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Detailed Load Analysis of the baseline 5MW DeepWind Concept

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DTU Vindenergi
Report 2014

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Reviewer: Uwe S. Paulsen

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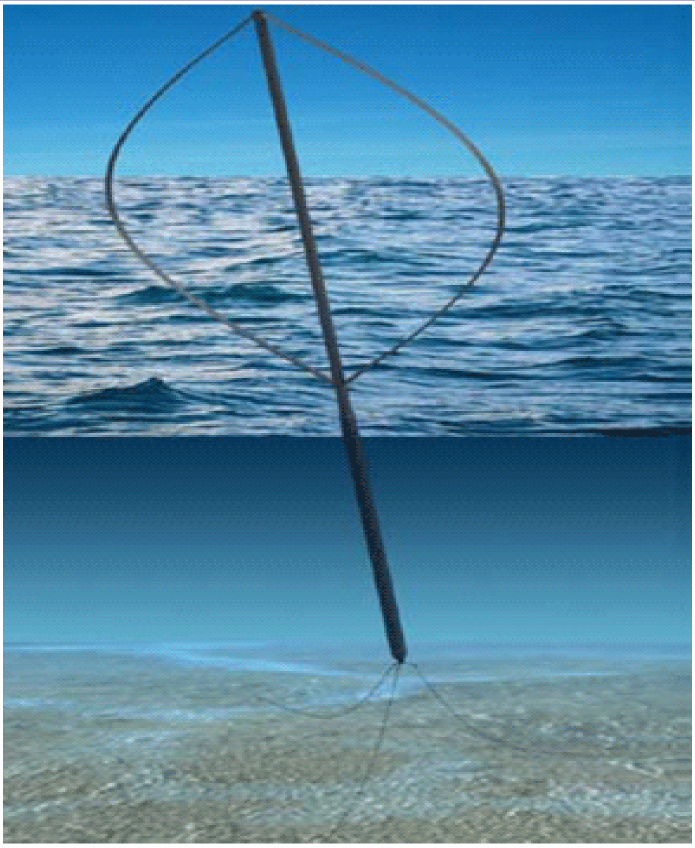

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Contents

1. Introduction

This report presents an overview of the design of the DeepWind vertical axis floating wind turbine. One could present this as the "final design", however, it is hoped that more design iterations will follow in the future, but under the umbrella of new and different projects. The state of the design that is reported here will be called version 2.2.0. The numbering system has just been introduced at the present design version, but the first 5MW design called the "baseline design" [1] was developed in 2011 and this will therefore be called version 1.0.0.

In this report, the design loads of the DeepWind 5 MW turbine are presented. The loads are calculated using Hawc2 (ver 11.8). The turbine controller is implemented according to principles outlined in work package 4 (Turbine operational control), only the normal production part of the controller is implemented. Hence, the calculated design loads only covers normal operations. In the Chapter 3 and 2 the modelled design is and simulation scenarios are introduced. In Chapter 5 the estimated loads are presented in the form of plots. In Appendix A the simulated loads are tabulated, and the input data for the numerical HAWC2 model is given in Appendix B.

2. Turbine Describtion

2.1. Version numbering

As mentioned in the general introduction (see chapter 1), the current described state of the DeepWind design is labelled as version 2.2.0 (major.minor.revision). Following well established version numbering practices in the software industry, future contributors and collaborators are encouraged to use these definitions:

- major: significant design changes
- minor: small(er) design changes
- revision: bug fixes and typo's

Because this versioning scheme has not been applied consistently throughout the duration of the DeepWind project, the version presented in this report is labelled 2.2.0, and the first 5MW design presented in 2011 [1], which is called the baseline design, is named 1.0.0.

2.2. General overview

In Figure 2.1, a schematic of the turbine is presented along with the main dimensions of the turbine. The main parameters of the turbine are specified in Table 2.1. The main deviations from the baseline design (v1.0.0) [1] are:

- the chord length has been reduced from 7.45m to 5.0m
- the solidity reduced from 0.23 to 0.17
- rotational speed increased from 5.26 to 5.95 rpm
- the rotor shape has been changed to reduce the mean flapwise loading over most part of the blade
- rotor height increased from 130m to 143m
- rotor radius decreased from 63.7m to 60.5m
- rotor height to diameter ratio increased from 0.81 to 1.18m

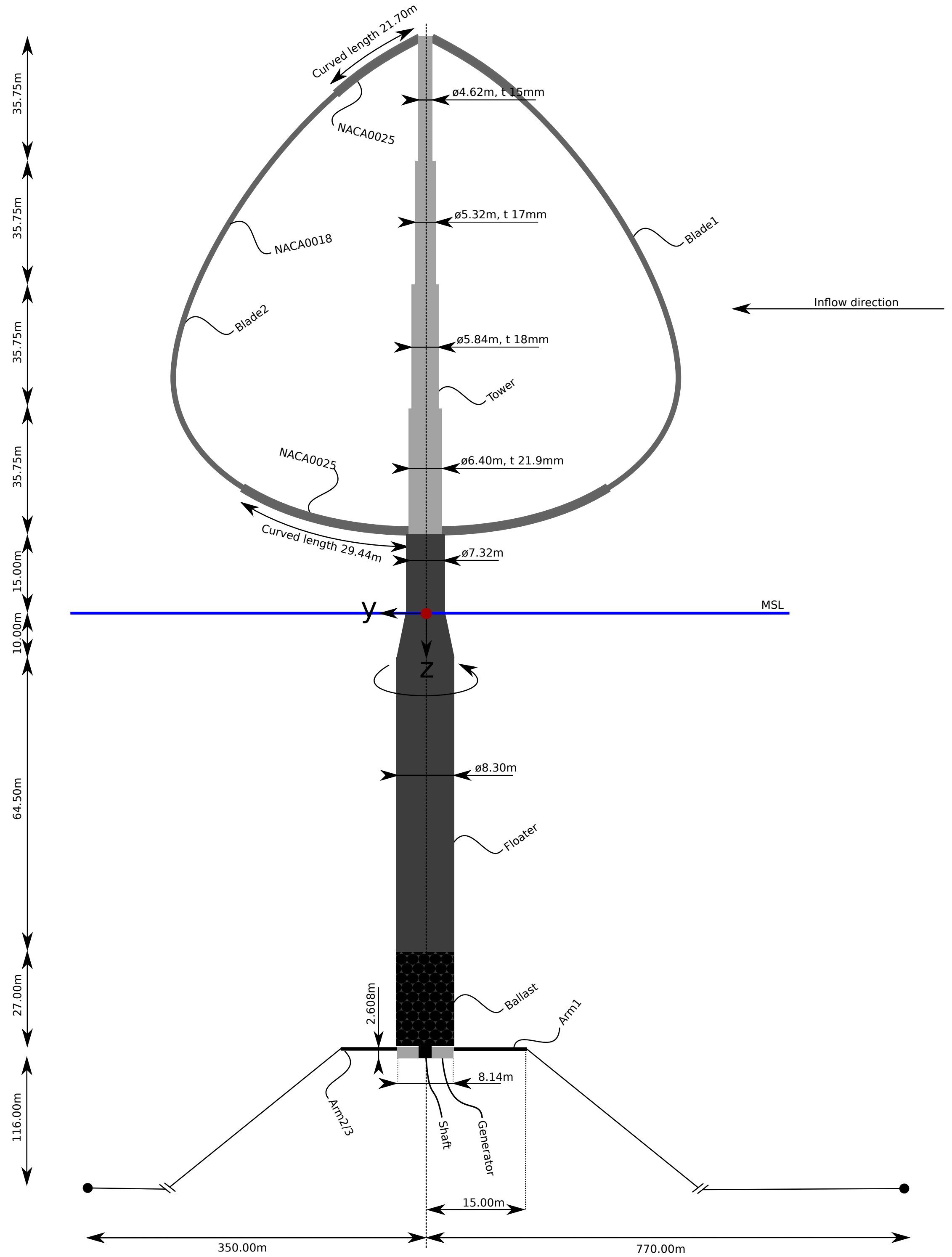


Figure 2.1.: Schematic, main dimensions and global reference system of the DeepWind 5MW turbine as used for the HAWC2 simulations discussed in this report.

Operational and Performance Data		
Rated Power	[MW]	5
Rated rotational speed	[rpm]	5.95
	[rad/s]	0.62
Rated wind speed	[m/s]	14
Cut in wind speed	[m/s]	4
Cut out wind speed	[m/s]	25
Geometry		
Rotor radius	[m]	60.49
Rotor height	[m]	143
Blade chord	[m]	5
Solidity	[-]	0.1653
Sweept area	[m^2]	11996
Mooring line length	[m]	719.6
Masses and Inertias		
Total mass (minus mooring)	[t]	5774
CoG, x (minus mooring)	[m]	0
CoG, y (minus mooring)	[m]	0
CoG, z (minus mooring)	[m]	67.7
I_{xx} (minus mooring, wrt CoG)	[m^4]	0.146E+11
I_{yy} (minus mooring, wrt CoG)	[m^4]	0.145E+11
I_{zz} (minus mooring, wrt CoG)	[m^4]	0.276E+09
Blade mass (1 blade)	[t]	48.03
Tower mass	[t]	354.70
Floater mass	[t]	1126.04
Ballast mass	[t]	3763.95
Generator mass (generator, bearings and shaft)	[t]	290.00
Arm mass (1 arm)	[t]	17.09
Mooring mass (1 mooring chain)	[t]	108.93

Table 2.1.: Main parameters of the DeepWind 6MW turbine design v1.2.0 UPDATE with masses and inertias. CoG and inertias are in the global reference frame, see Figure 2.3.

These design changes led to considerable weight reductions and particular for the blade weight that was reduced from 154 tons to around 45 tons. Another important design improvement was the increase of the rotational speed with about 13%.

Loads are extracted from the simulations at a number of positions. These positions are shown in Figure 2.3. At each position, forces and moments are extracted in all three directions. The forces will be denoted: F_x, F_y, F_z, and the moments are denoted: M_x, M_y, M_z. The coordinate systems are indicated in Figure 2.3, and are relate to the body at which they are attached. Hence, for rotating bodies like the blade and tower, the loads are given in the rotating coordinate system. The coordinate systems for the blade points are defined such that the z-axis is tangent to the blade at the point (In the figure, this is only shown for one point). Apart from the forces and moments, also the applied generator torque and power is extracted. Zero loss is assumed for the generator. The locations of

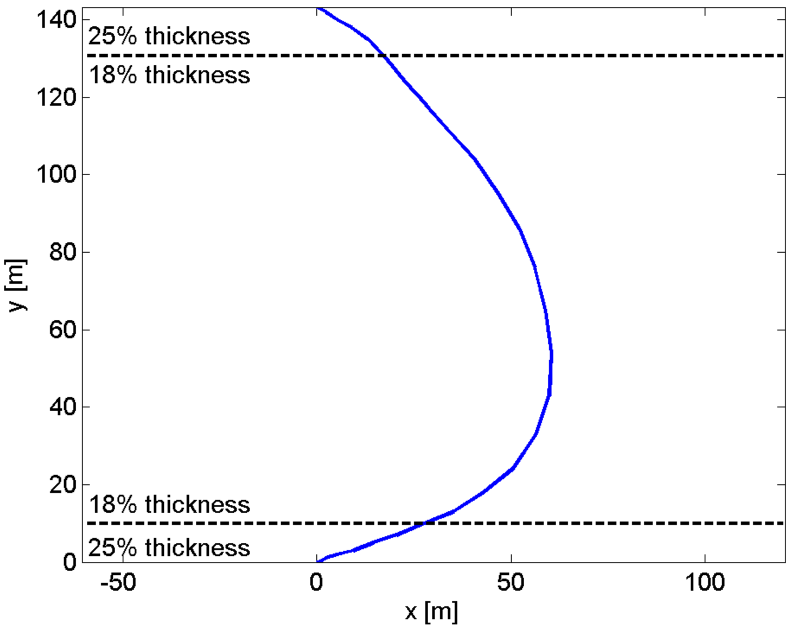


Figure 2.2.: Blade shape of the DeepWind design.

the points on the blades are given in Table 2.2. The measurement points on the arms are located at the end of the arms.

Point	Lengthwise location [m]
Blade 1, 1	0
Blade 1, 2	29.4
Blade 1, 3	56.5
Blade 1, 4	88.9
Blade 1, 5	122.0
Blade 1, 6	162.2
Blade 1, 7	200.4

Table 2.2.: Lengthwise location of the points on the blade. Zero is a the lower end of the blade

2.3. Derivation of the 2D airfoil data

Throughout the course of the development of the turbine, both the airfoil HAWC2 input data and the aerodynamic model in HAWC2 have been updated. In the first iteration of the aeroelastic model, the rotor consisted only out of the NACA0018 airfoil. However, the final rotor design defined two airfoils: the NACA0025 airfoil close to the rotor axis both

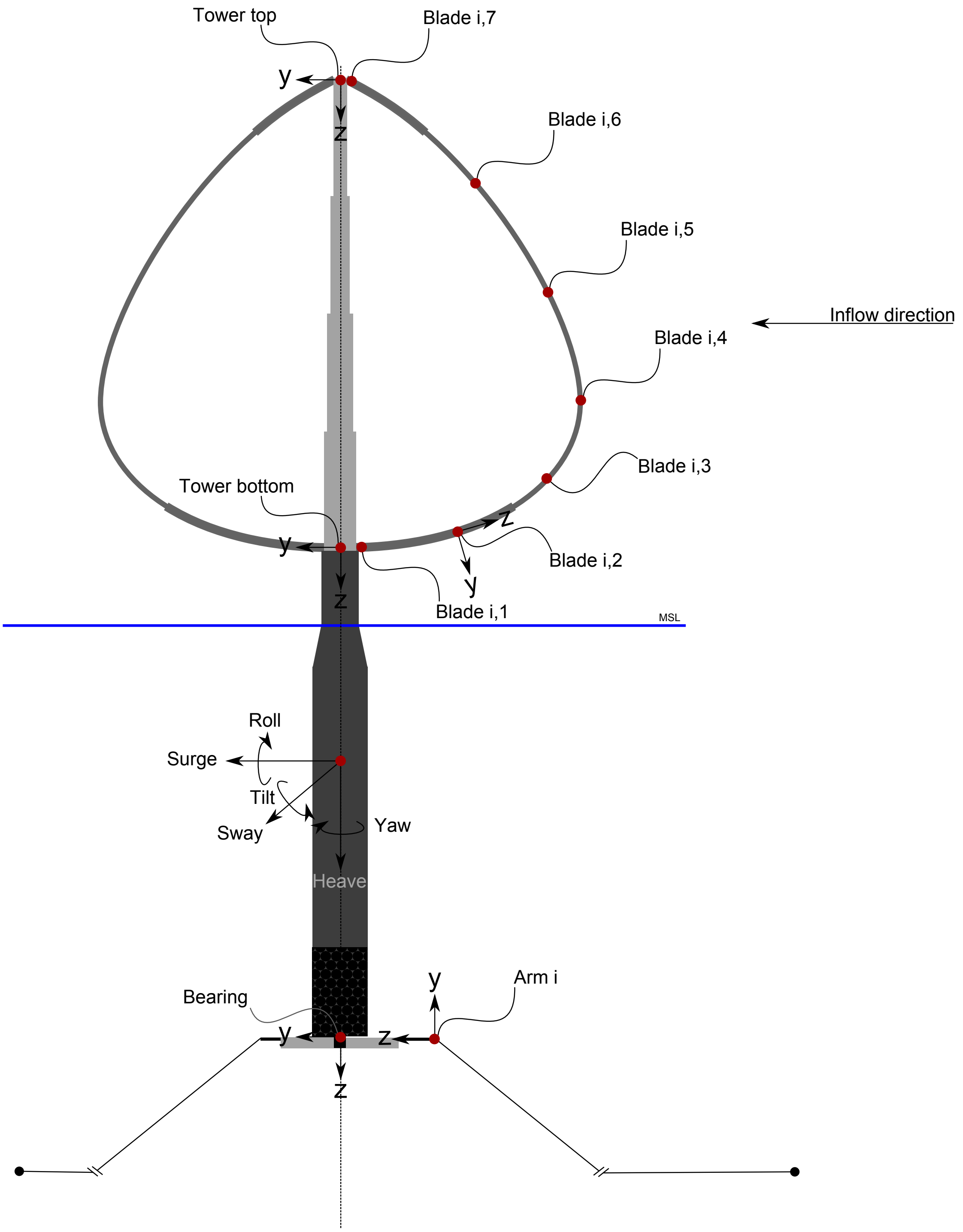
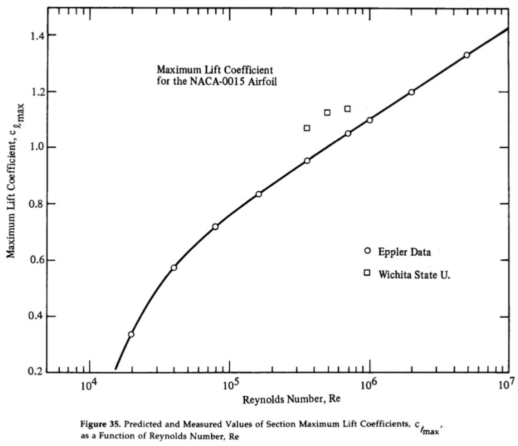


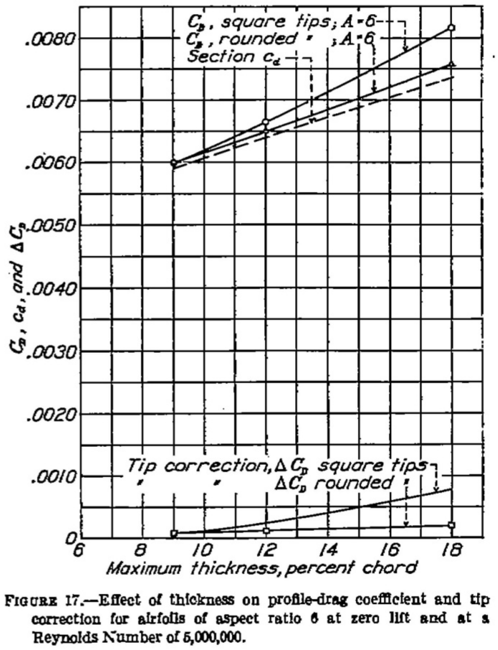
Figure 2.3.: Positions and coordinate systems of the points at which forces, moments and positions are reported.

at top and bottom of shaft, and the NACA0018 on the mid part. This updated rotor (consisting out the the NACA0018 and NACA0025 airfoils) was then later implemented in the aeroelastic model in HAWC2 as well.

The Reynolds number at the biggest radius of 60.5m is based on the mean tangential velocity of the blade (being 37m/s) is about 1.2x107. As there is no Cl and Cd data available for the NACA0018 and NACA0025 airfoils at such high Reynolds numbers, the data was derived based on different sources where the influence of parameters such as Reynolds number and airfoil thickness has been investigated. See figure 2.4(a) and 2.4(b) from [2] and [3] respectively. Also the report on airfoil data original written by Helge Petersen at Risø and later edited by Christian Bak [4] has been used as basis for derivation of the data set.



(a)

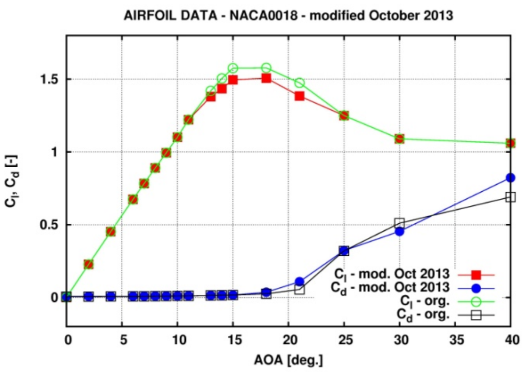


(b)

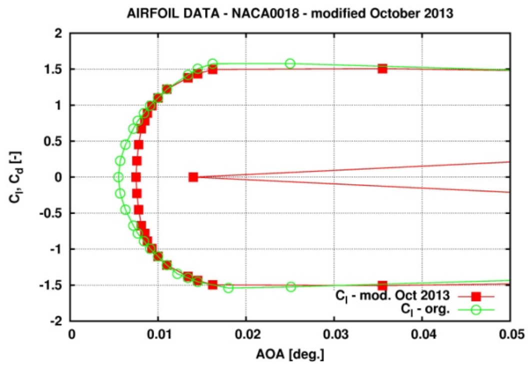
Figure 2.4.: (a) from [2] shows the maximum lift for the NACA0015 airfoil as function of Reynolds number. Figure (b) from [3] shows the minimum drag as function of airfoil thickness for a Reynolds number of 5 mill.

