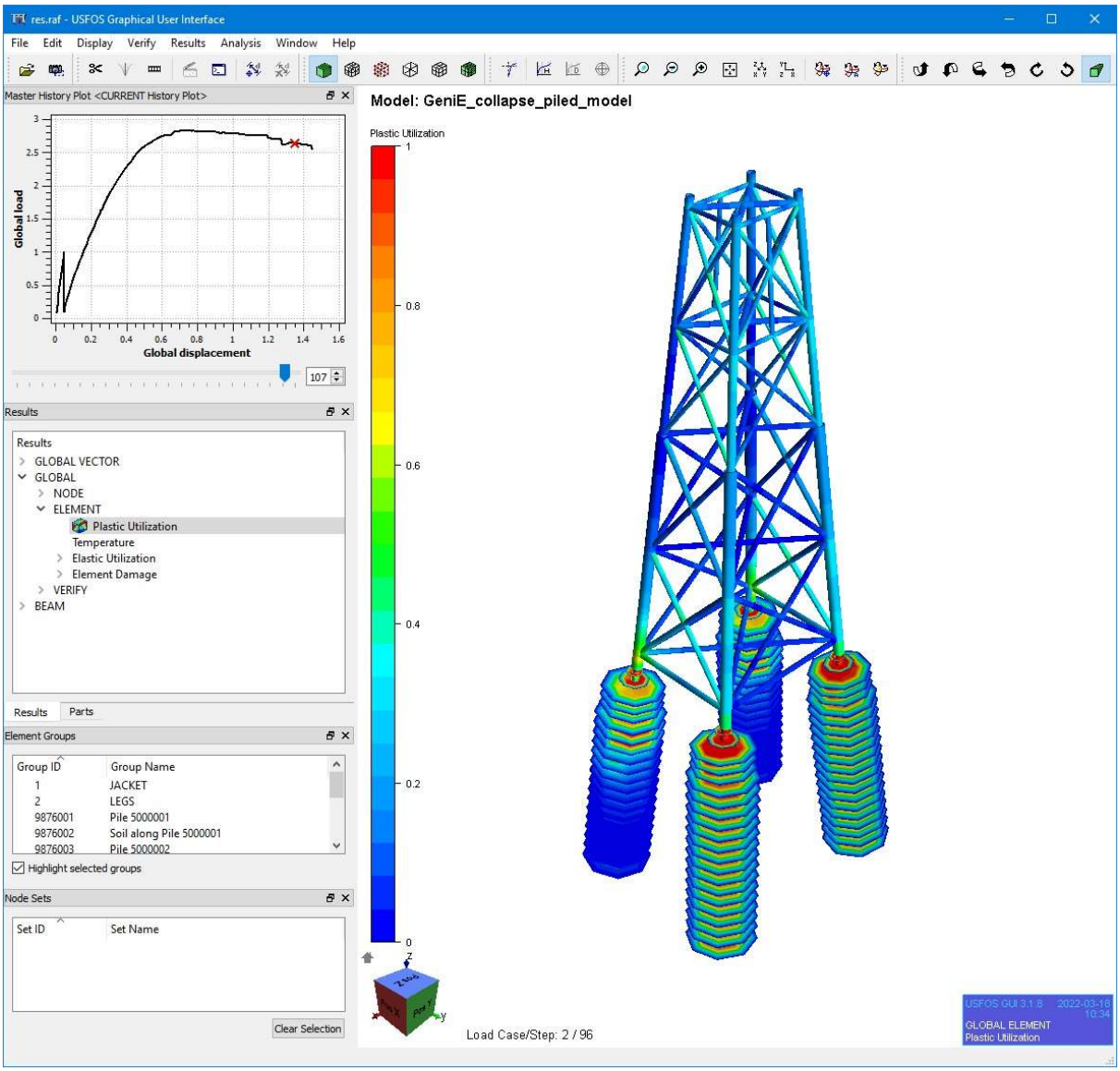

Figure 3-3 Examine analysis results for the piled jacket

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