

SESAM EXAMPLE

Jacket Earthquake Analysis





Sesam Example Jacket Earthquake Analysis Date: March 2022 Prepared by: Digital Solutions at DNV E-mail support: <u>software.support@dnv.com</u>

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1 Introduction

This example shows how to do a jacket earthquake analysis in Sesam. It is a subset, with some changes, of the example named 'Comprehensive Analysis of Jacket' and for this reason the model is superelement 7 and not the customary 1. The model shown in **Figure 1-1** below. The example is based on units kN and m.

The earthquake analysis is controlled by Sesam Manager, see **Figure 1-2** below. The example input is simplified for the purpose of illustrating the principles of this type of analysis.

The following programs and versions are used: Sesam Manager version 6.6, Sestra 10.15.



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



2 Establish the Workflow from Scratch

To create the workflow from scratch rather than establishing it by importing the ZIP file of this example do as follows:

• Create a new job based on the job template TwoAnalysesAndMerge:

🗷 Create Job	
Name and folder of new job:	
Job name:	
Job1	
Create job in folder	
C:\DNV\Workspaces	
Select Template:	
TwoAllarysesAllaweige	
Sesam examples	
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Figure 2-1 Create a Sesam Manager job based on a template

• This creates the workflow:

Job1	1				
\bigtriangledown					
🔀 SestraRun1	*				
First analysis, a static analysis when pa analysis	art of earthquake				
\bigtriangledown					
SestraRun2	*				
Second analysis, an eigenvalue analyse earthquake analysis	sis when part of				
\bigtriangledown					
🔀 PrepostMergingAnalyses	*				
Merge the second analysis results file into the first assuming first analysis file is a SIN file and second is SIF Note: If both are SIN then use prefix to separate files and specify prefix in InputFilePrefix/MergeInputFilePrefix					
\bigtriangledown					
FrameworkEarthquake	*				
Postprocess merged results file, e.g. analysis	an earthquake				
\bigtriangledown					

Figure 2-2 New Sesam Manager job based on template TwoAnalysesAndMerge



 Add one or two GeniE activities to the job above. Two models (T#.FEM files) are needed, one for static and one for eigenvalue analysis. These normally deviate slightly as the first model will have a gravity load case and the second model must have proper mass modelling, possibly with loads converted to mass, and hydrodynamic added mass. If both of these models are created from a single GeniE run then a single GeniE activity will suffice.



Figure 2-3 Add GeniE activity to the new Sesam Manager job based on template TwoAnalysesAndMerge

- For the first Sestra activity, SestraRun1, adjust the properties Description, SuperElementNumber, InputFilePrefix, LoadFilePrefix and OutputFilePrefix as required.
- The second Sestra activity, SestraRun2, must be modified from a static analysis to an eigenvalue analysis using the MultifrontLanczos solver and checking the EarthquakeAnalysis property so as to compute the modal earthquake excitation forces. Also adjust the properties Description, SuperElementNumber, InputFilePrefix, LoadFilePrefix and OutputFilePrefix as required.

	Prope	Properties 🗸 🕂 🕽					
	Sest	SestraActivity SestraRun2					
man man and the second se	Sea	rch			×		
First analysis, a static analysis when part of earthquake		ieneral					
analysis	1	Name	[SestraRun2			
	6	Description		Second analysis, an eigenvalue analysis when part of earthquake analysis	•		
\bigtriangledown	N N	Norkspace		C:\DNV\Workspaces\Job1\SestraRun2\			
		AnalysisType		Eigenvalue	~		
🔀 SestraRun2 🔗	0	CmdInputFile		default	Edit		
Second analysis, an eigenvalue analysis when part of earthquake analysis	F	PostExecuteScript	n na training anna training T	default Edit	Execute		
	1 Ei	genvalue					
\bigtriangledown		EarthquakeAnalys	sis				
		EigenvalueSolver		MultifrontLanczos	~		
🜠 PrepostMergingAnalyses 🔗 🕅	L L	NumberOfModes	;	10	\$		
Marge the second analysis results file into the first	9	Shift		No value			
intege the second analysis results the into the hist	Earth	quakeAnalysis					
	Prepa	are for subseque	nt eartho	juake analysis			
	III P	roperties 🖉 At	ttachmer	nts			

Figure 2-4 Modify second Sestra activity to an eigenvalue analysis computing modal excitation forces

- For the activity PrepostMergingAnalyses set the InputFilePrefix equal to the OutputFilePrefix of the eigenvalue analysis and the MergeInputFilePrefix equal to the OutputFilePrefix of the static analysis. This will merge the first analysis results (static) into the second analysis results (eigenvalue).
 - NOTE: The Description for the activity is misleading as it says, "Merge the second analysis results file into the first ...", correct is the other way around. You may want to adjust this text.