The initial airfoil coefficient dataset is compared with the set later established (October 2013) that included the corrections mentioned above (see [2], [3], and [4]). This comparison is presented in figure for the NACA0018 2.5.

For the updated rotor design of October 2013, the effect of the relatively thicker blade root NACA0025 profile on the maximum lift and drag coefficients can be established based on figure 2.6.



(a)



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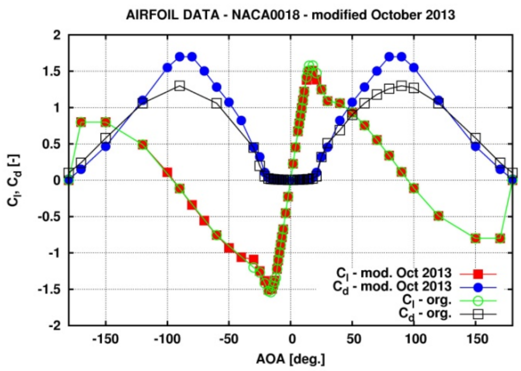
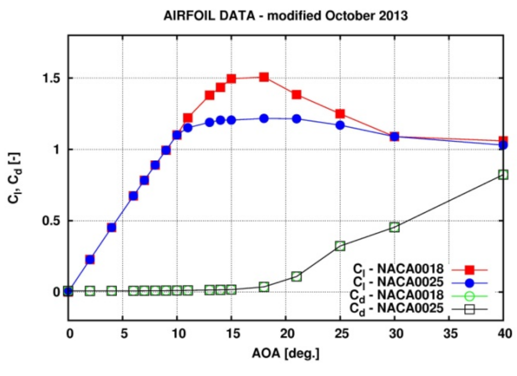
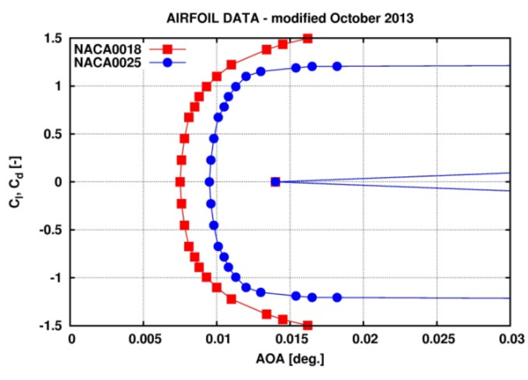


(c)

Figure 2.5.: A comparison with the original airfoil data set for the NACA0018 airfoil and the updated data set corresponding to the DeepWind rotor design in October 2013



(a)



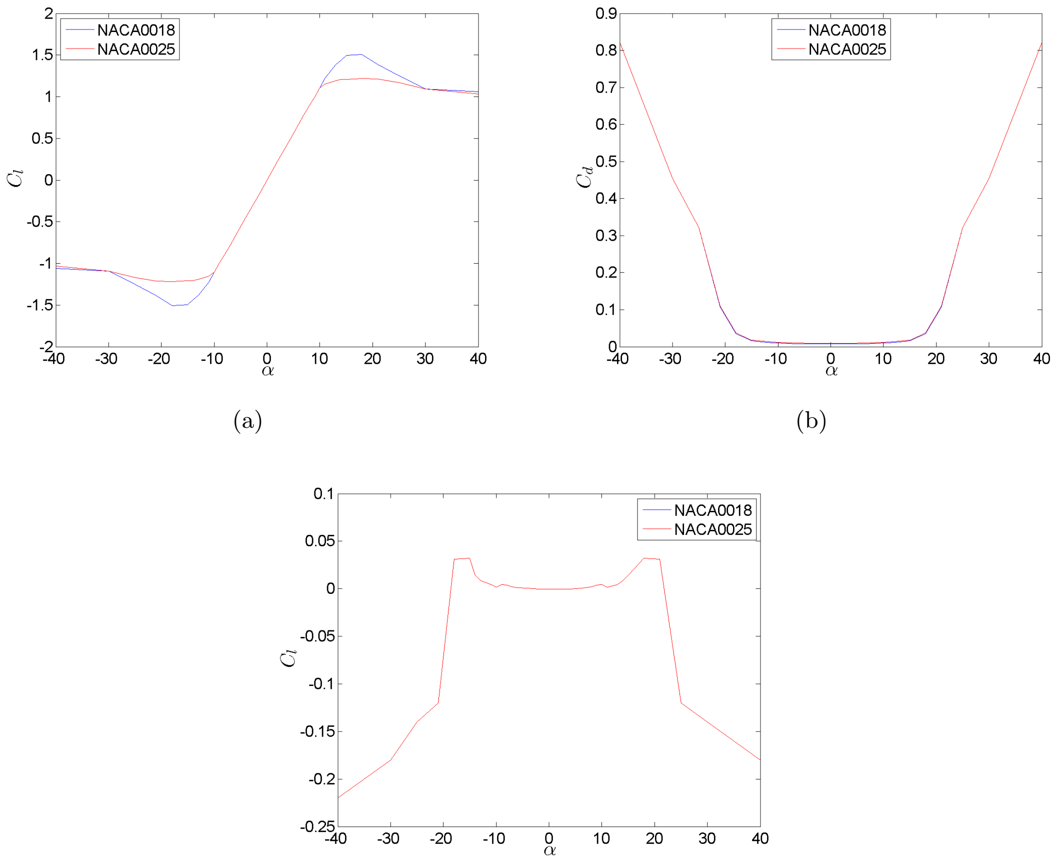
(b)

Figure 2.6.: The lift and drag coefficients for the modified airfoil data sets (Oct 2013) for both the NACA0018 and the NACA0025

2.4. Aerodynamic rotor design

The blades are connected to the tower in the half-chord point. The rotor shape layout is shown in figure 2.2. For a more detailed discussion on the rotor design, see [5].

Two different airfoils are used. In the upper and lower sections of the blades a NACA0025 airfoil is used, whereas at the middle sections a NACA0018 airfoil is applied. In Figure 2.7, the lift, drag and moment polars are shown. In chapter 4 the origin of this data is discussed in more detail. The chord length is 5m.



(a) (b) (c)

Figure 2.7.: Applied lift (a), drag (b) and moment coefficients (c) for the NACA0018 and NACA0025 airfoils plotted as a function of angle of attack

2.5. Blade structure

The blades are made from pultruded glass fibre reinforced epoxy. The result is a composite with a unidirectional fibre orientation, and the material properties can hence assumed to be orthotropic. The pultrusion process for these large blades has been studied in more detail in work package 2, and corresponding publications [6] [7] [8] [9] [10] [11] [12] [13].

The cross sections of the NACA0018 and NACA0025 airfoils are displayed in figure 2.8. Notice the two shear webs positioned which are positioned at 30% and 60% chord length. The thickness of the airfoil and shear web is 10mm. Note that there is no spar cap.

The structural data (cross sectional beam parameters) of the blade is specified in the HAWC2 input files that are presented in Appendix B (figure and tables B.6). [6] elaborates further on the derivation of the cross sectional beam parameters for these pultruded blades. However, one parameter that is not discussed in more detail is the amount of structural damping that one can expect for this blade design. In general, it is difficult to determine the structural damping numerically, but from experience we know that for glass fibre reinforced blades the structural logarithmic damping decrement is somewhere in between 1 and 5% for the first couple of blade modes. These values are for traditional horizontal axis wind turbine blades who are only clamped at the root, but the DeepWind blades are both clamped at the root and the top. Additionally, one might expect other differences because of the different production processes (lay-up with moulds versus pulltrusion). Due to the absence of any more substantial investigations, structural blade damping values are assumed to be within 1-5% (logarithmic decrement) for the first 4 eigen modes.

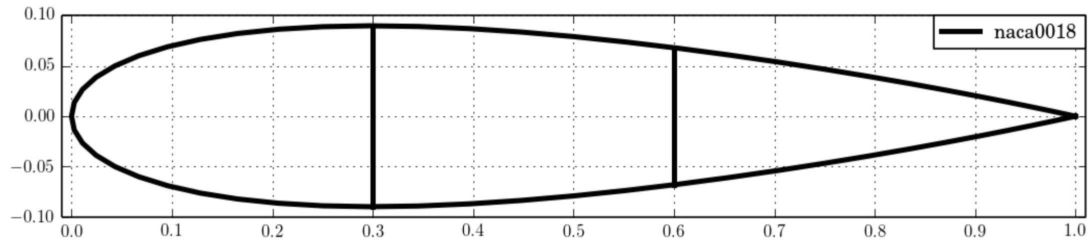
The structural design of this blade only considered a single static load case. Later aeroelastic simulations showed that the design as described above is not stable for all operating conditions (see further down in chapter 4). A more thorough design process that includes an aeroelastic stability analysis should prevent these instabilities. However, for the remainder of this report the blade edgewise and flapwise stiffness is assumed to be very high. The mass properties are, however, physically realistic as defined in the original description of this pulltruded blade.

2.6. Tower

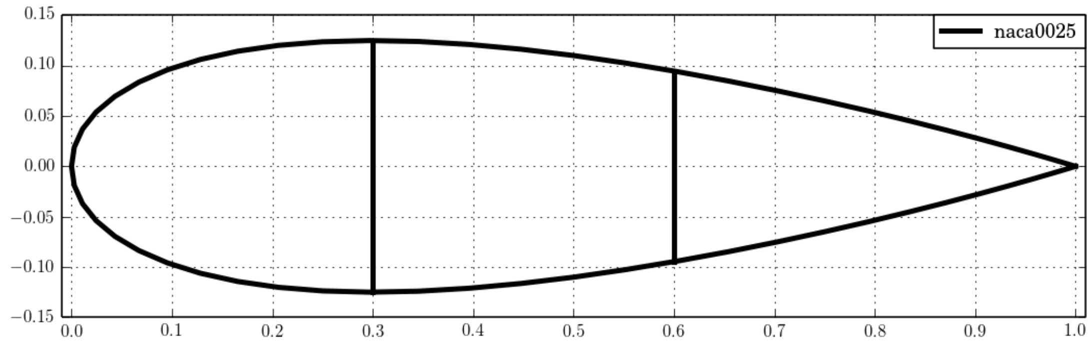
The tapered tower is made from construction steel. The outer dimensions and thickness are indicated in figure 2.1 and listed in table 2.3. The cross sectional beam parameters are derived based on first principle methods (mass and area moment of inertia for a thin walled circle and isotropic material properties), see also figure and tables B.2 in appendix B. The structural damping

2.7. Floater and mooring lines

The floater and the corresponding mooring lines have been discussed and designed in work package 5 and are documented in the deliverables connected to that work package. The floater beam properties for the aeroelastic model have been derived in a similar manner as the tower.



(a)



(b)

Figure 2.8.: NACA0018 (2.8(a)) and NACA0025 (2.8(b)) cross sections with shear webs located at 30% and 60% chord length.

The initial floater design used for this report is described in more detail in deliverable D5-1. The floater outer dimensions can be derived from figure 2.1, and the structural properties are listed in table 2.3, see also figure and tables B.1 in appendix B.

part	radius $[m]$	thickness $[mm]$	material	density $[kg/m^3]$
tower sec 1	4.62	15.0	construction steel	7805
tower sec 2	5.32	17.0	construction steel	7805
tower sec 3	5.84	18.0	construction steel	7805
tower sec 4	6.40	21.9	construction steel	7805
floater top	7.32	50.0	construction steel	7850
floater bot	8.30	50.0	construction steel	7850
ballast	8.30	-	un-compact, water saturated Olivine	2600

Table 2.3.: Structural properties and dimensions of the tower and floater.

2.8. Generator, bearings, and controller

The generator and bearings design and corresponding methodologies were investigated in great detail for work package 3, and are documented in the corresponding deliverables. The controller design procedure is outlined in work package 4. They will not be discussed further within the scope of this report.

3. Simulation Scenarios

Simulations are performed at wind speeds from 4 to 24 m/s. The simulations are performed in both deterministic inflow with a standard power law wind shear and in turbulent inflow (IEC Class C). Four different sea states are simulated. The sea states are summarized in Table 3.1. In all sea states, regular airy waves are used.

	H_s [m]	T_s [s]	Current [m/s]
Sea state 0	0	0	0
Sea state 1	4	9	0.35 for $V_0 < 14$ m/s, 0.7 for $V_0 > 14$ m/s
Sea state 2	9	13.2	0.35 for $V_0 < 14$ m/s, 0.7 for $V_0 > 14$ m/s
Sea state 3	14	16	0.35 for $V_0 < 14$ m/s, 0.7 for $V_0 > 14$ m/s

Table 3.1.: Simulated sea states.

4. The development of the set-up for the simulations

4.1. Introduction

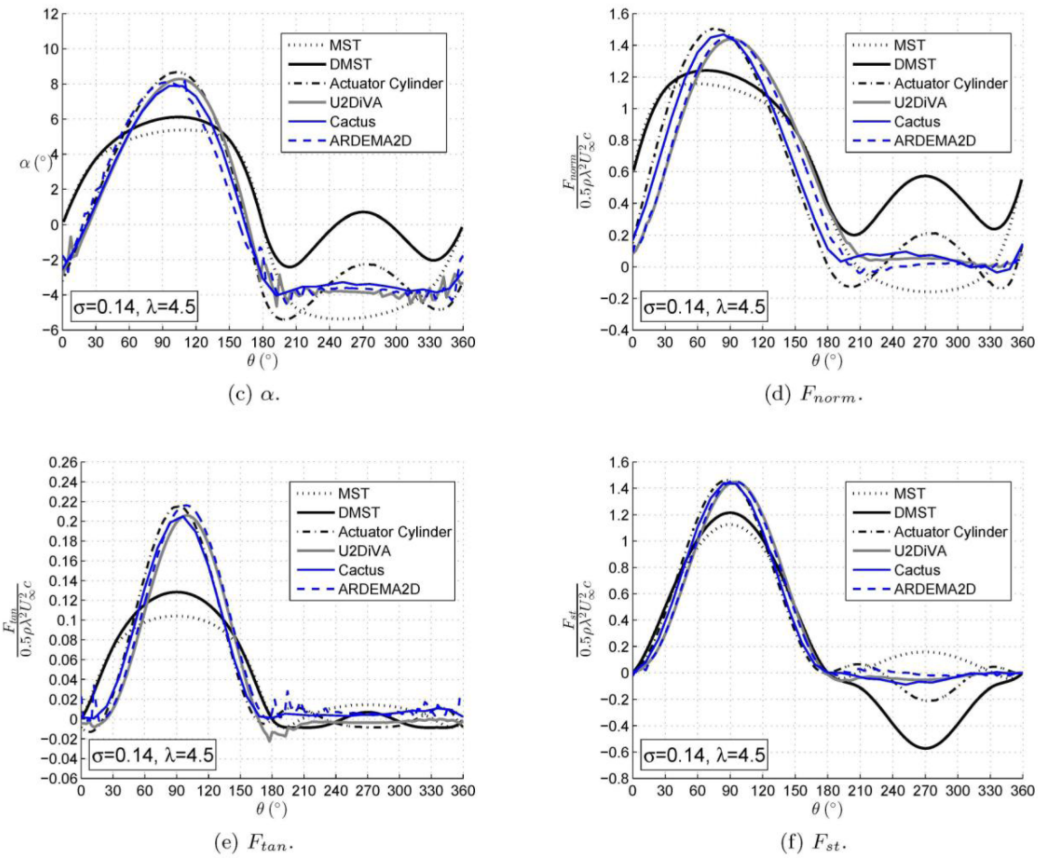
In this section we describe the final set-up for the simulations but also to some degree the path up to this stage. It should remembered that the development of the 5MW Deepwind design has been carried out in parallel with the development of the simulation tools. As mentioned above the first 5MW design1 was presented at an early stage of the project back in 2011. At this early stage the VAWT version of the HAWC2 simulation tool was quite different from the present version and much less comprehensive. This means that during the project new observations on changes in turbine performance or dynamics might be due to changes of the design; due to modified data input such as airfoil data or might be due to a new version of the simulation code. Therefore there is first a brief description of the HAWC2 code development. Then follows a presentation of the airfoil data set used for the final simulations.

4.2. Stages of the HAWC2 code development

During the first part of the project from 2010 to 2011 [1] the aerodynamic forces as well as the induction were simulated in a separate DLL. The induction was computed on basis of the commonly used multiple stream tube (MST) model from Strickland [14]. Also the hydrodynamic forces were computed in a separate DLL and all this slowed down the simulations considerably and did constitute a well integrated model. During 2012 a major work was conducted on implementing a new VAWT induction model, the Actuator Cylinder model [15], in HAWC2. The new induction model was fully integrated in the HAWC2 code without any use of DLLs and the implementation followed the same overall approach as the induction computation for HAWTs which means that the induction at each time step at the points in a grid covering the swept rotor surface. This method means that a dynamic inflow filter now can be applied on the computed instantaneous induction at each grid point. The filter simulates the main physics of the dynamics of the wake which means that the induction also changes slowly to a new stage e.g. when the wind speed is changing. The first HAWC2 version with the new VAWT aerodynamic modelling was ready in July 2012 in Version 11.4 as shown below:

- HAWC2MB 11.4: 20.07.2012 Induction model for VAWTC's implemented.
- HAWC2MB 11.6: 25.09.2013 Update for handling non vertical blade segments

The model was updated in 2013 in version HAWC2MB 11.6 for handling the non-vertical blade elements on a Darrieus type turbine. In 2014 a new validation exercise between several codes comprising the high fidelity vortex code from TUD. The general tendency was that the engineering induction modelling in HAWC2 compared quite good with the vortex model results whereas the often used MST and DMST models showed considerable deviations as illustrated in Figure 4.1.



(c) α.

(d) F_{norm}.

(e) F_{tan}.

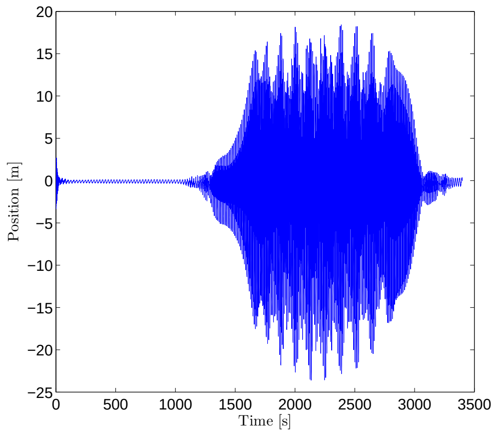
(f) F_{st}.

Figure 4.1.: An example of results from the code comparison exercise presented at TORQUE 2014 conference [16].

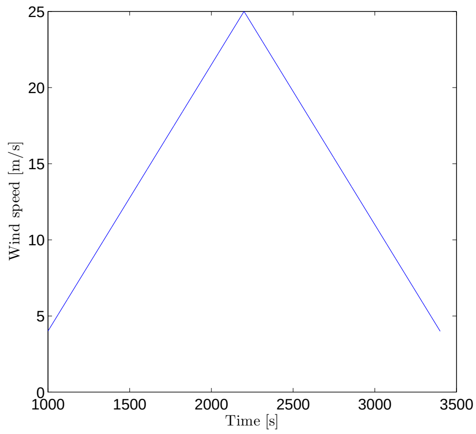
4.3. Blade edge wise instability

Simulations are performed at different development stages of the DeepWind hydro-servo-aeroelastic model. Furthermore, simulations are performed with different blade stiffnesses. In general, the blades of VAWTs encounter a large 2P load cycle in the edgewise direction due to significant changes in flow regime (from deep stall to attached flow at maximum lift and back). This load cycle presents a challenging environment for the blade structure. The proposed blade stiffness for the DeepWind turbine can not operate in a stable fashion. In Figure 4.2, the edgewise instability is illustrated by simulating a wind ramp at fixed rotor speed , and it shows a plot of the edgewise position of the blade point 4 (2.3).

