



SESAM EXAMPLE

Computing Dynamic Amplification Factors (DAFs)





Sesam Example

Computing Dynamic Amplification Factors (DAFs)

Date: April 2023

Prepared by: Digital Solutions at DNV

E-mail support: software.support@dnv.com

E-mail sales: digital@dnv.com

© DNV AS. All rights reserved

This publication or parts thereof may not be reproduced or transmitted in any form or by any means, including copying or recording, without the prior written consent of DNV AS.



Table of contents

1	INTRODUCTION	1
2	STATIC ANALYSIS	2
2.1	Static Results	2
3	DYNAMIC ANALYSIS	3
3.1	Dynamic Results	3
4	COMPARING STATIC AND DYNAMIC RESULTS – DAFS	4
4.1	DAFs at Base Level	4
4.2	DAFs at Selected Elevations	5

1 Introduction

This document explains how to compute dynamic amplification factors (DAFs). The procedure presented herein can be used for structures such as jackups, offshore jackets and wind turbine support structures. DAFs may be used for instance in a deterministic fatigue analysis by multiplying the stress concentration factors (SCFs) by the DAFs.

The example contains static and dynamic analyses in time domain. DAFs are computed as the ratio between the dynamic and the static responses.

The example is run as a job in Sesam Manager and is named ComputingDAF. Create a new job in Sesam Manager (any name) and import the ZIP file.

In this simplified analysis the single jackup leg shown in **Figure 1-1** is modelled using GeniE. The deck is simplified to a triangular prism. The triangular prism is given boundary conditions with fixed rotations so as to mimic the S-shaped deformation pattern of jackup legs enforced by the deck. The three bottom ends of the leg are fixed.

A wave of 5 m height and 8 s period passes through the structure from two different directions, 0 degrees (in the positive X direction) and 45 degrees. A deterministic wave load analysis is performed in Wajac. The waves are stepped 37 times at 10-degree intervals to cover the full wave cycles.

There are neither gravity, buoyancy nor any other loads since the purpose of the analysis is merely to compute dynamic amplification factors (DAFs).

Units are SI units (N and m). The following programs and versions are used: GeniE 8.5, Wajac 7.9, Sestra 10.17 and Xtract 6.0.

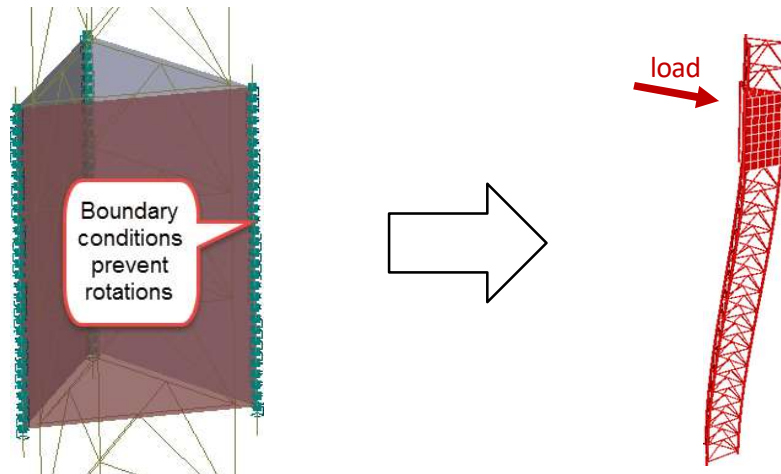


Figure 1-1 Single jackup leg with triangular prism and boundary conditions representing the deck structure

2 Static Analysis

Run the GeniE activity to create the model. Wave load computation in Wajac and static as well as dynamic analyses in Sestra are executed under the control of GeniE.

2.1 Static Results

The SESTRALIS file in sub-folder GeniEModelling\Static contains the sum of reaction forces in the fixed nodes, i.e. the base reactions. This data can be compared with the dynamic results to find the DAFs at base level. See section 4.1.

To find DAFs at other elevations (assuming that the DAFs are constant for all members at the same elevation) Xtract can be used to retrieve nodal displacements at various elevations.