3 Earthquake Analysis by Importing Workflow

Create a new job with a preferred name. Do not select any template for this job. Import the ZIP file Jacket_4Leg_Earthquake.zip provided with this example. Your job should then contain the workflow shown in **Figure 1-2**. In addition to the workflow, the ZIP file contains a GeniE model of a four-legged jacket in the form of a gnx file as well as js input files with all necessary additional input.

An earthquake analysis is based on a merged results file from two analyses in Sestra:

- Static analysis
- Eigenvalue (free vibration) analysis

It is required that the two models are equal (same node numbering and coordinates and same element numbering).

The modelling for static analysis of gravity loading (including equipment) and buoyancy is activity **GeniEStaticModel**. To compute buoyancy Wajac is run under the control of GeniE. (Wajac may alternatively be run after GeniE and under the control of Sesam Manager.) Ensure that *StaticT7.FEM* and *StaticL7.FEM* are found in the repository after the GeniE run. StaticS7.FEM also produced is irrelevant in this case.

The free vibration model is created by activity **GeniEEigenvalueModel**. To compute added mass Wajac is run under the control of GeniE. Ensure that *EigenvalueT7.FEM* and *EigenvalueL7.FEM* are found in the repository after the GeniE run.

The static analysis in Sestra is performed by activity **SestraRun1**. Ensure that the results file *StaticR7.SIN* is found in the repository after the Sestra run.

The eigenvalue analysis in Sestra is performed by activity **SestraRun2**. Note that the free vibration analysis must include computation of modal earthquake excitation forces. This is achieved by checking the EarthquakeAnalysis property (that sets the MOLO parameter on the CMAS command to Sestra equal to 1). The MultifrontLanczos eigenvalue solver is used to compute 20 modes. Sestra produces the results file EigenvalueR7.SIN. Ensure that this file is found in the repository after running Sestra.

The merging of the two results files in Prepost is done by activity **PrepostMergingAnalyses**. The static analysis should preferably be merged into the eigenvalue analysis and not the other way around. (If the eigenvalue analysis is merged into the static analysis, then the resulting file will contain mass representation from the static analysis. The print of modal masses in Framework will in such case present incorrect modal mass as fraction of total mass. Otherwise the earthquake results will be correct.) Note that the property AnalysisType for the Prepost activity has been set to MergeResultFiles. This involves a default PreExecuteScript to be created that will copy EigenvalueR7.SIN to *MERGED_EigenvalueR7.SIN* so as to keep the original EigenvalueR7.SIN. Furthermore, the required input to Prepost is automatically created. Since the files to be merged in this example both are SIN formatted the StaticR7.SIN is first reformatted to SIF whereupon this is merged into MERGED_EigenvalueR7.SIN. Ensure that the file MERGED_EigenvalueR7.SIN is found in the repository after running Prepost. Notice that the file is larger than both of the merged results files.

Then run the earthquake analysis in Framework. This is activity **FrameworkEarthquake**. A screen dump of code check results (usage factors) is shown in **Figure 3-1** below.





Figure 3-1 Code check results of earthquake loading computed by Framework



To verify the total mass participation (effective modal mass) the individual modal mass participation factors in Framework are printed to a file named *EarthquakeMass.LIS*. The table in **Figure 3-2** below is taken from this file.

The encircled columns to the right are the accumulated mass participations in the X, Y and Z directions as fractions of the total mass. The encircled values at bottom are the mass participations (effective modal masses) and the total masses.