In an attempt to have a broader overview of this instability problem, the tower and rotor combination (without the presence of the floater and hydrodynamics) is simulated for



(a)



(b)

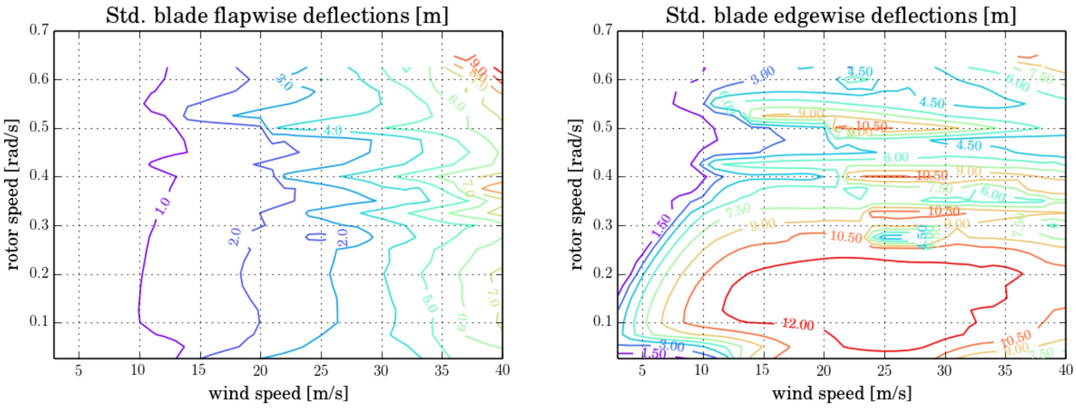
Figure 4.2.: Edgewise position (b) of blade point 4 relative to blade root. Simulated with a rated rotational speed of 0.62 rad/s, and for a given wind ramp (a).

a wide range of rotor and wind speeds in order to see if the problem persists for other operating conditions. Based on figure 4.3 it can be concluded that these instabilities occur over a wide range of operating conditions, and that the structural re-design process of the blade ideally should include some sort of aeroelastic stability check or boundary condition to avoid these issues. These results are based on simulations for which the wind speed ranges from 3 to 40 m/s (with 1 m/s steps) and rotor speeds from 0.025 to 1.0 rad/s (with 0.025 rad/s steps) totalling 1520 different cases. Each simulation runs for 500 seconds and the first 200 seconds are cut off in order to avoid the initial transients. Notice that for rotor speeds of 0.6 rad/s and above the simulations do not converge any longer due to the occurrence of the edgewise vibrations. In this case the absent of a stable numerical solution can be considered as an indicator or proxy for a failing structure.

Figure 4.3 can also serve as a point of departure for the development of control strategies. One could derive a wind versus rotor speed curve covering a wide range of operational conditions while navigating around unfavourable operating points.

For many of the individual cases (as shown in figure 4.3) with large amplitudes on the edge wise blade deflection, the frequency response analysis shows a strong peak on 0.27 Hz (see figure 4.4 as an example). A more thorough analysis on the modes shapes, their respective damping and how they interact with for instance the rotor speed and aerodynamics is required before a more definitive answer can established on the exact source of these instabilities.

Structural damping is, among others, one source of uncertainty. By verifying the effect of different structural damping values of the blade, the sensitivity to the edge wise blade instability can be established. Figure 4.5 shows the relation between the HAWC2 input parameter for the structural damping of the blade (Rayleigh damping) and the logarithmic damping decrement in percentage. Realistic or conservative values would result in logarithmic damping decrement values around 1-5% for the first few blade modes (referring to



(a) (b)

Figure 4.3.: Standard deviations on blade flap- (a), and edge wise deflection (b) for the flexible rotor. Notice that when there are no results available the contours are interrupted. This means that for those wind and rotor speed combinations the simulation was not able to run correctly due to aeroelastic stability issues.

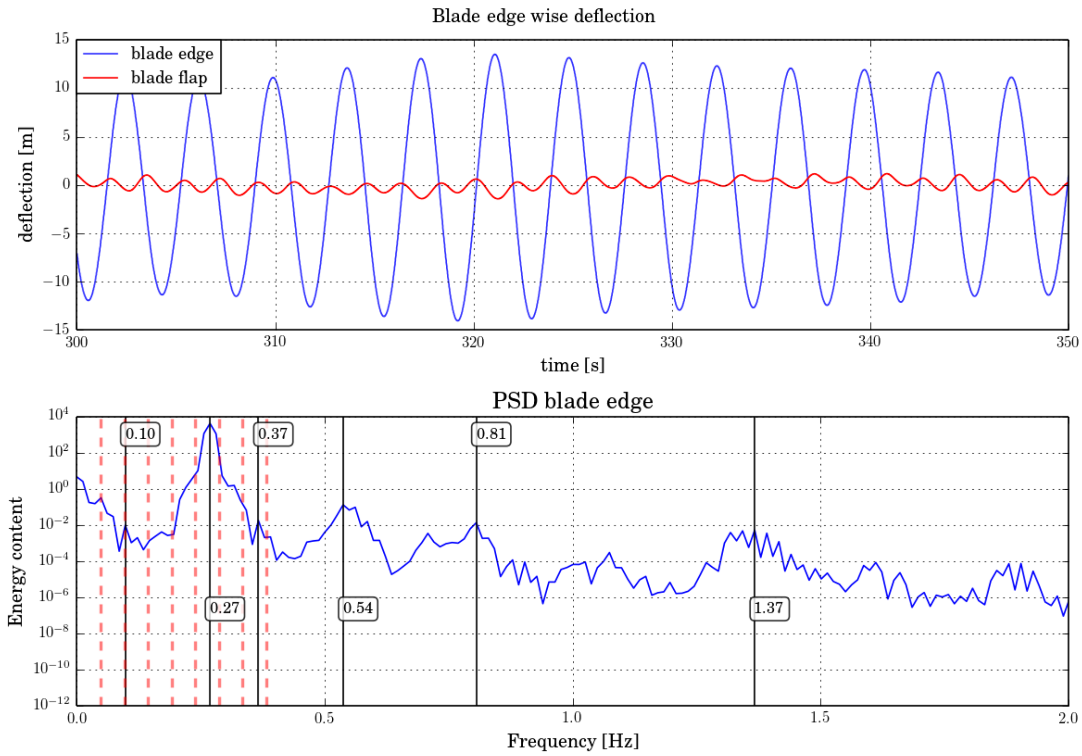


Figure 4.4.: Flap- and edge wise position of blade point relative to the blade root. Simulated with a wind speed of 7 m/s and a rotor speed of 0.15 rad/s. The dashed red lines indicate multiples of the rotor frequency: 2p, 4p, 6p, ..., up to 16p.

Rayleigh damping input parameters of 0.002 and 0.005 in figure 4.5). Less realistic values would be form 0.015 and up.

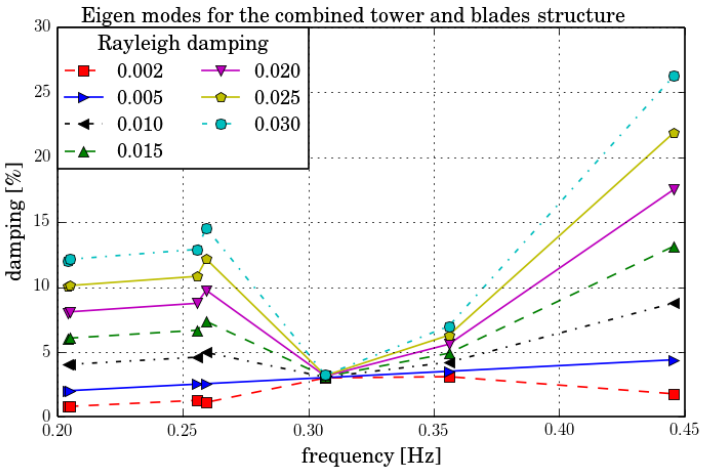
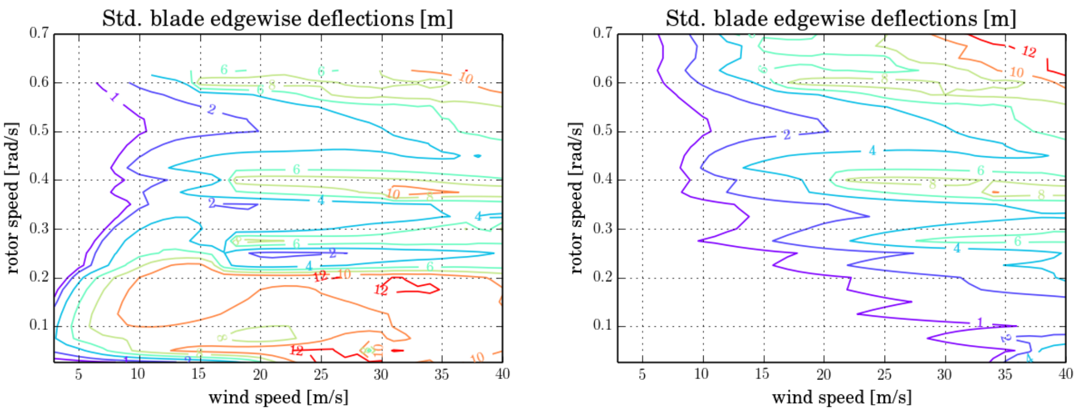


Figure 4.5.: A set of Rayleigh damping parameters and their effect on the structure eigen modes (frequency and damping) of the flexible blades and tower clamped to the ground (no floater and no hydrodynamics). Only the first 6 modes shown.

The influence of structural blade damping is then tested on the range of wind speeds and rotor speeds as used in the paragraphs above. The results shown earlier (figures 4.2(a), and 4.3) had a Rayleigh damping input parameter for the blades of 0.002. For figures 4.6(a) and 4.6(b) the damping is increased to 0.01 and 0.02 respectively. Notice that even for the highly damped case the instability problem still persist at the boundaries of the operation envelope in storm conditions. Figure 4.6 shows that a modest increase in structural blade damping properties can not mitigate this instability problem, and that other measures are required as well. The discussion on how to mitigate the instability problem is referred to future work.

Due to the observed instability and the effect on the shape of the power curve, the structural design of the blade should be revisited to ensure that stable operation at the increased rated speed. However for this the report the design load simulations the blade is modelled as stiff. This simplification will remove the some of the dynamic blade load content, however, tower, floater and generator loads should be less affected by the simplification. The computed blade loads can still serve as an initial design basis for the structural blade design. The design load simulations are performed with a rated rotational speed of 0.62 rad/s.



(a) (b)

Figure 4.6.: Standard deviations of blade edge wise deflections for Rayleigh damping inputs of 0.01 (a) and 0.02 (b) for the flexible rotor.

5. Simulation Results

5.1. Static equilibrium and some notes wrt installation

5.1.1. Introduction

A simplified static stability analysis of the floating DeepWind wind turbine is carried out for tilting angles between 0 (horizontal position) and 90 degrees (normal vertical orientation). When considering different installation procedures of the DeepWind concept, one possible strategy would be to tow the floater in a horizontal position to the side, and at the side let it sink to transition to the vertical position. However, this and other more detailed installation strategies are not considered here. Instead, as a first step, a simple static stability analysis is performed for different ballast levels and for a range of tilting angles.

5.1.2. A simple static stability analysis

The parameters that are used in this analysis are presented in figure 5.1, and in table 5.1.

symbol	description
MSL	mean sea level;
ρ_s	steel density;
ρ_w	water density;
g	gravitational acceleration;
m_{tow}	tower mass, blades included;
z_{tow}	centre of mass vertical location of the system composed of the tower and the two blades;
R_{1ext}	floater external radius in the region of maximum diameter;
R_{1int}	floater internal radius in the region of maximum diameter;
R_{2ext}	floater external radius in the region of minimum diameter;
R_{2int}	floater internal radius in the region of minimum diameter;
L_1	length of the floater maximum diameter region;
L_2	length of the floater miniumum diameter region;
L_3	length of the floater conic region;
L_{fl}	total floater length;
V_1 and m_1	total volume (water displaced) and mass of the floater maximum diameter region;
V_2 and m_2	total volume (water displaced) and mass of the floater miniumum diameter region;
V_3 and m_3	total volume (water displaced) and mass of the floater conic region;
$R_{g,ext}$	generator external radius;
L_g	generator lenght;
V_g	generator case volume (water displaced);
m_g	generator mass (290E+03 kg);
$z_{g,in}$	initial vertical location of the generator centre of mass in relation to the bottom part of the floater (13.5 m);
m_b	ballast mass(3760E+03 kg);
$z_{b,in}$	initial vertical location of the ballast centre of mass in relation to the bottom part of the floater (6.5 m);
F_B	buoyancy force;
L_u	length of the floater part which lies under the MSL;
L_{out}	length of the floater part which stays above the MSL;
z_g	vertical location of the generator centre of mass in relation to the bottom part of the floater;
z_b	vertical location of the ballast centre of mass in relation to the bottom part of the floater;
G	point representing the centre of mass of the all system;
B	point representing the centre of buoyancy of the all system;
α	tower tilt angle;
M	stabilizing moment;

Table 5.1.: Symbols and their respective description for the simplified static stability analysis of the DeepWind turbine.

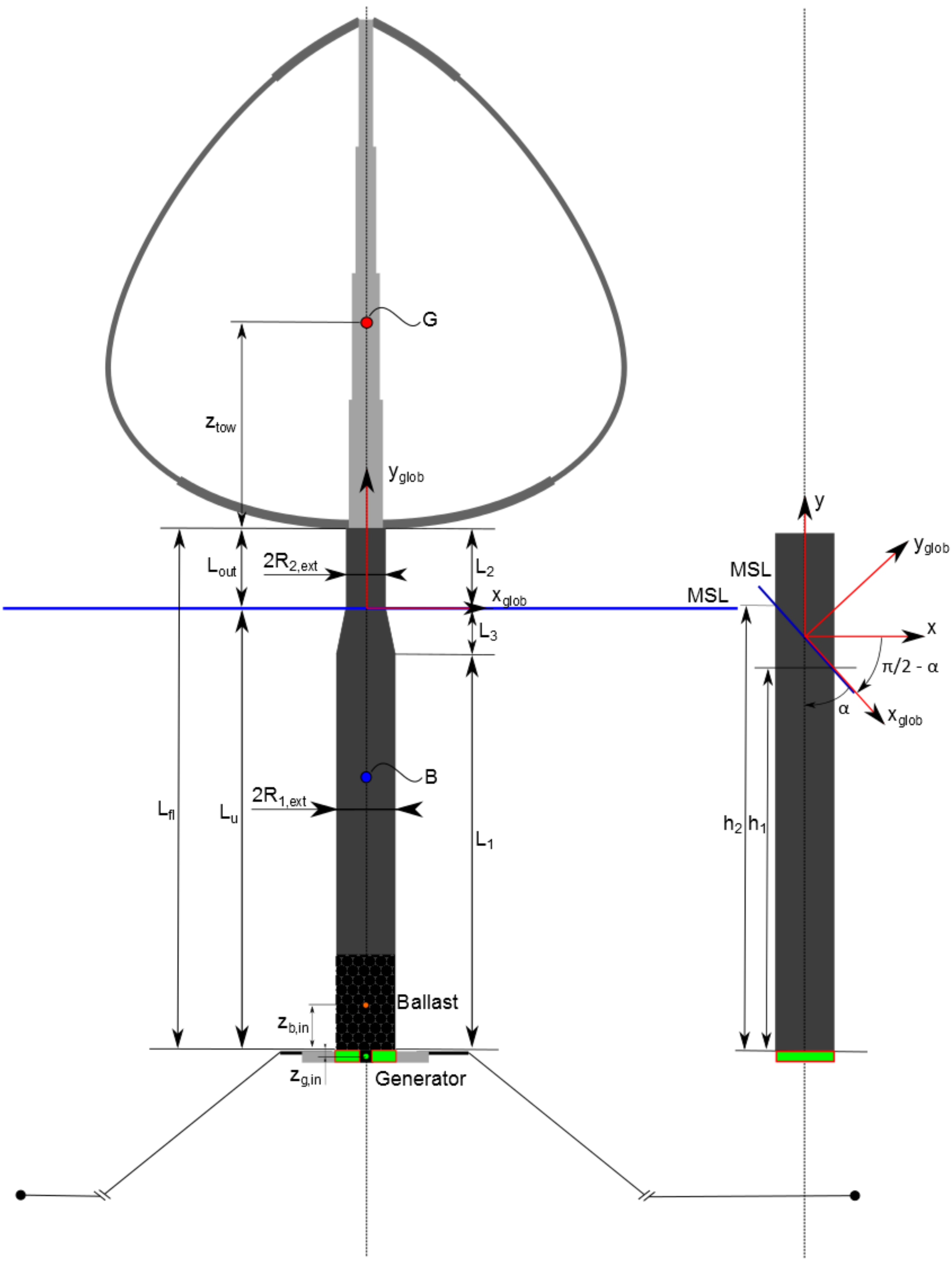


Figure 5.1.: Schematic and main dimensions of the DeepWind 5MW turbine with the definition of the global reference system and the parameters used during the following model.

The floater volume, which is representative of the displaced volume of water, is calculated by adding together the three following terms:

$$V_1 = \pi R_{1ext}^2 L_1 \tag{5.1}$$

$$V_2 = \pi R_{2ext}^2 L_2 \tag{5.2}$$

$$V_3 = \frac{1}{3}\pi \left(R_{1ext}^2 + R_{1ext}R_{2ext} + R_{2ext}^2\right) L_3 \tag{5.3}$$

$$V_{fl} = \Sigma V_i \tag{5.4}$$

In the same way the floater mass is obtained as the sum of:

$$m_1 = \rho_s \pi \left(R_{1ext}^2 - R_{1int}^2\right) L_1 \tag{5.5}$$

$$m_2 = \rho_s \pi \left(R_{2ext}^2 - R_{2int}^2\right) L_1 \tag{5.6}$$

$$m_3 = \rho_s \frac{1}{3}\pi \left(\left(R_{1ext}^2 + R_{1ext}R_{2ext} + R_{2ext}^2\right) - \left(R_{1int}^2 + R_{1int}R_{2int} + R_{2int}^2\right)\right) L_3 \tag{5.7}$$

$$m_{fl} = \Sigma m_i \tag{5.8}$$

The generator case volume is obtained from the external radius:

$$V_g = \pi R_{g,ext}^2 L_g \tag{5.9}$$

while the generator mass is an input.