Run the first Xtract activity. This activity creates and exports graphs of the X displacement in three nodes, node 23 at top, node 16 below the deck and node 13 a few meters below the water surface. See **Figure 2-1**. Note that different versions of GeniE *may* create different node numbers. If so, the Xtract input must be adjusted.

The graphs include both wave directions, i.e. altogether 6 curves. The exported graph data are found in text files (in sub-folder XtractActivity1) named `Node n XdisplDir d Stat.txt`, where n is the node number and d is the direction. This data can be compared with the dynamic results to find the DAFs at the selected elevations. See section 4.2.

The static responses may be animated in Xtract (Result Case Animation). The animation of the single wave cycle is automatically repeated. Since 37 10-degree steps are analyzed in Wajac the 37th and 1st steps are the same. The 37th step should be excluded from the animation to avoid a short stop (which hardly will be noticeable).

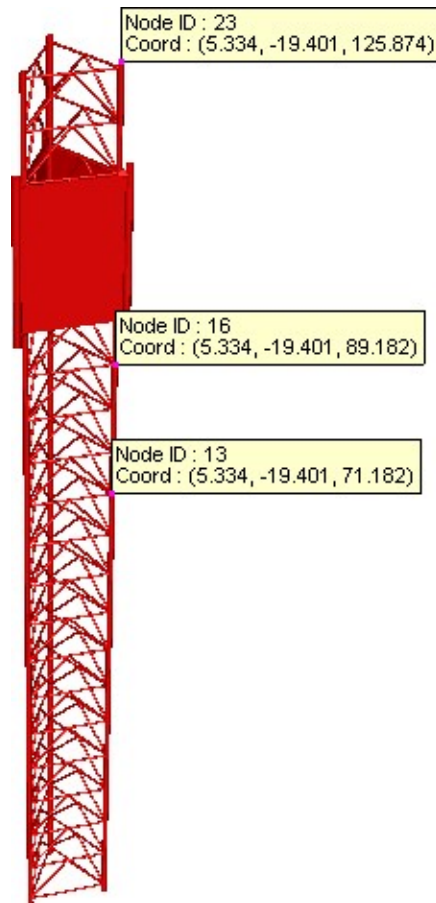


Figure 2-1 Nodes selected for graphing



3 Dynamic Analysis

The GeniE activity executes a dynamic analysis in addition to a static analysis. In Wajac, added mass will also be computed, otherwise the input is the same as for the static analysis.

In the dynamic analysis in Sestra, the wave cycle is repeated until the transient phase is passed and steady state is found. (Wave loads suddenly hit the structure and it starts to move.) This is specified by editing the dynamic structural analysis in the GeniE activity monitor and selecting 'Use Cyclic Loads' and 'Steady State Detection' plus other parameters. Setting 'Store Cycles' equal to 'Max Cycles' (and both higher than the number of cycles required to reach steady state) ensures that results for *all* cycles are stored on the results file.

3.1 Dynamic Results

Sestra produces the files <timestamp>_reactions_lohi.csv, where *i* is the load history number, i.e. wave load case. Load history 1 is wave direction 0 degree and 2 is wave direction 45 degree. These files are found in the sub-folder GeniEModellingDynamic. The data in these files can be compared with the sum of reaction forces in the fixed nodes found in the SESTRALIS for the static analysis to find the DAFs at base level. See section 4.1.

Run the second Xtract activity. This activity creates and exports graphs of the X displacement in the same three nodes as for the static analysis.

The graphs include both wave directions, i.e. altogether 6 curves. The exported graph data are found in text files (in sub-folder XtractActivity2) named Node n XdisplDir d Dyn.txt, where *n* is the node number and *d* is the direction. This data can be compared with the static results to find the DAFs at the selected elevations. See section 4.2.

The dynamic responses may be animated in Xtract (Result Case Animation). The animations will include all wave cycles required to reach steady state and then start over again. Therefore, there will be an abrupt jump when the animation restarts beginning with the transient phase.

4 Comparing Static and Dynamic Results – DAFs

4.1 DAFs at Base Level

Data found in the SESTRALIS from the static analysis and the files <timestamp>_reactions_lohi.csv from the dynamic analysis are compared to find DAFs at base level. The files <timestamp>_reactions_lohi.csv files contain results for *all* cycles up to, and including, the steady state cycle. Therefore, the data to compare with the static results is the last cycle only, i.e. the last 37 rows.