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$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Mode	Period	EMM (X	()	EMM (Y)	EMM(Z)	DMM (X)	DMM (Y)	DMM(Z)	AMM (X)	AMM (Y)	AMM (Z)
2 2.395 1.73E+04 8.49E-03 2.93E-01 0.7222 0.0000 0.0000 0.7222 0.7019 0.0000 3 1.294 1.01E+00 4.90E+01 1.43E-03 0.0000 0.0020 0.0000 0.7222 0.7019 0.0000 4 0.906 2.13E-02 6.50E+03 2.39E-01 0.2579 0.0000 0.0000 0.7223 0.7039 0.0000 5 0.841 6.17E+03 1.67E-02 2.35E+00 0.2579 0.0000 0.0000 0.9802 0.9690 0.0002 6 0.699 1.01E+00 5.21E+00 6.67E-03 0.0000 0.0000 0.0000 0.9802 0.9693 0.0002 7 0.555 3.62E-03 6.52E-04 6.98E+02 0.0000 0.0003 0.9802 0.9693 0.0402 9 0.529 2.01E-04 7.98E+01 1.22E+00 0.0000 0.0033 0.0011 0.9802 0.9693 0.0402 10 0.442 5.17E+01 4.94E-02 6.79E+03 0.0022 0.0000 0.3869 0.9858 0.9725	1	2.966	4.43F	-03	1.72E+04	9.76E-02	0.0000	0.7019	0.0000	0.0000	0.7019	0.0000
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	2	2.395	1.73E	+04	8.49E-03	2.93E-01	0.7222	0.0000	0.0000	0.7222	0.7019	0.0000
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	3	1.294	1.01E	+00	4.90E+01	1.43E-03	0.0000	0.0020	0.0000	0.7223	0.7039	0.0000
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	4	0.906	2.13E	-02	6.50E+03	2.39E-02	0.0000	0.2652	0.0000	0.7223	0,9690	0.0000
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	5	0.841	6.17E	+03	1.67E-02	2.35E+00	0.2579	0.0000	0.0001	0.9801	0.9690	0.0002
7 0.555 3.62E-03 6.52E-04 6.98E+02 0.0000 0.0000 0.0398 0.9802 0.9693 0.0400 8 0.539 1.24E-04 3.65E-01 4.47E+00 0.0000 0.0000 0.0003 0.9802 0.9693 0.0400 9 0.529 2.01E-04 7.98E+01 1.22E+00 0.0000 0.0033 0.0011 0.9802 0.9693 0.0402 10 0.447 8.36E+01 2.86E-02 5.35E+03 0.0035 0.0000 0.3048 0.9802 0.9725 0.3451 11 0.442 5.17E+01 4.94E-02 6.79E+03 0.0022 0.0000 0.3869 0.9858 0.9725 0.7320 12 0.436 1.84E-01 2.70E+02 2.72E+02 0.0000 0.0011 0.0155 0.9858 0.9726 0.7475 13 0.428 9.88E-04 2.96E+02 1.09E+00 0.0000 0.0011 0.9858 0.9899 0.7490 15 0.414 2.35E-02 1.33E+00 9.81E+02 0.0000 0.0001 0.0002 0.9858 0.9899<	6	0.699	1.01E	+00	5.21E+00	6.67E-03	0.0000	0.0002	0.0000	0.9802	0.9693	0.0002
8 0.539 1.24E-04 3.65E-01 4.47E+00 0.0000 0.0000 0.0003 0.9802 0.9693 0.0402 9 0.529 2.01E-04 7.98E+01 1.22E+00 0.0000 0.0033 0.0011 0.9802 0.9693 0.0402 10 0.447 8.36E+01 2.86E-02 5.35E+03 0.0035 0.0000 0.3048 0.9802 0.9725 0.3451 11 0.442 5.17E+01 4.94E-02 6.79E+03 0.0022 0.0000 0.3869 0.9858 0.9725 0.7320 12 0.436 1.84E-01 2.70E+00 2.72E+02 0.0000 0.0011 0.0155 0.9858 0.9725 0.7420 13 0.428 9.88E-04 2.96E+02 1.09E+00 0.0000 0.0011 0.0051 0.9858 0.9847 0.7475 14 0.414 2.35E-02 1.33E+00 9.81E+02 0.0000 0.0001 0.0051 0.9858 0.9899 0.8049 16 0.366 6.77E-05 5.09E-03 3.59E+00 0.0000 0.0000 0.90051 0.985	7	0.555	3.62E	-03	6.52E-04	6.98E+02	0.0000	0.0000	0.0398	0.9802	0.9693	0.0400
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	8	0.539	1.24E	-04	3.65E-01	4.47E+00	0.0000	0.0000	0.0003	0.9802	0.9693	0.0402
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	9	0.529	2.01E	-04	7.98E+01	1.22E+00	0.0000	0.0033	0.0001	0.9802	0.9725	0.0403
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	10	0.447	8.36E	+01	2.86E-02	5.35E+03	0.0035	0.0000	0.3048	0.9837	0.9725	0.3451
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	11	0.442	5.17E	+01	4.94E-02	6.79E+03	0.0022	0.0000	0.3869	0.9858	0.9725	0.7320
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	12	0.436	1.84E	-01	2.70E+00	2.72E+02	0.0000	0.0001	0.0155	0.9858	0.9726	0.7475
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	13	0.428	9.88E	-04	2.96E+02	1.09E+00	0.0000	0.0121	0.0001	0.9858	0.9847	0.7475
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	14	0.418	1.37E	-03	1.26E+02	2.56E+01	0.0000	0.0051	0.0015	0.9858	0.9899	0.7490
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	15	0.414	2.35E	-02	1.33E+00	9.81E+02	0.0000	0.0001	0.0559	0.9858	0.9899	0.8049
17 0.369 9.34E-04 1.01E-01 1.88E-01 0.0000 0.0000 0.0000 0.9858 0.9899 0.8051 18 0.360 2.22E-03 3.52E+00 9.84E-04 0.0000 0.0001 0.0000 0.9858 0.9901 0.8051 19 0.356 1.17E+02 4.11E-05 8.98E+00 0.0049 0.0000 0.0005 0.9907 0.9901 0.8057 20 0.351 2.01E-02 5.70E-02 6.05E-01 0.0000 0.0000 0.0000 0.9907 0.9901 0.8057 Direction X Y Z Sum of EMM 2.3718E+04 2.4256E+04 1.4134E+04 2.3940E+04 2.4499E+04 1.7542E+04	16	0.386	6.77E	-05	5.09E-03	3.59E+00	0.0000	0.0000	0.0002	0.9858	0.9899	0.8051
18 0.360 2.22E-03 3.52E+00 9.84E-04 0.0000 0.0001 0.0000 0.9858 0.9901 0.8051 19 0.356 1.17E+02 4.11E-05 8.98E+00 0.0049 0.0000 0.0005 0.9907 0.9901 0.8057 20 0.351 2.01E-02 5.70E-02 6.05E-01 0.0000 0.0000 0.9907 0.9901 0.8057 Direction X Y Z Sum of EMM 2.3718E+04 2.4256E+04 1.4134E+04 2.3940E+04 2.4499E+04 1.7542E+04	17	0.369	9.34E	-04	1.01E-01	1.88E-01	0.0000	0.0000	0.0000	0.9858	0.9899	0.8051
19 0.356 1.17E+02 4.11E-05 8.98E+00 0.0049 0.0000 0.0005 0.9907 0.9901 0.8057 20 0.351 2.01E-02 5.70E-02 6.05E-01 0.0000 0.0000 0.9907 0.9901 0.8057 Direction X Y Z Sum of EMM 2.3718E+04 2.4256E+04 1.4134E+04 Total Mass 2.3940E+04 2.4499E+04 1.7542E+04	18	0.360	2.22E	-03	3.52E+00	9.84E-04	0.0000	0.0001	0.0000	0.9858	0.9901	0.8051
Z0 0.351 Z.01E-02 S.70E-02 S.05E-01 O.0000 O.0000 O.0000 O.9907 O.9901 O.9901 <tho< th=""> <tho< th=""></tho<></tho<>	19	0.356	1.176	+02	4.11E-05	8.98E+00	0.0049	0.0000	0.0005	0.9907	0.9901	0.8057
Direction X Y Z Sum of EMM 2.3718E+04 2.4256E+04 1.4134E+04 Total Mass 2.3940E+04 2.4499E+04 1.7542E+04	20	0.351	2.018	02	5.70E-02	6.05E-01	0.0000	0.0000	0.0000	0.9907	0.9901	0.8057
Sum of EMM 2.3718E+04 2.4256E+04 1.4134E+04 Total Mass 2.3940E+04 2.4499E+04 1.7542E+04	Direction X Y Z											
Total Mass 2.3940E+04 2.4499E+04 1.7542E+04	Sum of EMM 2.3718E+04 2.4256E+04 1.4134E+04											
	Total Mass 2.3940E+04 2.4499E+04 1.7542E+04											