The buoyancy force is the result of the vertical equilibrium:

$$F_B = g\left(m_{tow} + m_{fl} + m_g + m_b - \rho_w V_g\right) \tag{5.10}$$

From the buoyancy force the length of the floater part which stays under the MSL can be obtained (in absolute value) as:

$$L_u = \frac{F_B}{\rho_w g \pi R_{1ext}^2} \tag{5.11}$$

$$L_{out} = L_{fl} - L_u \tag{5.12}$$

The ballast centre of mass vertical coordinate is:

$$z_b = -L_u + z_{b,in} \tag{5.13}$$

while the generator centre of mass vertical position is at:

$$z_g = -L_u - z_{g,in} \tag{5.14}$$

The system centre of mass calculation is done in the MSL coordinate system (x_{glob}, y_{glob}). The origin is located on the MSL. The position of the centre of mass is fixed in the tower reference system, but in the global reference system it rotates together with the tower tilt angle (α), which is taken in reference to the horizontal MSL.

$$x_G = 0 \tag{5.15}$$

$$z_G = \frac{m_{tow}\left(z_{tow} + L_{out}\right) + m_{fl}\left(-\frac{L_{fl}}{2} + L_{out}\right) + m_g z_g + m_b z_b}{m_{tow} + m_{fl} + m_g + m_b} \tag{5.16}$$

$$\begin{Bmatrix} x_{G,glob} \\ z_{G,glob} \end{Bmatrix} = \begin{bmatrix} \cos\left(\frac{\pi}{2} - \alpha\right) & -\sin\left(\frac{\pi}{2} - \alpha\right) \\ \sin\left(\frac{\pi}{2} - \alpha\right) & \cos\left(\frac{\pi}{2} - \alpha\right) \end{bmatrix} \begin{Bmatrix} x_G \\ z_G \end{Bmatrix} \tag{5.17}$$

The system centre of buoyancy is calculated in the mean see level coordinate system. The origin is located on the MSL. The floater is approximated with a cylinder truncated by the plane representing the MSL. h_1 is the minimum height of the sectioned cylinder and h_2 is the maximum one, defined as:

$$h_1 = L_u - \frac{R_{1ext}}{\tan\alpha} \tag{5.18}$$

$$h_2 = L_u + \frac{R_{1ext}}{\tan\alpha} \tag{5.19}$$

The water volume displaced is then:

$$V_u = \frac{1}{2}\pi R_{1ext}^2\left(h_1 + h_2\right) \tag{5.20}$$

while the coordinates of the centre of mass of the water volume displaced by the floater are:

$$x_{B,fl} = -\frac{R_{1ext}\left(h_2 - h_1\right)}{4\left(h_1 + h_2\right)} \tag{5.21}$$

$$z_{B,fl} = -L_u + \frac{\left(5h_1^2 + 6h_1h_2 + 5h_2^2\right)}{16\left(h_1 + h_2\right)} \tag{5.22}$$

By combining formulas 5.21 and 5.22 with the coordinates of the centre of mass of the generator case, the centre of buoyancy coordinates are obtained in the tower coordinate system and then, through the same rotational matrix as in 5.17, in the global reference system.

$$x_B = \frac{\rho_w V_u x_{B,fl} + \rho_w V_g x_g}{\rho_w V_u + \rho_w V_g} \tag{5.23}$$

$$z_B = \frac{\rho_w V_u z_{B,fl} + \rho_w V_g z_g}{\rho_w V_u + \rho_w V_g} \tag{5.24}$$

$$\begin{Bmatrix} x_{B,glob} \\ z_{B,glob} \end{Bmatrix} = \begin{bmatrix} \cos\left(\frac{\pi}{2} - \alpha\right) & -\sin\left(\frac{\pi}{2} - \alpha\right) \\ \sin\left(\frac{\pi}{2} - \alpha\right) & \cos\left(\frac{\pi}{2} - \alpha\right) \end{bmatrix} \begin{Bmatrix} x_B \\ z_B \end{Bmatrix} \tag{5.25}$$

Knowing the position and the application point of the buoyancy force and the weight force, the stabilizing moment is calculated as:

$$M = -x_{B,glob} F_B + x_{G,glob} \left(m_{tot} g\right) \tag{5.26}$$

where the moment is assumed positive if clockwise.

5.1.3. Results and discussion

The analysis results are presented as a function of the ballast used. Figure 5.2 shows the stabilizing moment as a function of the tower tilt angle α. Knowing that a positive moment is required for stability, figure 5.2 illustrates that a certain amount of ballast is necessary. However, for towing in a horizontal configuration, a different set of requirements will determine the most favourable conditions. By lowering the amount of ballast the up-righting moment can be reduced significantly such that manipulating and controlling the structure into a vertical position becomes theoretically manageable. However, a more detailed installation strategy and dynamic simulations are required for transitioning between vertical and horizontal position, as well as towing the structure.

The positions of the centre of mass and the centre of buoyancy for different ballast and for a tilt angle are represented in Figure 5.3, where only the stable cases are presented.

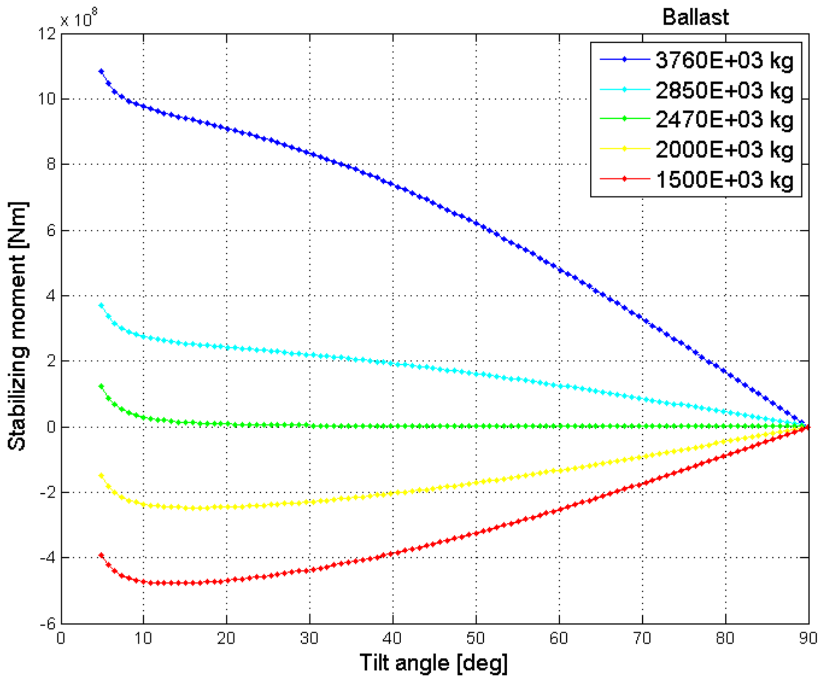
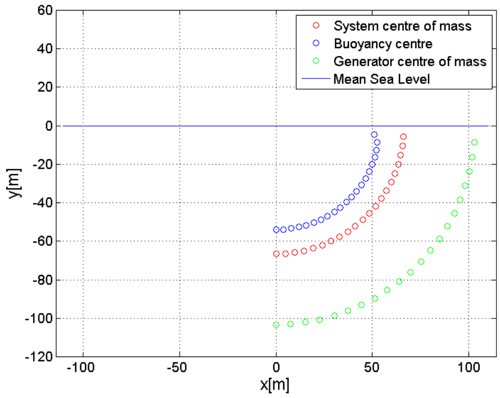
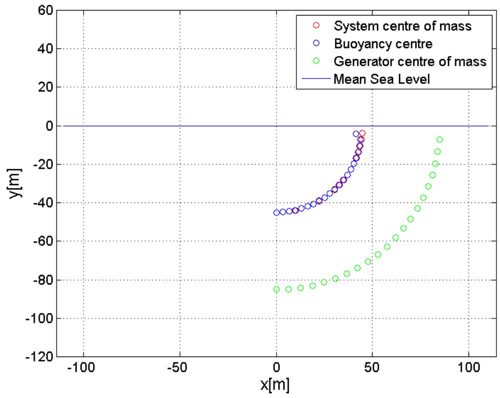


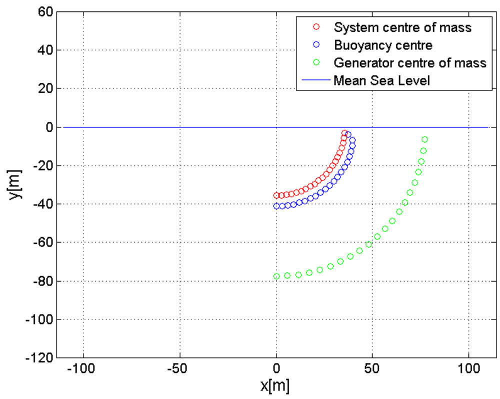
Figure 5.2.: Stabilizing moment as a function of the tilt angle for different ballast value. Note that a negative moment indicates an unstable configuration. 90 degrees refers to a vertical position of the floater.



(a)



(b)



(c)

Figure 5.3.: The positions of the centre of mass and the centre of buoyancy for different tower tilt angle are shown for different ballast: 3760E+03 kg (a), 2850E+03 kg (b) and 2740E+03 kg (c).

5.2. Rigid body motion

The rigid body eigenperiods and dampings of the floating structure, including mooring system is calculated using Hawc2's eigenvalue solver. The results are presented in Table 5.2. Note that, however, these results do not take into account the effect of wind speed and aerodynamic forces. Additionally, the rotor speed is set to zero.

Description	Period [s]	Damping [% log. dec.]
Surge	97.1	1.59
Sway	95.2	1.55
Tilt	30.0	2.92
Roll	29.9	2.86
Yaw	27.6	0.14
Heave	27.2	0.16

Table 5.2.: Rigid body eigenfrequencies and dampings of the floating structure and mooring system

5.3. Steady state aerodynamic thrust, torque and power

The aerodynamic thrust T is based on the total integrated shear forces F and moments M at the tower bottom (see figure 2.3. The resultant of the shear force in the horizontal plane determines the magnitude of the aerodynamic thrust force. The position at which this force is applied is at distance d above the tower bottom. This distance d should result in the same moment M at the tower bottom, hence $d = M/F$. This point can also be described as the centroid of the thrust force. However, one should note that this approach does not take the following into account:

- A possible alignment error between the resultant of the shear force and moment in the horizontal plane is ignored
- Shear force and moment contributions due to structural dynamics and gravity are also included in this thrust force

Ideally, one should integrate the calculated distributed aerodynamic forces, but at the time of writing this method was not implemented yet for the vertical axis wind turbine module in HAWC2. For the purpose of this investigation, and due to the fact that only steady simulations are used that have a clamped tower bottom (ignoring the floater), the included errors for this approach should be minimal.

In order to illustrate the magnitude of the load variations inherently connected with the DeepWind vertical axis wind turbine concept, the rotor torque, resultant thrust force, and thrust direction are plotted as function of azimuth angle in figures 5.4, 5.6, and 5.7 respectively. These figures are based on steady state simulation results (using HAWC2) where the rotor bottom is fixed to the ground, and hence ignoring the floater and its interactions with water and waves. Notice in figure 5.4 how for 6 m/s the rotor speed variance has a limited effect on torque since the operational point is around optimal tip speed ratio's. At 14 m/s a reducing the rotor speed below the rated speed of 0.625 rad/s results into a significant torque reduction due to stalled flow at azimuth angles around 0 and 180 degrees. For the 25 m/s case the reader can observe how reducing the rotor speed results again in torque reductions at especially 0 and 180 degrees due a deeply stalled blade.

Note that as mentioned earlier in section 2.5 the blade is very stiff to avoid edgewise vibration issues.

A global torque and power performance overview of the DeepWind concept is given in figures 5.5(a) and 5.5(b). By considering wind speeds ranging from 3 until 41 m/s (with 1 m/s steps), and rotor speeds from 0.025 until 1.0 rad/s (with 0.025 rad/s steps) a grid is created holding all possible operating points. This grid is constructed based on 1520 HAWC2 simulations, and the azimuthal resolution is set to 1 deg resulting in 360 points per simulation. The mean aerodynamic torque and power contour lines are plotted in figures 5.5(a) and 5.5(b) respectively.

The mean resultant thrust forces and their corresponding centroid positions (relative to the tower bottom) are given in figures 5.8(a) and 5.8(b).

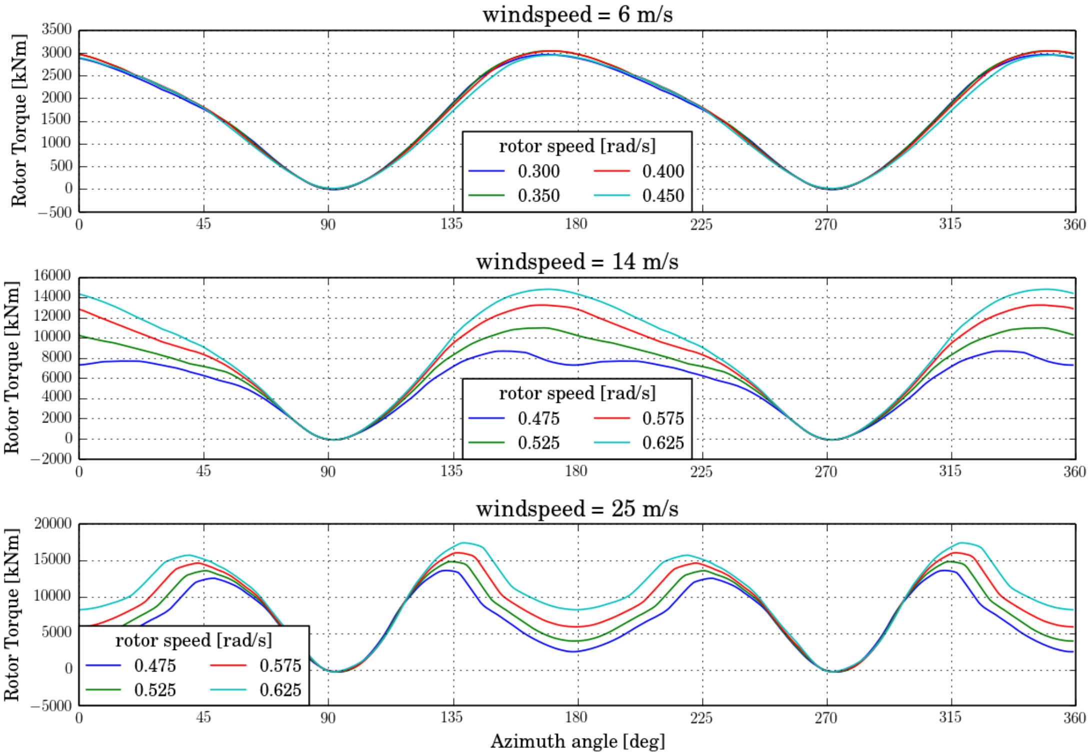
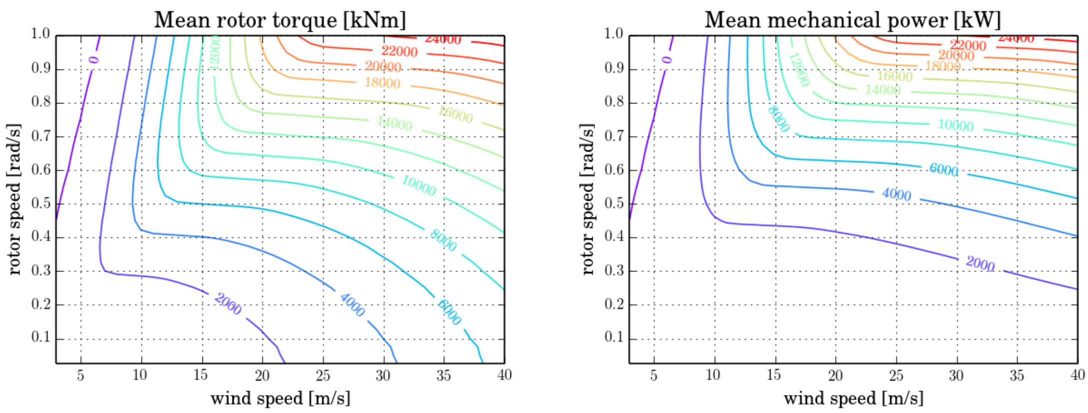


Figure 5.4.: Torque variations as function of rotor azimuth angle for a set of rotor and wind speed combinations. Note that the rated rotor speed is around 0.625 rad/s. Stiff rotor blades.



(a) (b)

Figure 5.5.: Mean aerodynamic torque (a) as function of rotor and wind speed. Mean aerodynamic power (b) as function of rotor and wind speed.

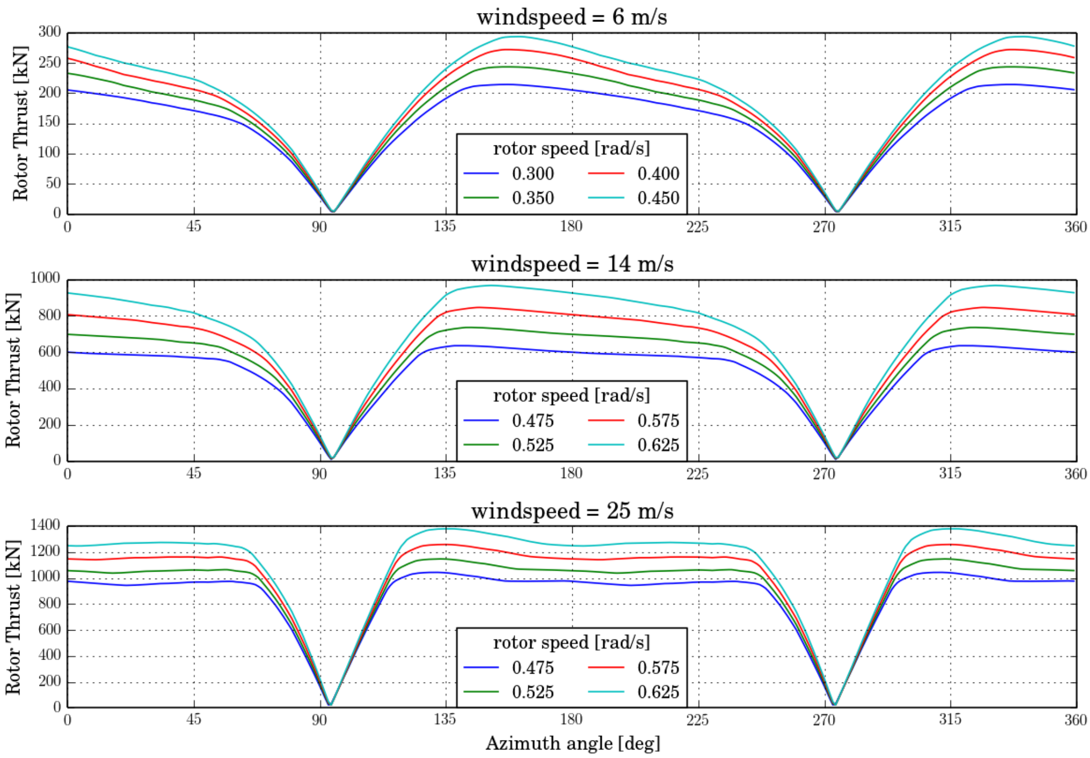


Figure 5.6.: Thrust variations as function of rotor azimuth angle for a set of rotor and wind speed combinations. Note that the rated rotor speed is around 0.625 rad/s.

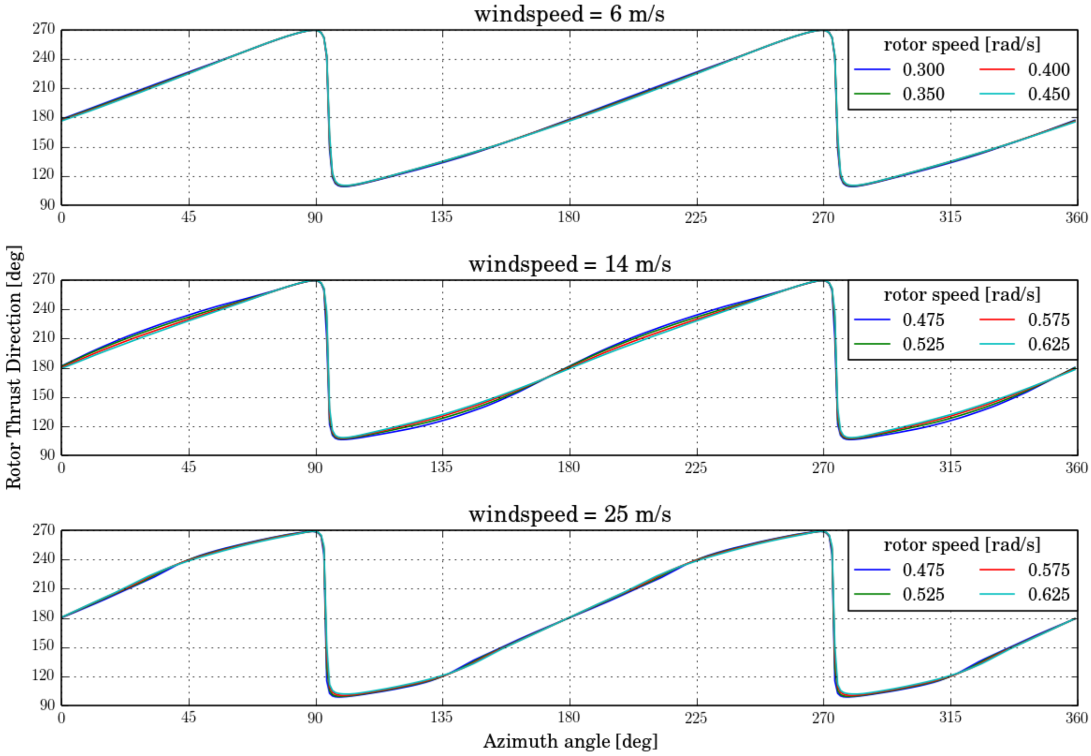


Figure 5.7.: Thrust direction variations as function of rotor azimuth angle for a set of rotor and wind speed combinations. Note that the rated rotor speed is around 0.625 rad/s. When the line formed by the blades is aligned with the wind, the azimuth angle is zero. Further, the rotation direction is clockwise meaning that a thrust direction of 180 degree has the same direction as the wind vector.

