

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.

C Export to Usfos		x
Save in: GeniE_collapse_fixe	ed_model 💽 🎯 🏂 🗁 🖽 🕶	
Marce Anno	Lal Date modified	The
hand have been and have been an	men man man man	, mar have the second
File name: Geni	iE_collapse_fixed_model_ufo.fem	Save
Save as type: Usfo	os Files (*.fem) 🗨 🔿	Cancel
Output Pushover Data Checks		
Evport structural data	Prefix of Liefos files: GeniE collapse fixed	
		1
I♥ Export structural loads ₩?	Select analysis:	83
Export environmental data 9?	Select combination	8?
Export environmental loads 9?	Analysis control: Pushover	02
Include wind data and loads		

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.

10	100 0.1	1					
	Loadcase	Fem No	cmb Fact	I Fact	mx Ld	n Step	mir_^
1	GravPlusBuoy	5	1	0.1	1	100	0.01
2	WaveAnalysis.WLC(1, 1)	2	1	0.1	1	100	0.01

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.

Usfos data checks (Il	LEGAL)			
Fill tool				1
Fill All	None	-	🗖 UsersRisk	
			-	1
BeamLengthRatio:	None	▲ 85	UsersRisk	
EccentricityRatio:	None	▲ 85	🔲 UsersRisk	
SoilThicknessRatio:	None	▼ 8?	🗖 UsersRisk	
ShellMinAngle:	None	· Q2	UsersRisk	

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.

TT USFOS Analysis Control	×
Files	
Control: Workspaces\Jackets\Run_Jacket4Leg_Collapse\GeniE_collapse_fixed_model\GeniE_collapse_fixed_model_control.fo	em Edit
Model: NV\Workspaces\Jackets\Run_Jacket4Leg_Collapse\GeniE_collapse_fixed_model\GeniE_collapse_fixed_model_ufo.fo	em Edit
(Optional): orkspaces\Jackets\Run_Jacket4Leg_Collapse\GeniE_collapse_fixed_model\GeniE_collapse_fixed_model_ufo_load.fr	em Edit
Result: C:\DNV\Workspaces\Jackets\Run Jacket4Leg Collapse\GeniE collapse fixed model\res	
1: Control 2: Model 3: (Ontional)	
HEAD Model: GeniE_collapse_fixed_model Analysis: WaveAnalysis Exported from GeniE, Date: 17-3-2022, Time: 15:59:6	•
CSAVE 0 1 1	
nLoads nPostStp mxPStp mxPDis	
CUSFOS 10 100 0.1 1.	
5 0.1 <u>1.</u> 100 0.01	
2 0.1 (8.) 100 0.01	
ncnods	
CNODES 1	
' Node Id idof dfact	
47 1 1.	
	*
<	>
Select Font Save As Sa	ve Close
Output	
Command line:	Apply
✓ Output ✓ Editors Open *.out file Always on top Memory: 200 Run Ab	ort Close

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:
 - o 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.



ontrol:	paces\Jackets\Run_Ja	acket4Leg_Collaps	e\GeniE_c <mark>olla</mark> pse_	piled_model\Gen	iE_collapse_pil	ed_model_contro	ol.fem 🤇	Edit
lodel:	rkspaces\Jackets\Rur	n_Jacket4Leg_Coll	apse\GeniE_collap	se_piled_model\	GeniE_collapse	_piled_model_ufo	o.fem	Edit
Optional)	ces\Jackets\Run_Jac	ket4Leg_Collapse\	GeniE_collapse_pi	led_model	_collapse_piled	I_model_ufo_load	d.fem	Edit
esult:	C:\DNV\Workspaces	Vackets\Run_Jack	et4Leg_Collapse\	GeniE_collapse_p	viled_model\res			
litors								
: Contro	ol 2: Model 3:	(Optional)						
SAVE	Exporte restart re 0	d from GeniE, sult prir 1	Date: 18-3- nt 1	2022, Time:	10:11:33			
USFOS	nLoads 10 Load Case Id 5 2	nPostStp 100 1Fact 0.1 0.1	mxPStp 0.1 mxLd 1.	mxPDis 1. nStep 100 100	minStp 0.01 0.01			
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CUSFOS	nLoads 5 10 Load Case Id 5 2 ncnods	nPostStp 100 1Fact 0.1 0.1	mxPStp 0.1 mxLd 8	mxPDis 1. nStep 100 100	minStp 0.01 0.01			>
CUS FOS	nLoads 10 Load Case Id 5 2 ncnods	nPostStp 100 1Fact 0.1 0.1	mxPStp 0.1 mxLd 1. 8.	mxPDis 1. nStep 100 100	minStp 0.01 0.01	Save As	Save	> Close
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CUSFOS	nLoads 10 Load Case Id 5 2 ncnods	nPostStp 100 1Fact 0.1 0.1	mxPStp 0.1 mxLd 1. 8	mxPDis 1. nStep 100 100	minStp 0.01 0.01	Save As	Save	Close
CUSFOS elect Font Dutput	nLoads 10 Load Case Id 5 2 ncnods t	nPostStp 100 1Fact 0.1 0.1	mxPStp 0.1 mxLd 1. 8.	mxPDis 1. nStep 100 100	minStp 0.01 0.01	Save As	Save	Close

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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