Figure 3-2 Accumulated mass participations in the X, Y and Z directions as fractions of the total mass

For this example we find that the mass participation is 99.07%, 99.01% and 80.57% for the X-, Y- and Z-directions, respectively.



The accumulated mass participations in the X, Y and Z directions as fractions of the total mass may be taken into Excel and graphed, see **Figure 3-3** below. As seen, rather few modes contribute with nearly all mass participation. This is typical for jacket structures. The contribution to the Z-direction is, as can be expected, from the higher modes. To achieve a high percentage contribution for the vertical direction a high number of modes must be included.



Figure 3-3 Accumulated mass participations graphed against mode number



About DNV

We are the independent expert in risk management and quality assurance. Driven by our purpose, to safeguard life, property and the environment, we empower our customers and their stakeholders with facts and reliable insights so that critical decisions can be made with confidence. As a trusted voice for many of the world's most successful organizations, we use our knowledge to advance safety and performance, set industry benchmarks, and inspire and invent solutions to tackle global transformations.

Digital Solutions

DNV is a world-leading provider of digital solutions and software applications with focus on the energy, maritime and healthcare markets. Our solutions are used worldwide to manage risk and performance for wind turbines, electric grids, pipelines, processing plants, offshore structures, ships, and more. Supported by our domain knowledge and Veracity assurance platform, we enable companies to digitize and manage business critical activities in a sustainable, cost-efficient, safe and secure way.