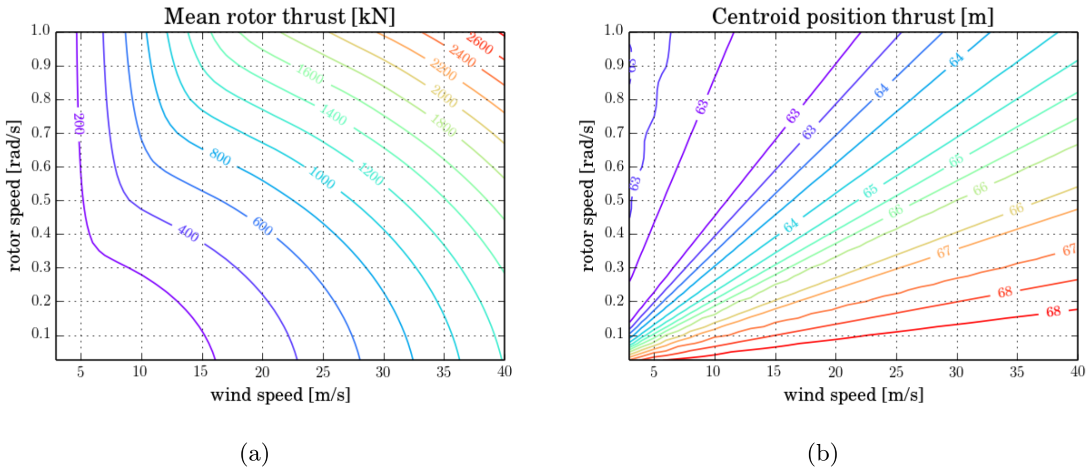


Figure 5.8.: Mean aerodynamic thrust (a) as function of rotor and wind speed. Mean centroid position of the thrust relative to tower bottom (b).

5.4. Generator torque control and yaw instabilities

The controller design has been discussed in great detail in work package 4 and related deliverables. For this work a simplified model was created, and only a limited set of load cases was considered. This simplified approach is a requirement in order to be able to consider many different design iterations. The implementation of the controller as described in work package 4, deliverable D4.3 is a Matlab-Simulink model; while for the interactions with HAWC2 this is a MS Windows DLL programmed in Delphi/Pascal. Both implementations have not been compared in great detail. As a result it is not possible to claim at this stage that the controllers will behave the same in general. However, the controller implementation for the HAWC2 model has received careful attention, and is based upon the strategies outlined in deliverable D4.3.

The tuned controller as defined in work package 4 performs well for below rated conditions in the HAWC2 simulations. Above rated conditions show an interaction between the generator torque and the yawing motion of the generator casing. In a first attempt to solve these problems, the simplified controller design model was updated to reflect the latest design changes of the DeepWind turbine. Additionally, the aerodynamic load tables used for these simulations are now based on HAWC2 simulations of the rotor mounted on a rigid platform that is fixed to the ground (mean values for these load tables are given in figures 5.5(a) and 5.5(b)). However, the simplified model with control behaved as expected, and both possible differences in controller implementation and/or more complex interactions in the HAWC2 simulations might be causing this.

The instabilities are visualized in figures 5.9 and 5.10: for a small portion of a 2000 second long simulation the stator yaw angle, rotor speed , generator torque, wind speed and water level (indicating wave height) is shown. Notice that the instability is grows but dies suddenly after 50 seconds, to be build up again later. One should also pay attention to the very wide range of the yaw excursions: they go from -62 to 42 degrees. This pattern is repeated over the entire duration of the 2000 seconds of the simulation. At higher wind speeds the instability persists (not shown here) and does not have the lower frequent beating characteristics that are clearly visual in figures 5.9 and 5.10. Further, one can notice that a very similar behaviour is revealed for a case with for which the environmental conditions are turbulent with waves (figure 5.9) or without (figure 5.10).

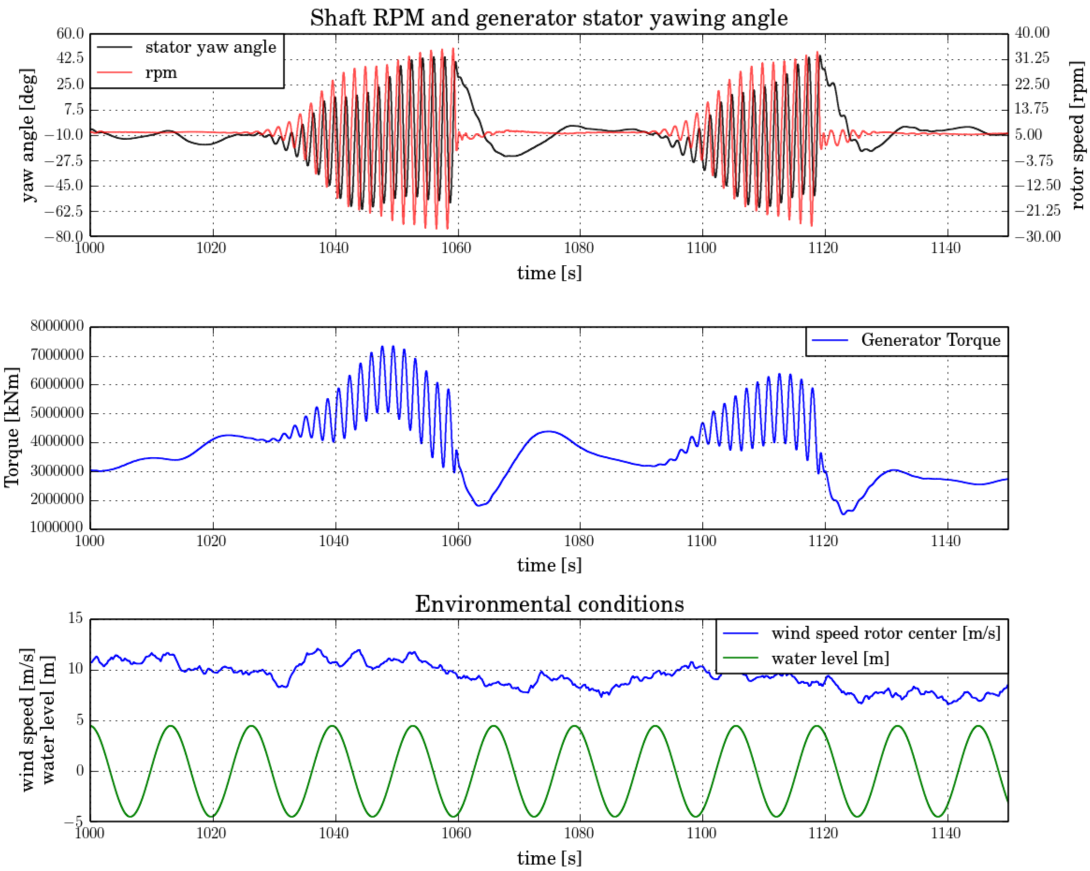


Figure 5.9.: Yaw instabilities and generator torque control interactions for a case at 10 m/s (turbulent inflow) and with sea state 2 (9m regular waves, or refer to table 3.1). Torque arms are 9m long, and their hydrodynamic drag coefficient is 0.6

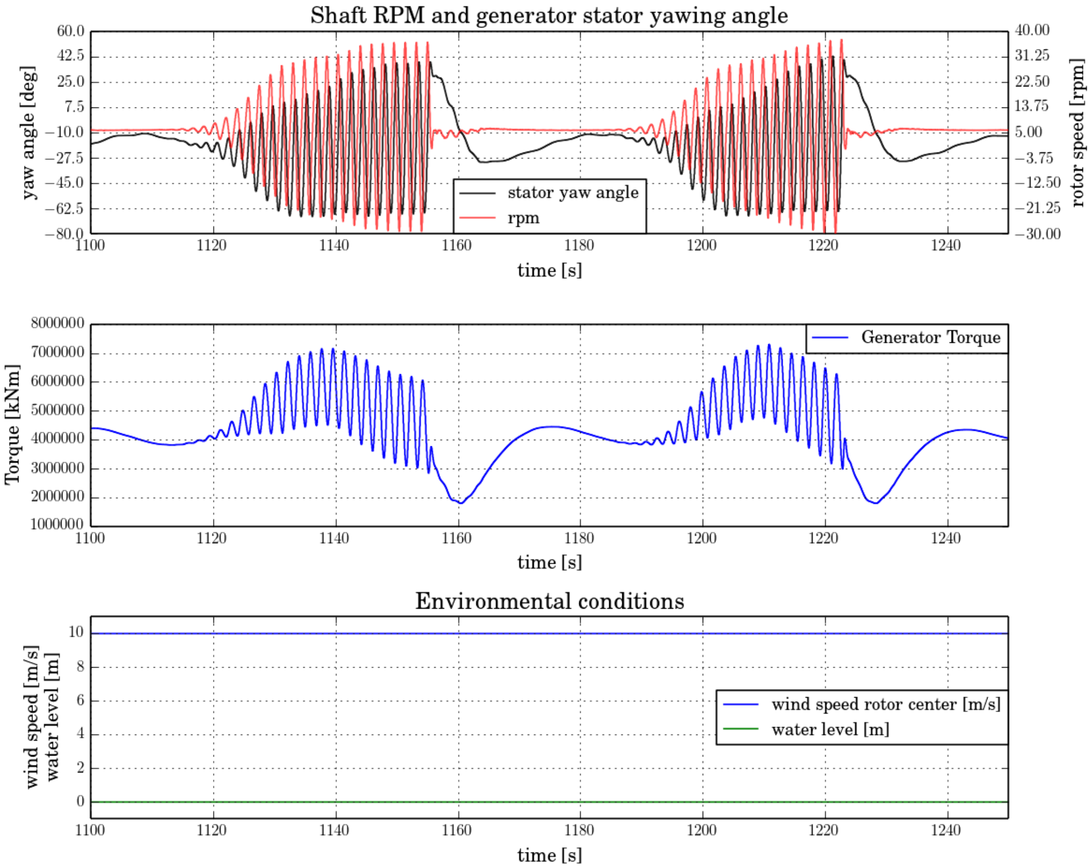


Figure 5.10.: Yaw instabilities and generator torque control interactions for a case at 10 m/s (deterministic inflow) and steady sea (no waves). Torque arms are 9m long, and their hydrodynamic drag coefficient is 0.6

In a second attempt to regulate these instabilities, the generator torque arms (more specifically the arms to which the mooring lines are attached, see also figure 2.1) are increased from 9 to 15 meters, and the hydrodynamic drag coefficient of the arms is increased from 0.6, which is a realistic value, to a higher but still physically acceptable 1.0. The hydrodynamic drag force acts as a viscous damper on the yawing motion of the generator casing.

The yawing stiffness of the generator casing originates from the mooring lines. In order to get a more clear overview of the yaw instability problem, the yaw stiffness of the system is derived based on HAWC2 simulations. To this end, a series of predetermined torque/yaw moments are applied on the generator casing and their corresponding yaw angles is recorded. The yaw stiffness is then established as:

$$K_{yaw} = M_{yaw}/\phi_{yaw} \tag{5.27}$$

By repeating this process for arm lengths of 9, 15 and 25 meters, figure 5.11 can be constructed (and tabulated values in table 5.3). Although this process is computationally heavy, the stiffness is derived accurately including non linear effects for increasing yaw angles. Notice that the mooring line length and the anchor points are not changed.

Finally it is noted that the original design proposal had torque arms of 9 meter length (or equivalently, the mooring lines fair leads have a 9m radius), but due to the instabilities reported here they are increased to 15 meter. Since the original controller and corresponding simplified model as proposed in work package 4 (turbine operational control) operates in a stable fashion, one could investigate why the HAWC2 implementation of the controller can not mitigate these unfavourable conditions. However, at the time of writing this is only mend as a recommendation for future work.

Torque arm length [m]	Yaw stiffness [Nm/rad]
9	$1.403e7$
15	$2.323e7$
25	$3.795e7$

Table 5.3.: Average yaw stiffness based on yaw angles below 4 degrees

Typical yaw responses for the torque arms of 15m length and hydrodynamic drag coefficient of 1.0 are shown in figures 5.12 and 5.13. A similar beating phenomena compared to the 9m torque arms is observed in figure 5.12, however, now the yaw angle excursions are limited to a few degrees instead of 100. This indicates that the root cause of the problem is not entirely eliminated, but the increased yaw stiffness and damping reduces the problem to manageable proportions. In figure 5.13 another typical response is shown whereby a more or less constant amplitude vibration of approximately 4-5 degrees characterises the yaw response of the stator.

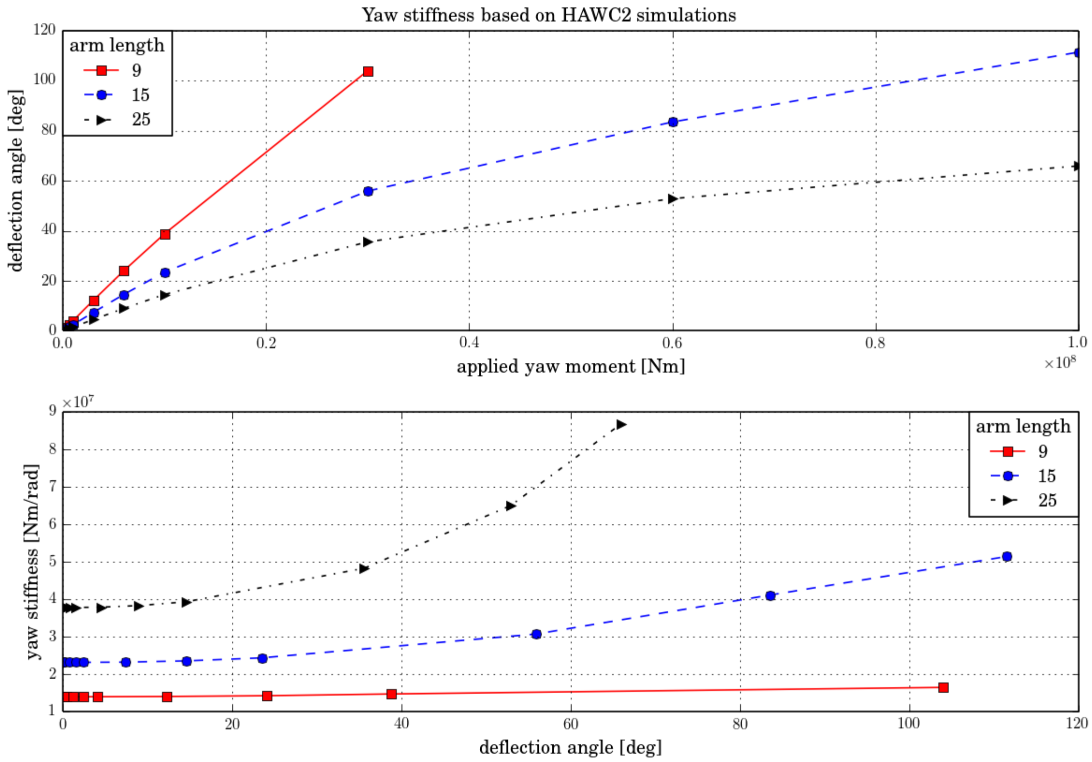


Figure 5.11.: Yaw stiffness due to the presence of the mooring lines derived from HAWC2 simulations (no wind nor waves, steady state conditions have reached). Notice the non constant and non linear stiffness especially for longer torque arms

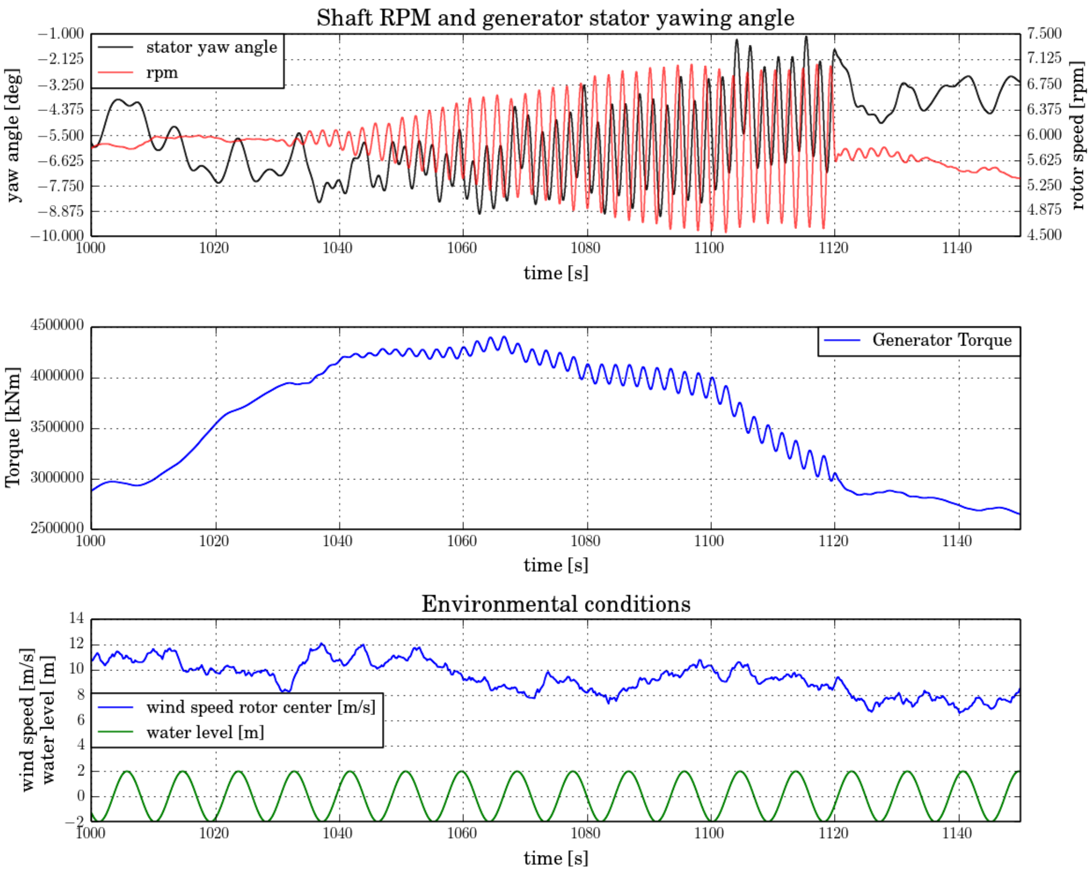


Figure 5.12.: Limited yaw stator angle and generator control interactions for a typical case at 8 m/s (turbulent inflow) and sea state 1 (4m regular waves, or refer to table 3.1). Torque arms are 15m long, and their hydrodynamic drag coefficient is 1.0