The data to compare are therefore:

- Reaction force sum 'tx' in SESTRALIS, result cases 1-37, with 'FX' in <timestamp>_reactions_lohi1.csv, last 37 rows
- Reaction force sum 'tx' in SESTRALIS, result cases 38-74, with 'FX' in <timestamp>_reactions_lohi2.csv, last 37 rows
- Reaction force sum 'ty' in SESTRALIS, result cases 38-74, with 'FY' in <timestamp>_reactions_lohi2.csv, last 37 rows

The data are graphed below. The spreadsheet with the graph is attached to the job. The horizontal axis is time in seconds. The vertical axis is force in newton. The same colour is used for corresponding static and dynamic results with dashed for dynamic and solid for static results.

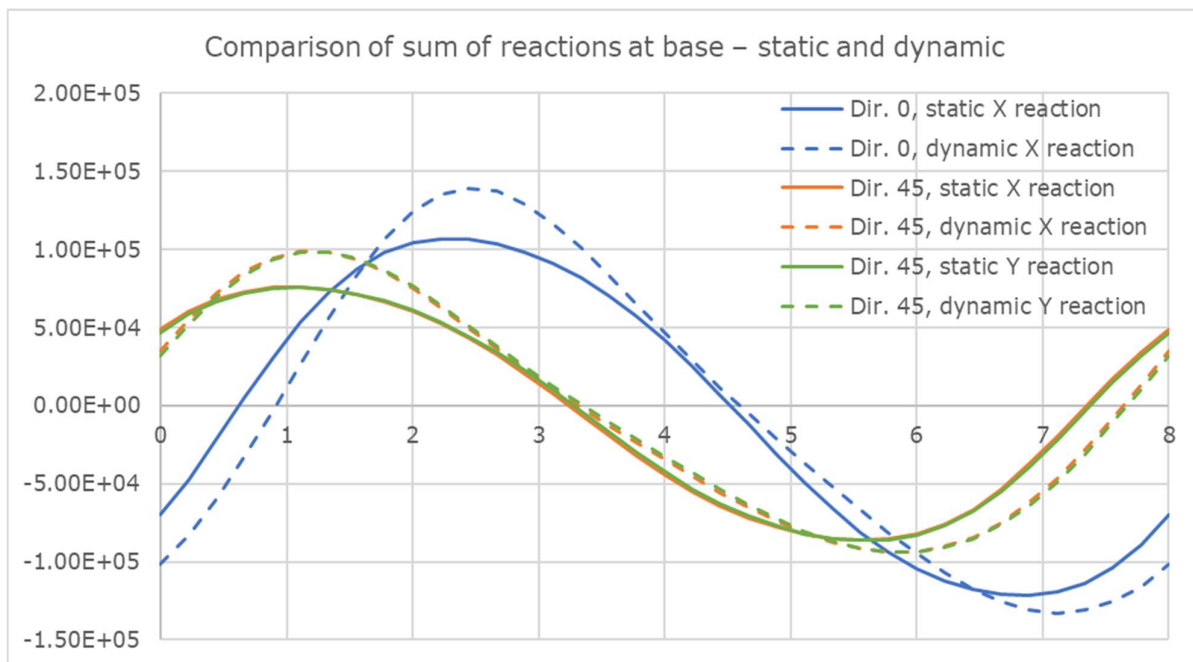


Figure 4-1 Comparison of reactions at base for static and dynamic responses

In the graph above it is seen that the dynamic response (dashed curves) is higher than the static (solid curves) response. Furthermore, the X and Y reaction forces are more or less the same for both the static and dynamic analyses of the wave in direction 45.

Based on the graph above and the underlying data the DAFs at base level can be computed as:

Direction 0: $DAF = 1.39E5/1.07E5 = 1.30$

Direction 45 (X reaction): $DAF = 9.90E4/7.61E4 = 1.30$

I.e. the DAF at base level is 1.30.