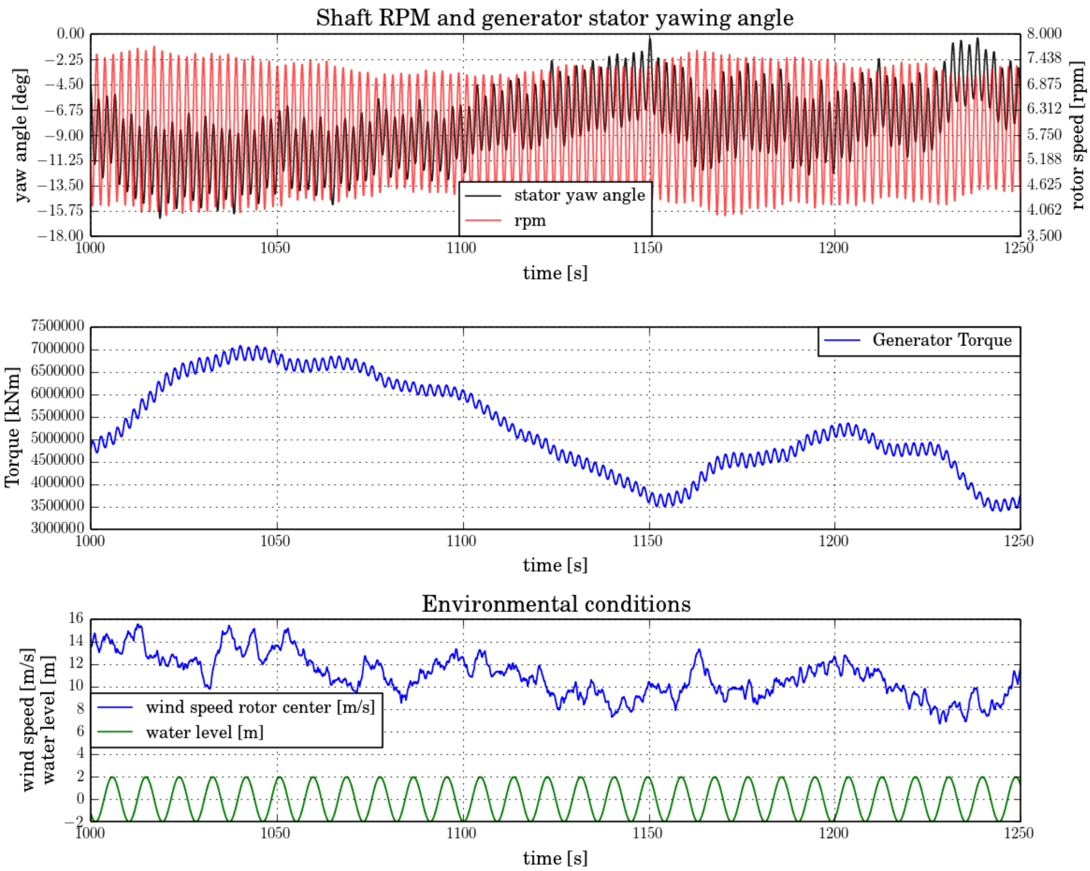
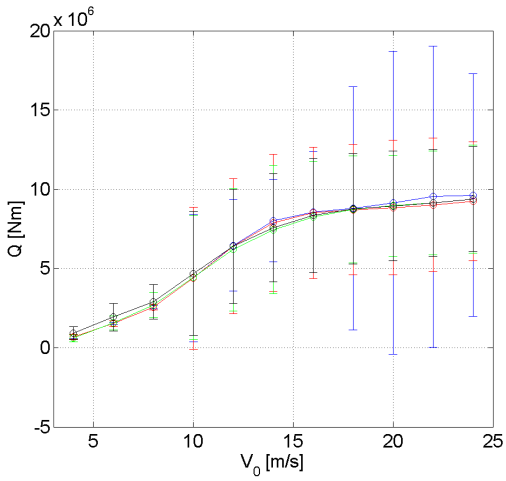


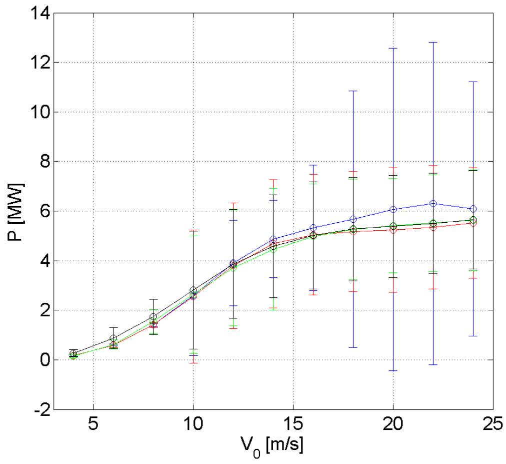
Figure 5.13.: Limited yaw stator angle and generator control interactions for a typical case at 10 m/s (turbulent inflow) and sea state 1 (4m regular waves, or refer to table 3.1). Torque arms are 15m long, and their hydrodynamic drag coefficient is 1.0

5.5. Deterministic Inflow

5.5.1. Generator Torque and Power



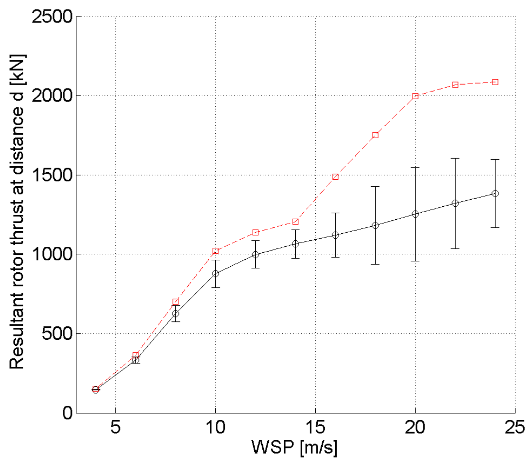
(a)



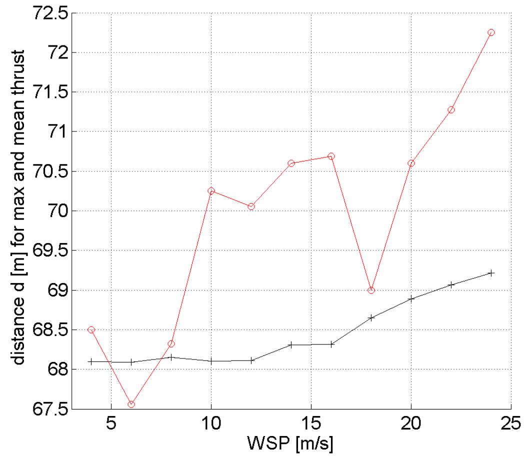
(b)

Figure 5.14.: a) Generator torque, b) Generator Power. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.2. Rotor thrust



(a)



(b)

Figure 5.15.: a) Resultant rotor thrust force in the horizontal plane, b) vertical position of the thrust force above the tower base. Black: mean values, red maxima. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.3. Pitch and Roll of Rotor, Yawing Generator

Plots of the pitch angle of the rotor during operation, the conventions of the pitch, yaw and roll movements are shown in Figure 2.3.

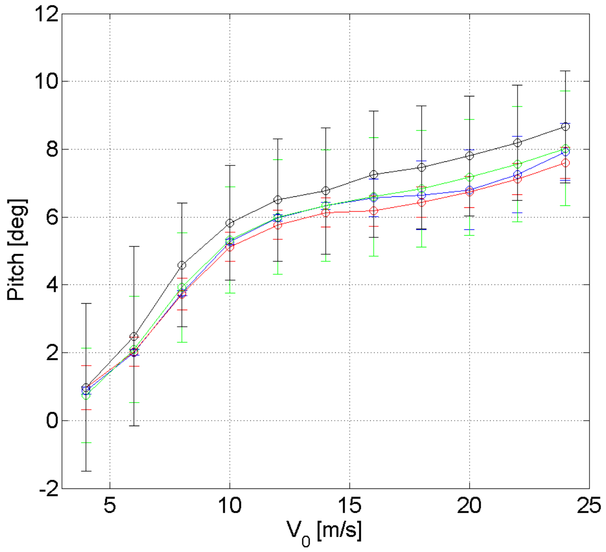


Figure 5.16.: Pitch of rotor. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

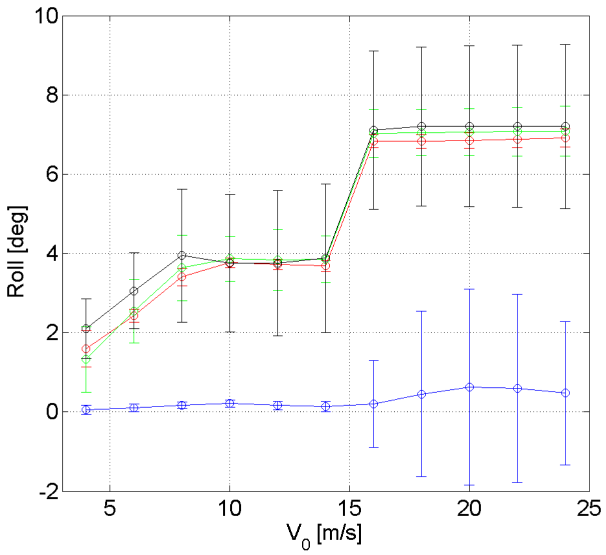


Figure 5.17.: Roll of rotor. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

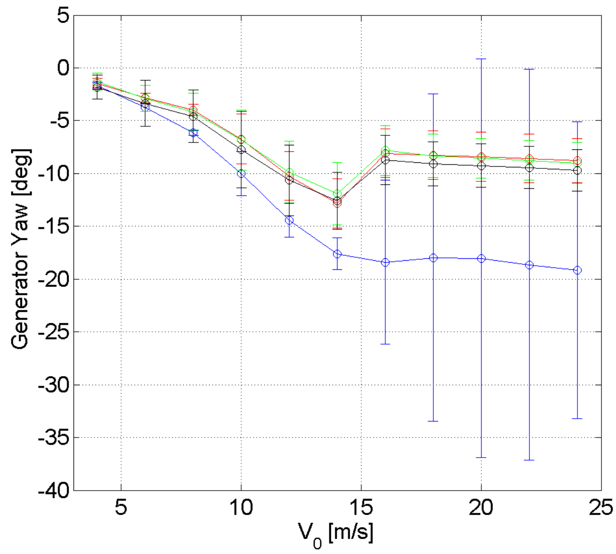
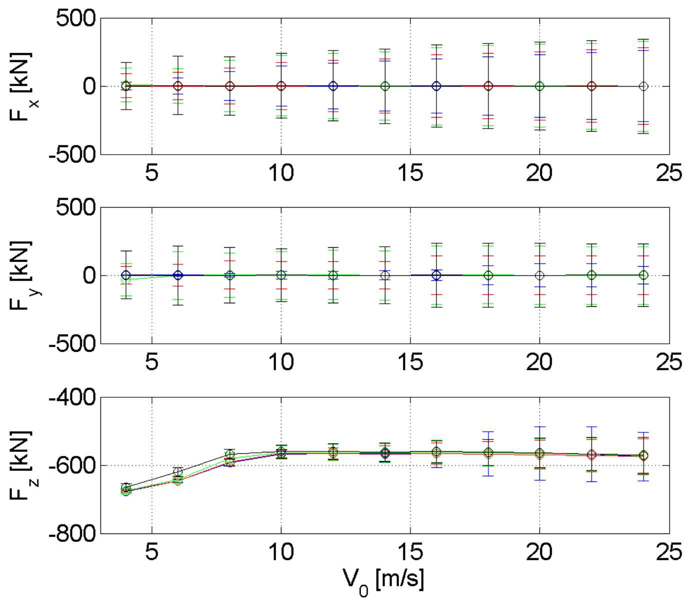


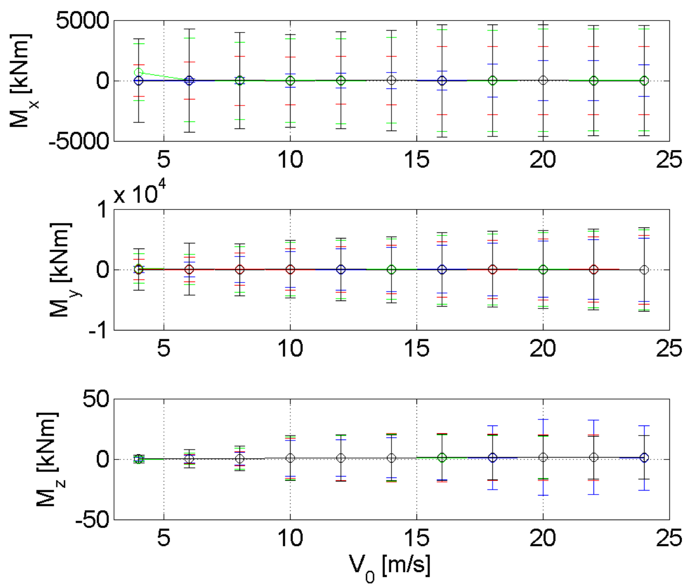
Figure 5.18.: Yaw of generator casing. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.4. Tower Top

Plots of loads in the tower top.



(a)

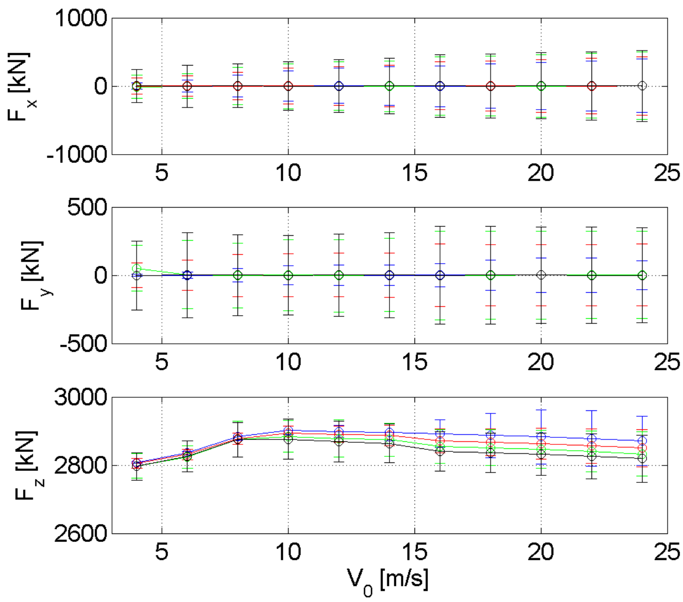


(b)

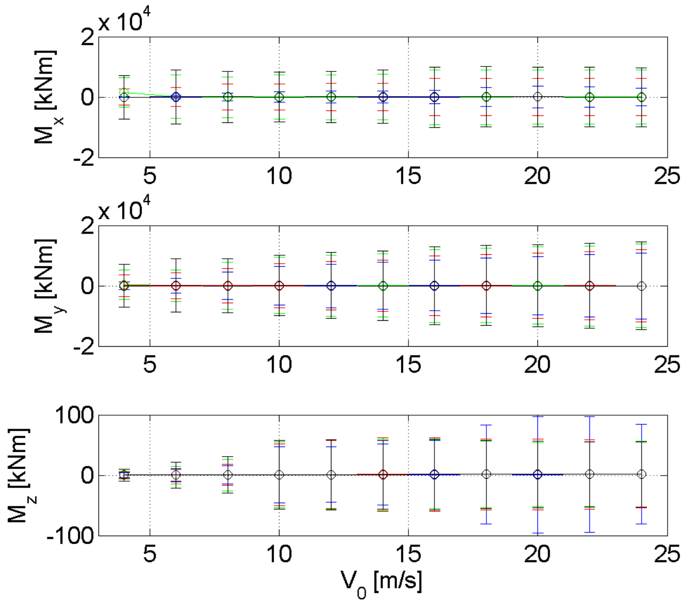
Figure 5.19.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.5. Tower Bottom

Plots of loads in the tower bottom.



(a)

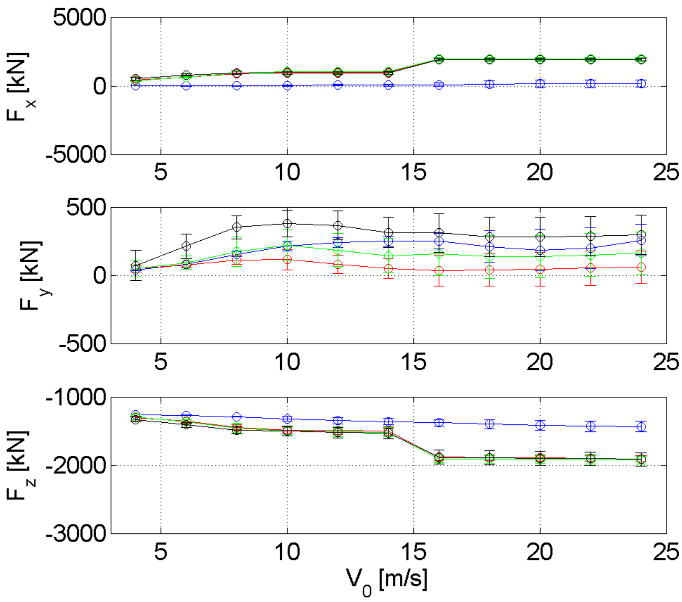


(b)

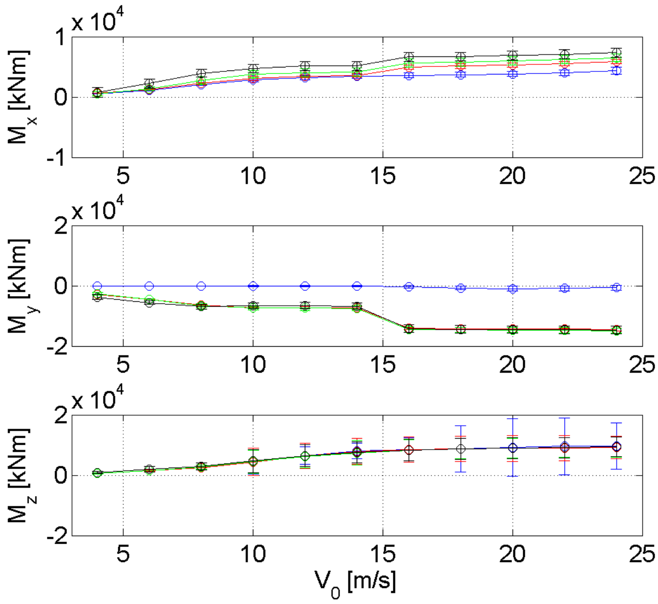
Figure 5.20.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.6. Shaft

Plots of loads in the Shaft.



(a)

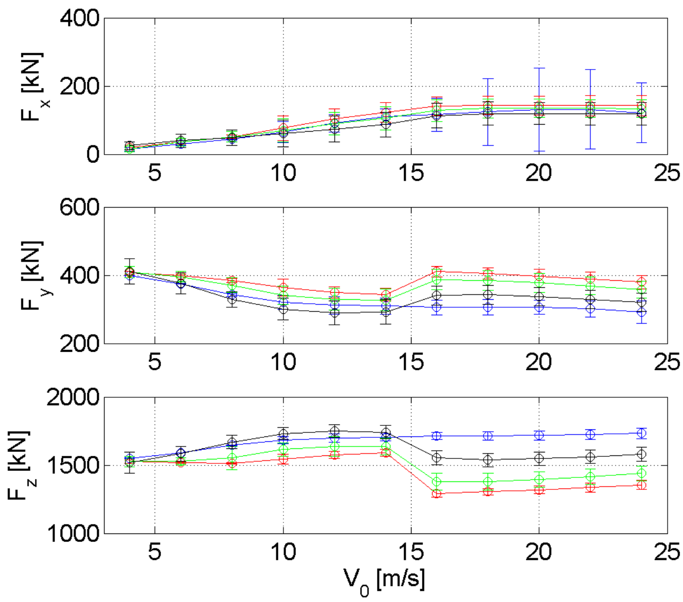


(b)

Figure 5.21.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.7. Arm 1

Plots of loads in the arm 1.



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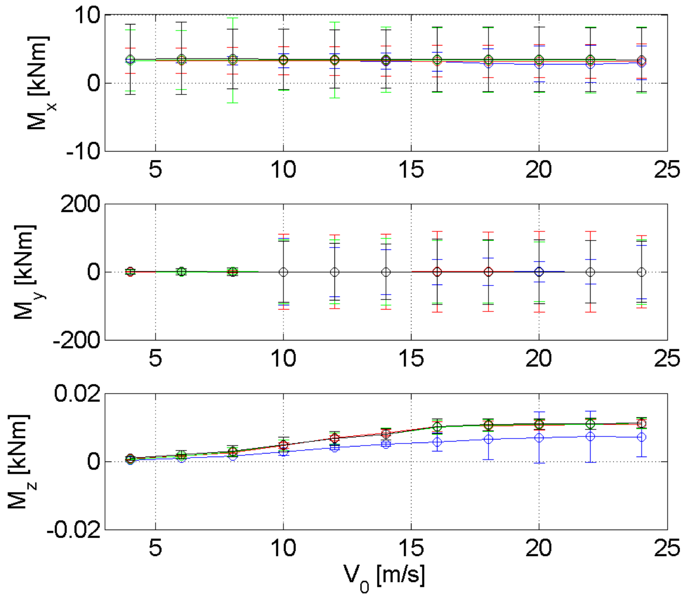
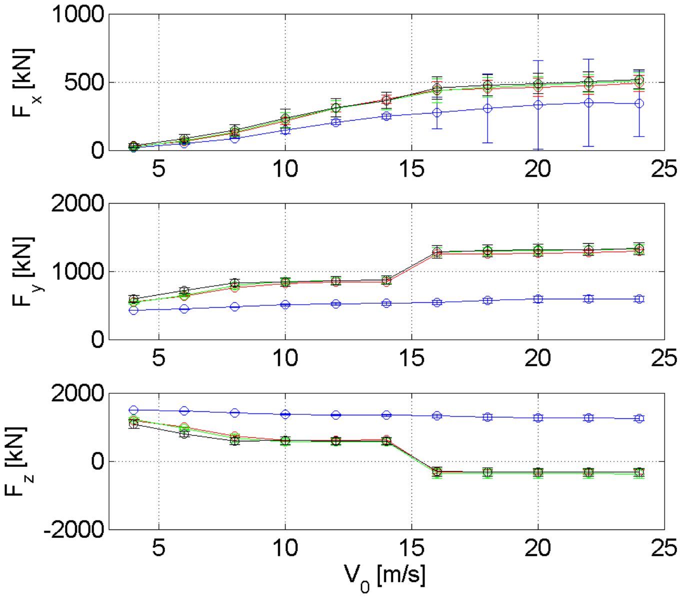


(b)

Figure 5.22.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.8. Arm 2

Plots of loads in the arm 2.



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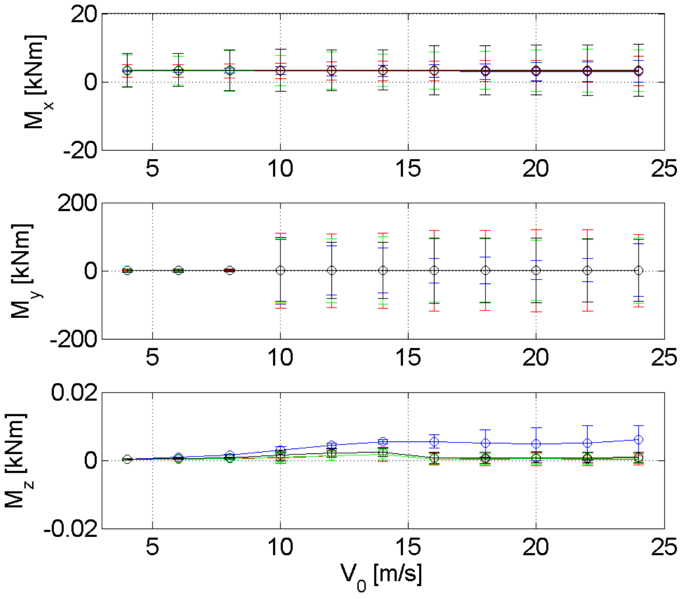
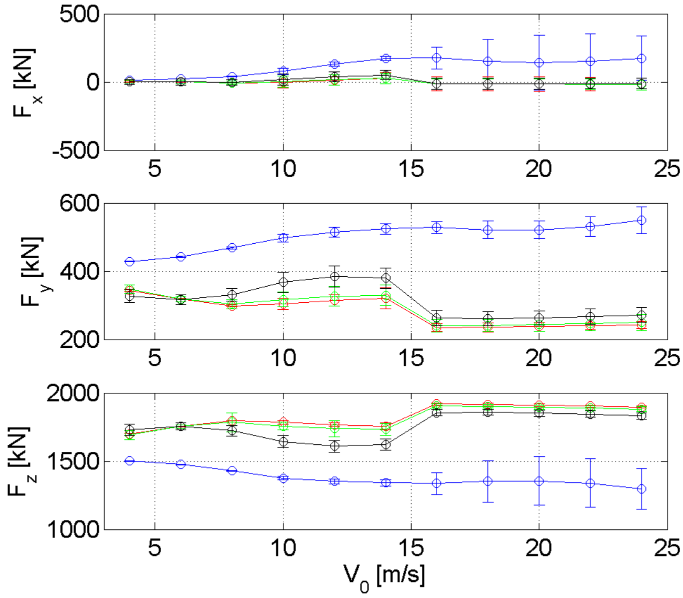


(b)

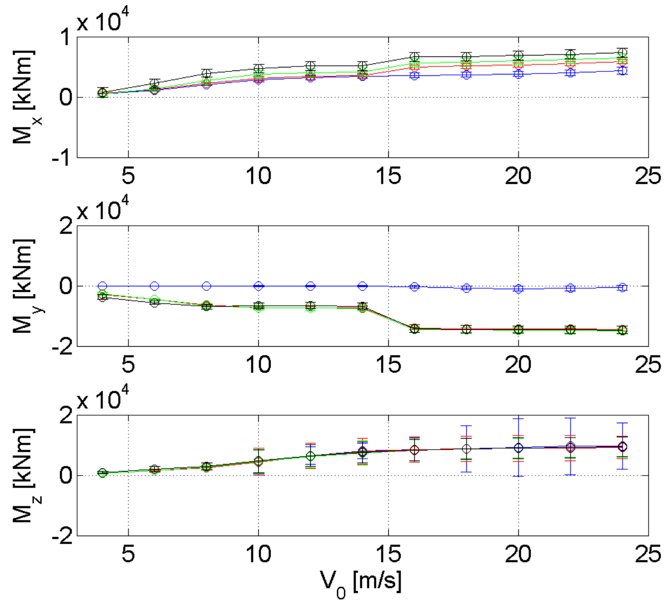
Figure 5.23.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.9. Arm 3

Plots of loads in the arm 3.



(a)

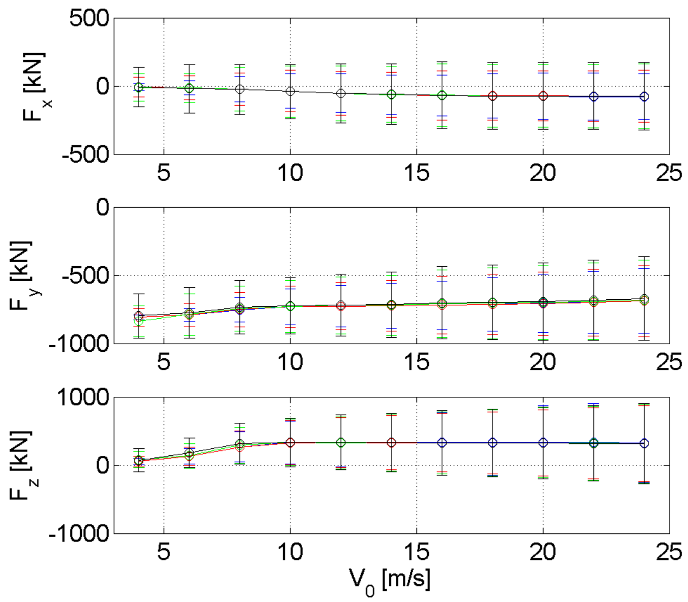


(b)

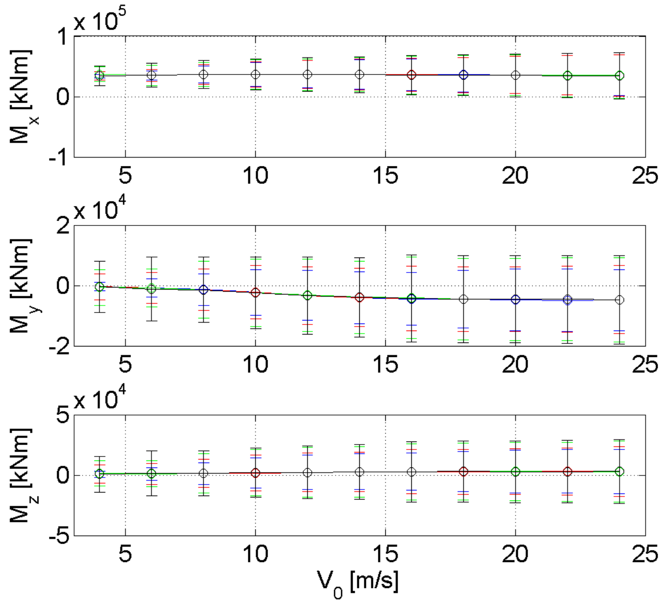
Figure 5.24.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.10. Blade 1, Point 1

Plots of loads in the blade point 1.



(a)

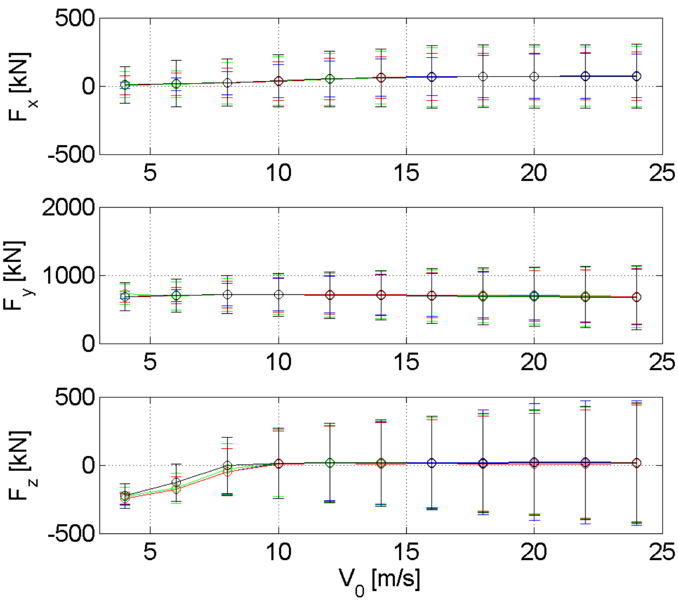


(b)

Figure 5.25.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.11. Blade 1, Point 2

Plots of loads in the blade point 2.



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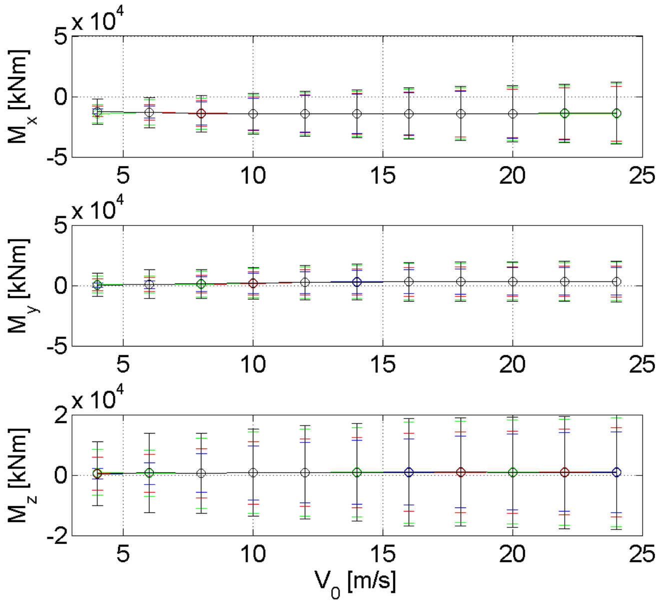
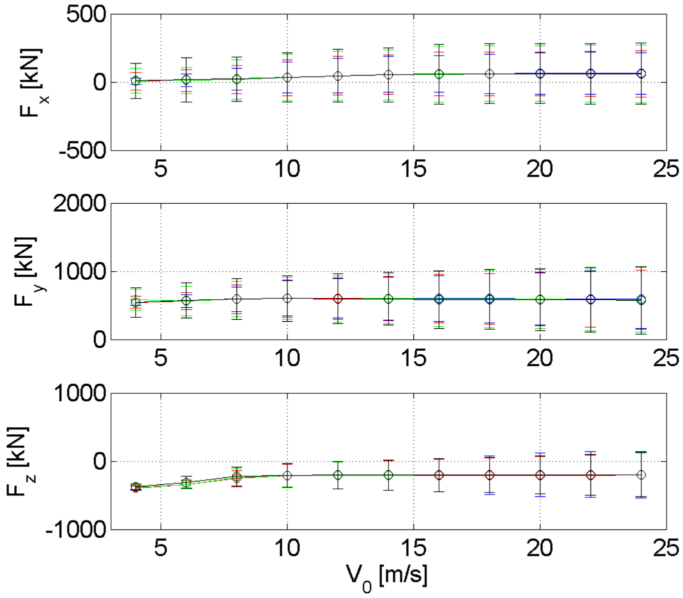


(b)

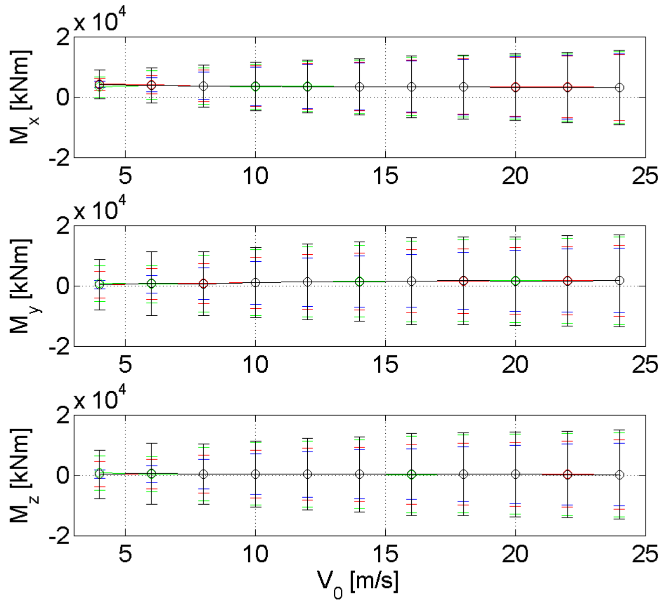
Figure 5.26.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.12. Blade 1, Point 3

Plots of loads in the blade point 3.



(a)

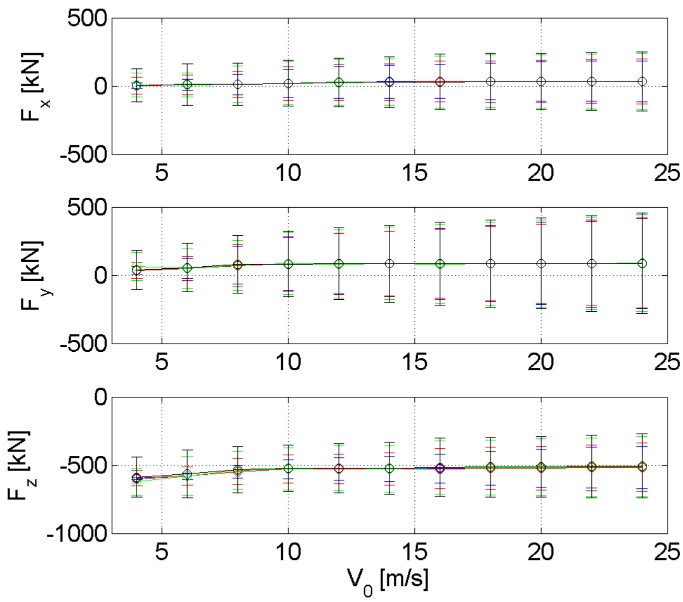


(b)

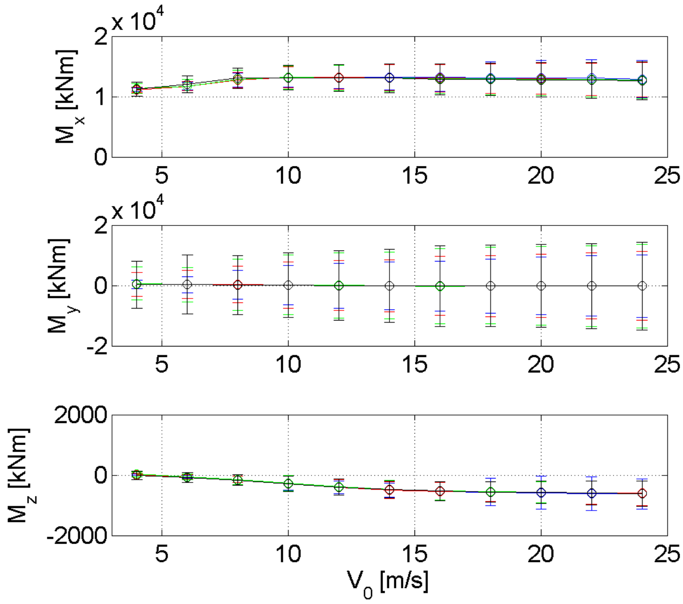
Figure 5.27.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.13. Blade 1, Point 4

Plots of loads in the blade point 4.



(a)

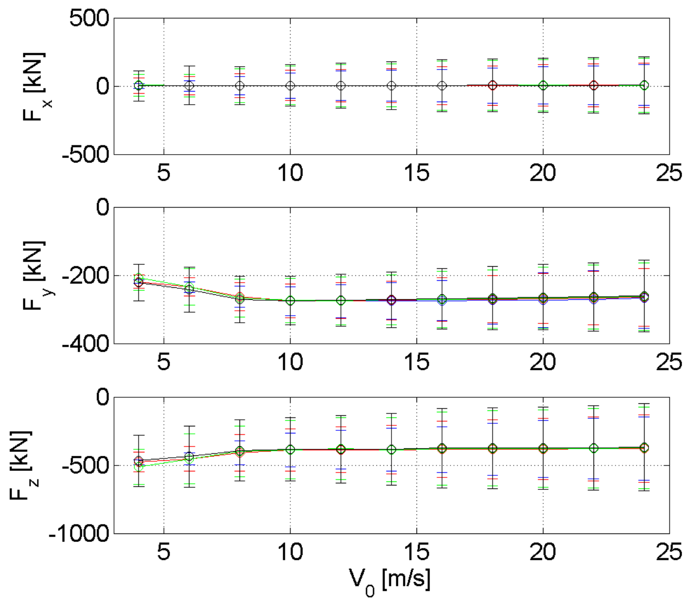


(b)

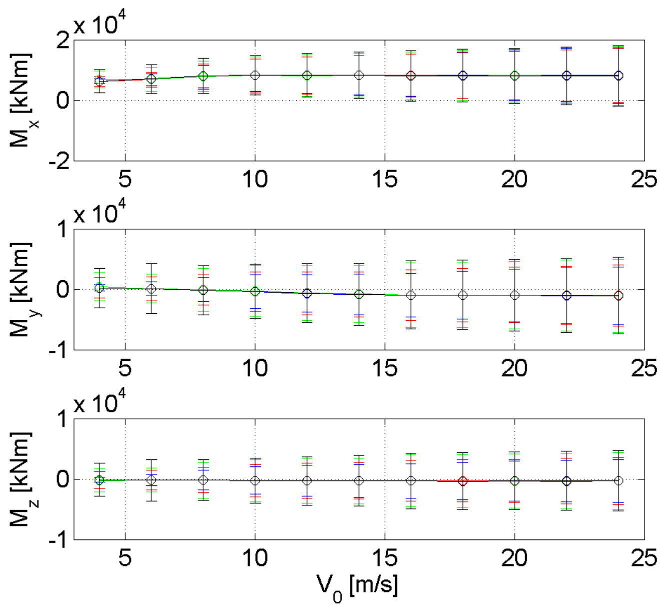
Figure 5.28.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.14. Blade 1, Point 5

Plots of loads in the blade point 5.