4.2 DAFs at Selected Elevations

X displacements for selected nodes have been saved by Xtract to files *NodenXdisplDirdStat.txt* and *NodenXdisplDirdDyn.txt* for the static and dynamic analyses, respectively. These data are compared to find DAFs at the elevations of the selected nodes. This data is graphed below. (See another tab of the same spreadsheet as used for the DAFs at base level.) The same colour is used for corresponding static and dynamic results, dashed for dynamic and solid for static results.

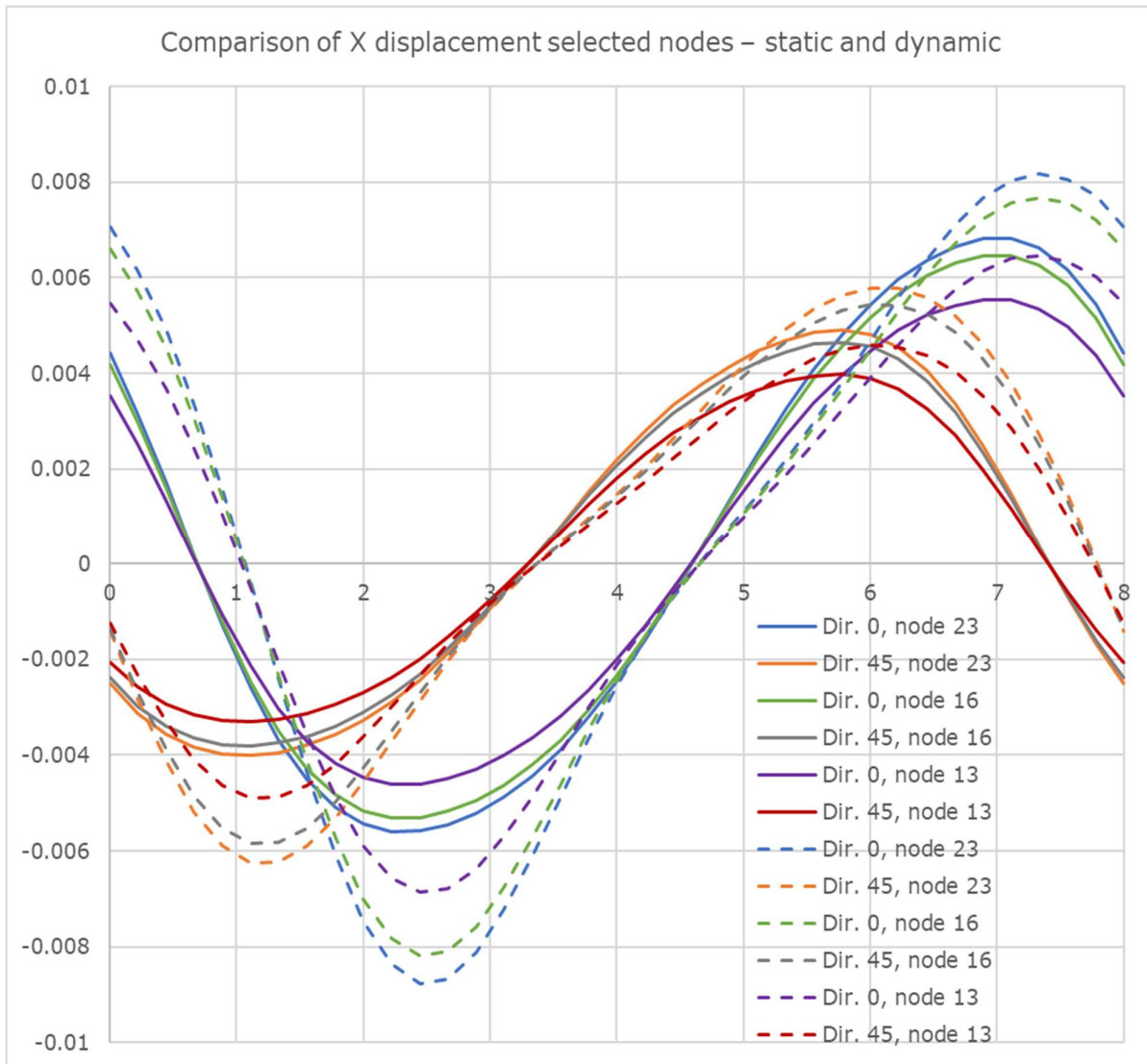


Figure 4-2 Comparison of X displacement for static and dynamic responses

In the graph above it is seen that the dynamic response (dashed curves) is higher than the static (solid curves) response.

Based on the graph above and the underlying data, the DAFs at the various elevations can be computed as the dynamic displacement range (maximum value – minimum value) divided by the static displacement range. In the attached

spreadsheet, tab 'Displacement - DAFs elevations', conditional formatting has been used to colour, for each column, the maximum value red and minimum value green.

Node 23 elevation (top):

Direction 0: $DAF = (0.008165+0.00876)/(0.00682+0.0056) = 1.36$

Direction 45: $DAF = (0.005778+0.00625)/(0.004905+0.00401) = 1.35$

This gives an average DAF at node 23 elevation. DAF = 1.36

Node 16 elevation (below deck):

Direction 0: $DAF = (0.007677+0.00819)/(0.006462+0.00532) = 1.35$

Direction 45: $DAF = (0.00544+0.00584)/(0.004651+0.00381) = 1.33$

This gives an average DAF at node 16 elevation. DAF = 1.34

Node 13 elevation (few metres below water surface):

Direction 0: $DAF = (0.006467+0.00687)/(0.005539+0.00461) = 1.31$

Direction 45: $DAF = (0.00459+0.00489)/(0.00398+0.0033) = 1.30$

This gives an average DAF at node 13 elevation. DAF = 1.31

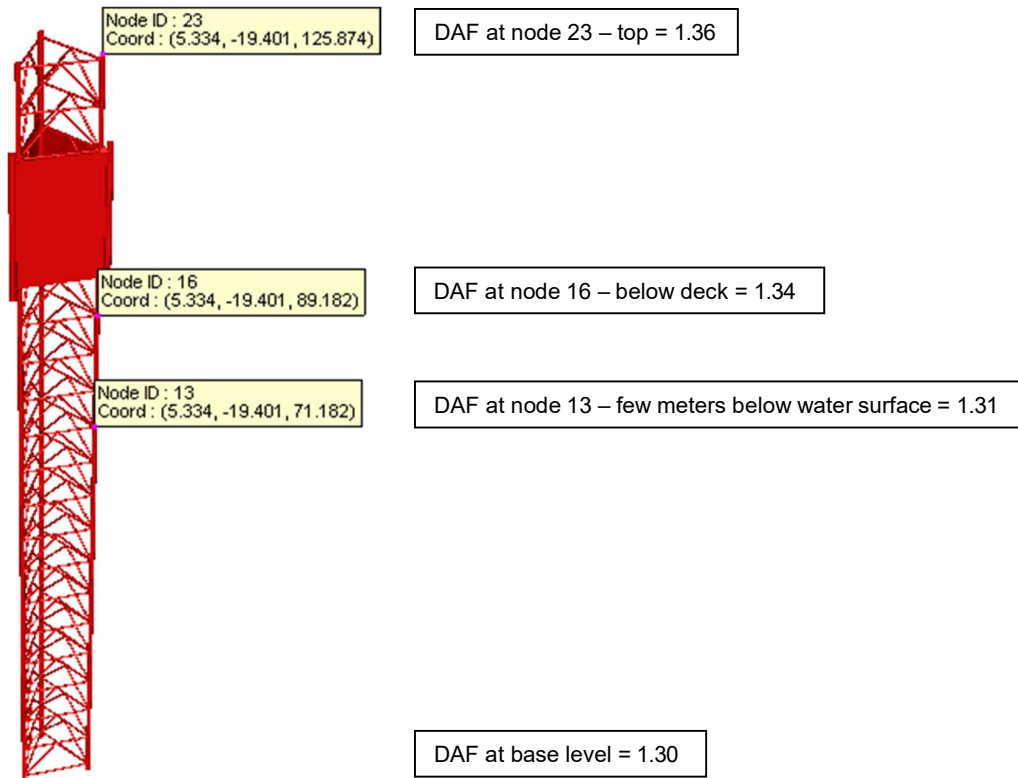


Figure 4-3 DAFs at various elevations



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.