(a)

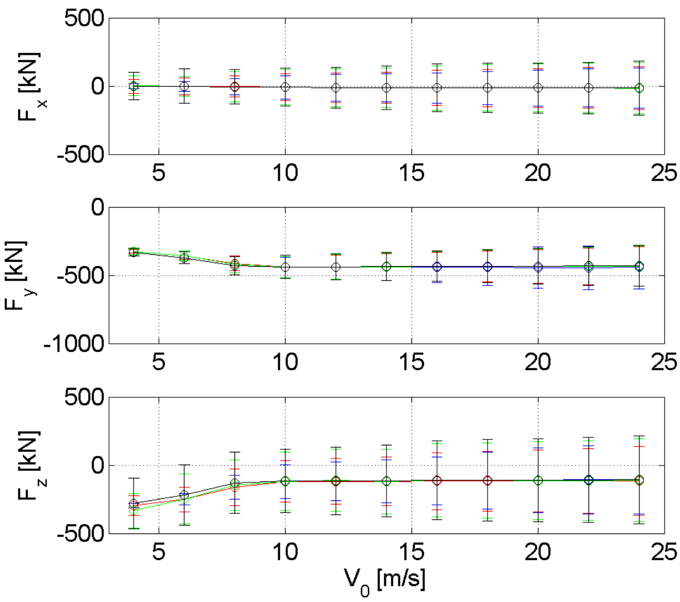


(b)

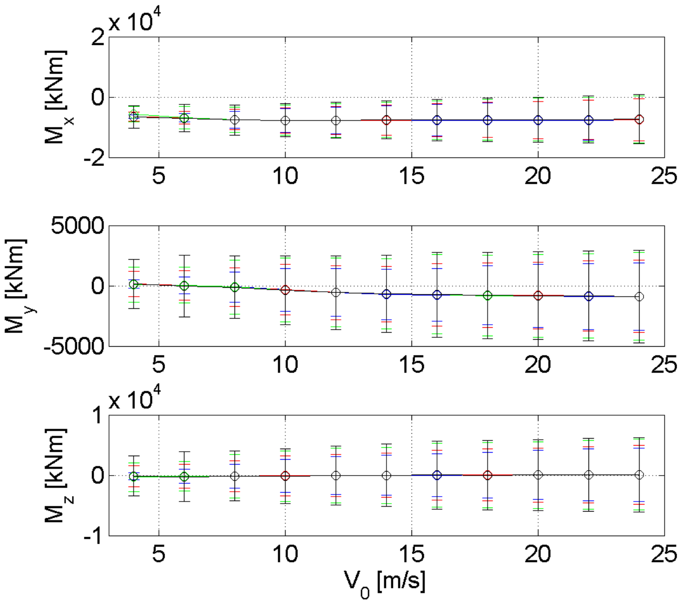
Figure 5.29.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.15. Blade 1, Point 6

Plots of loads in the blade point 6.



(a)

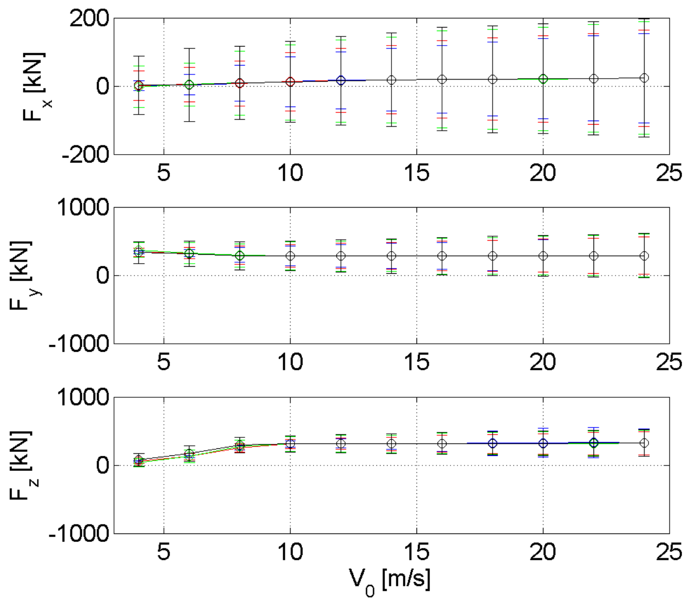


(b)

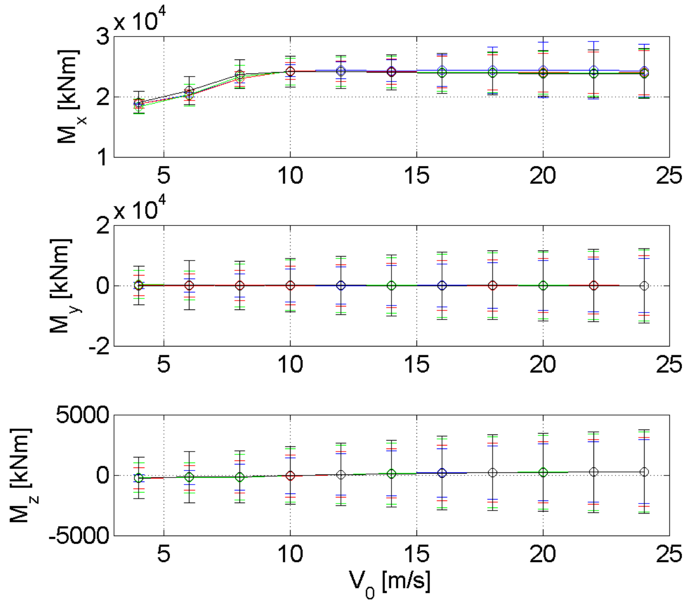
Figure 5.30.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.5.16. Blade 1, Point 7

Plots of loads in the blade point 7.



(a)



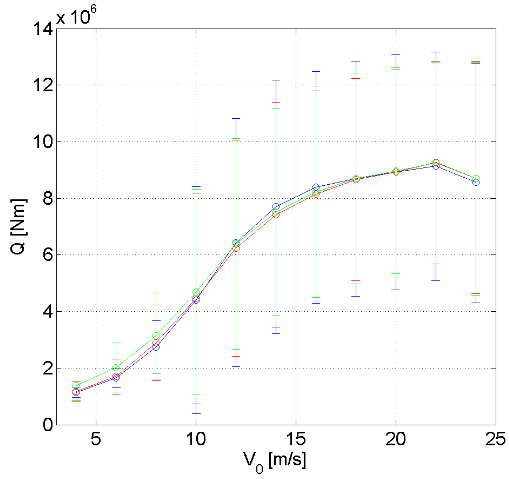
(b)

Figure 5.31.: a) Forces, b) Moments. Blue: Sea state 0, red: Sea state 1, green: Sea state 2, black: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

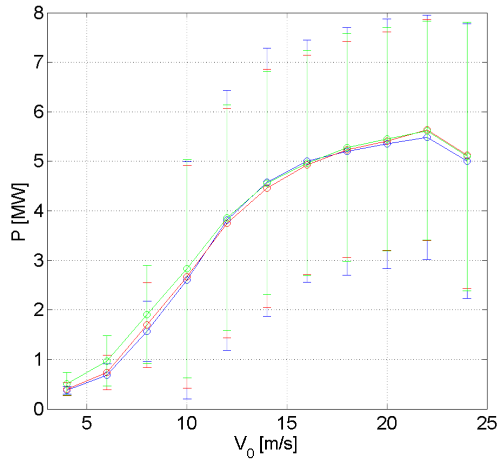
5.6. Turbulent Inflow

Turbulent inflow that fullfills the IEC standard for class C turbulence is applied in the simulations in the form of Mann turbulence.

5.6.1. Generator Torque and Power



(a)



(b)

Figure 5.32.: a) Generator torque, b) Generator Power. Blue: Sea state 1, red: Sea state 2, green: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.6.2. Pitch and Roll of Rotor

Plot of the pitch angle of the rotor during operation.

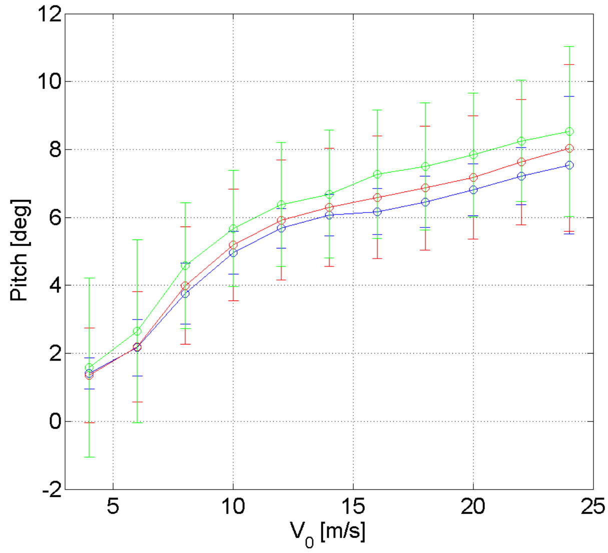


Figure 5.33.: Pitch of rotor. Blue: Sea state 1, red: Sea state 2, green: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

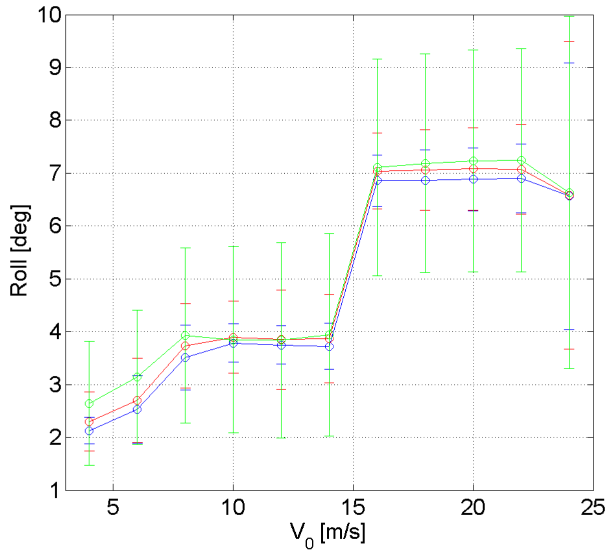
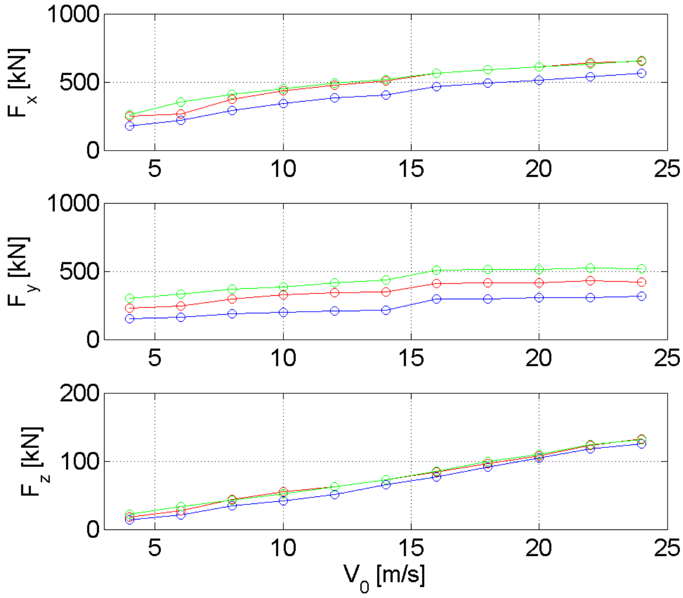


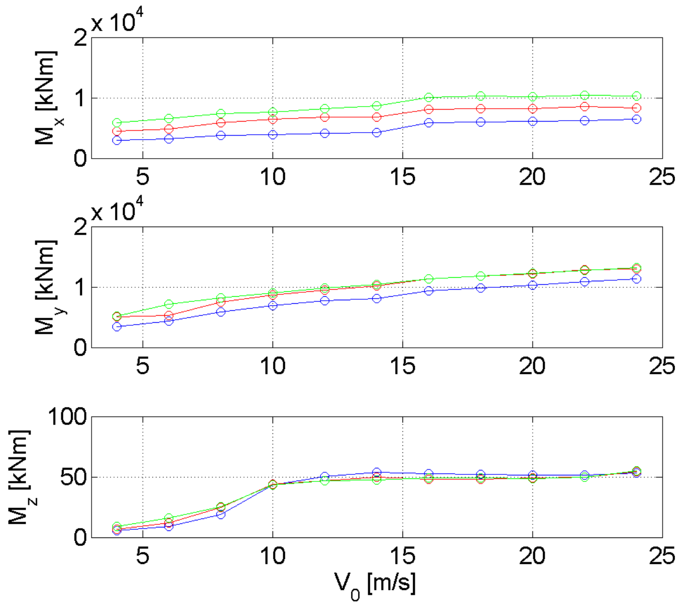
Figure 5.34.: Roll of rotor. Blue: Sea state 1, red: Sea state 2, green: Sea state 3. The circles represents the mean values, whereas the whiskers represents the standard deviation.

5.6.3. Tower Top

Plots of loads in the tower top.



(a)

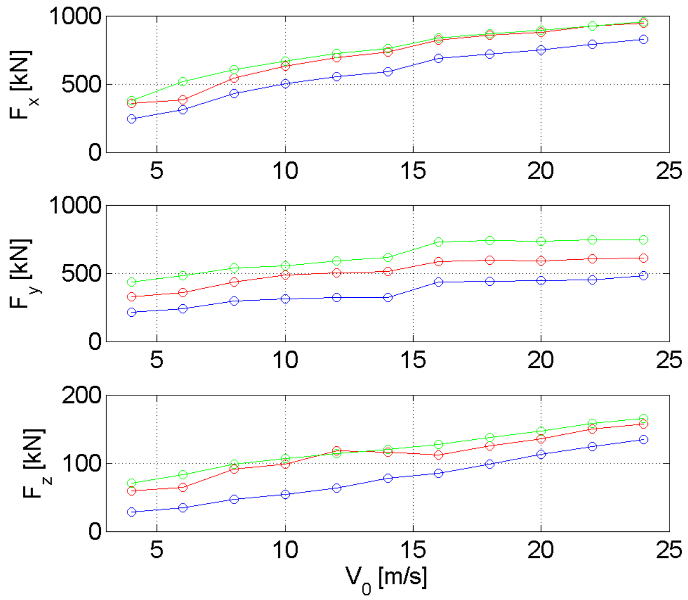


(b)

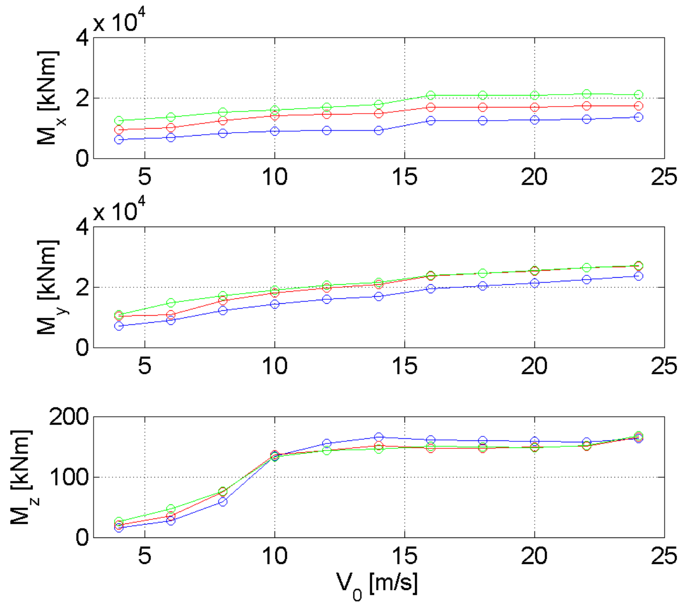
Figure 5.35.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.4. Tower Bottom

Plots of loads in the tower bottom.



(a)

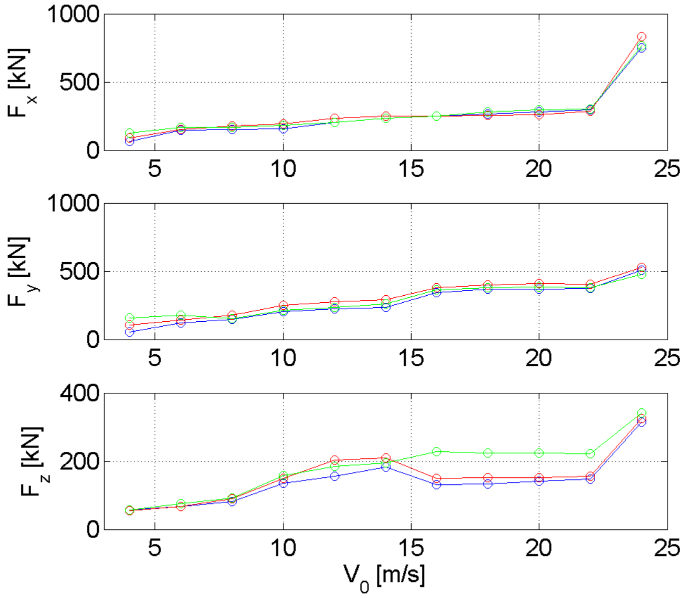


(b)

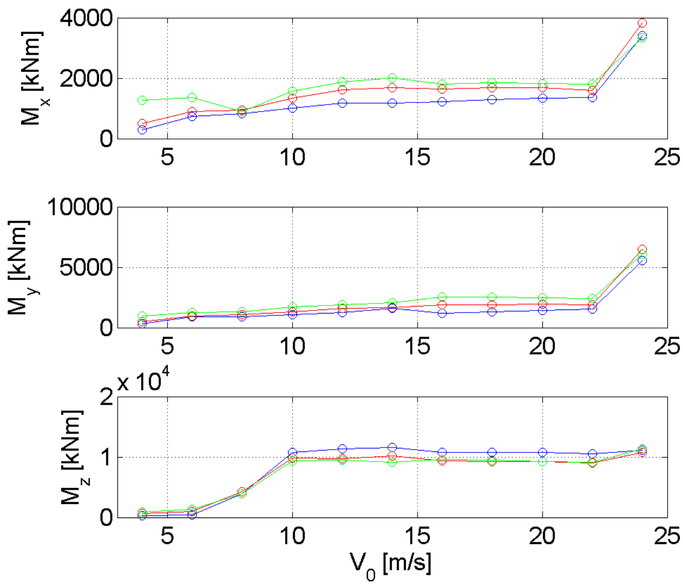
Figure 5.36.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.5. Shaft

Plots of loads in the generator.



(a)

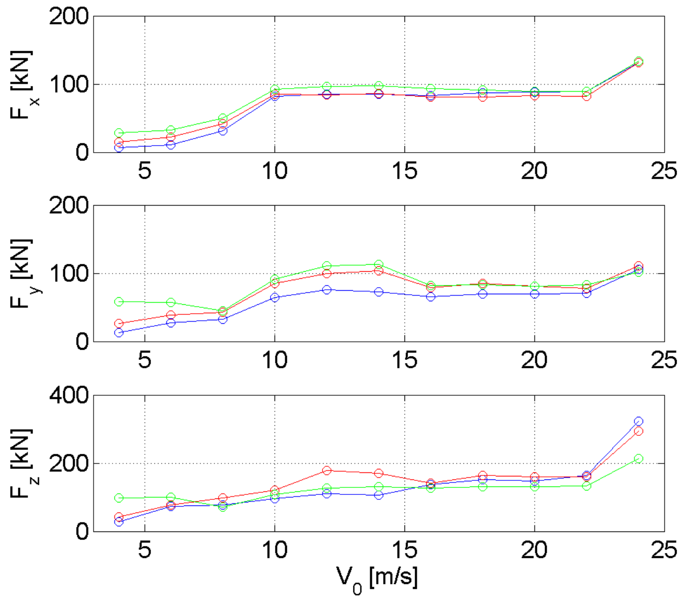


(b)

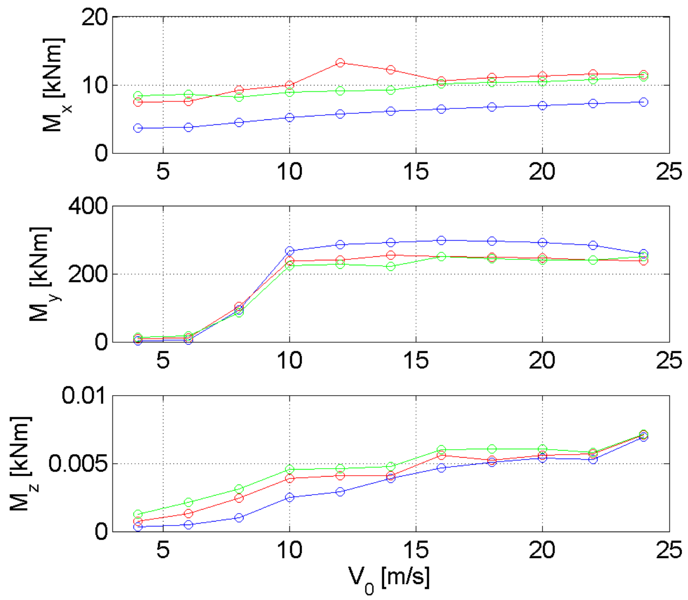
Figure 5.37.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.6. Arm 1

Plots of loads in the arm 1.



(a)

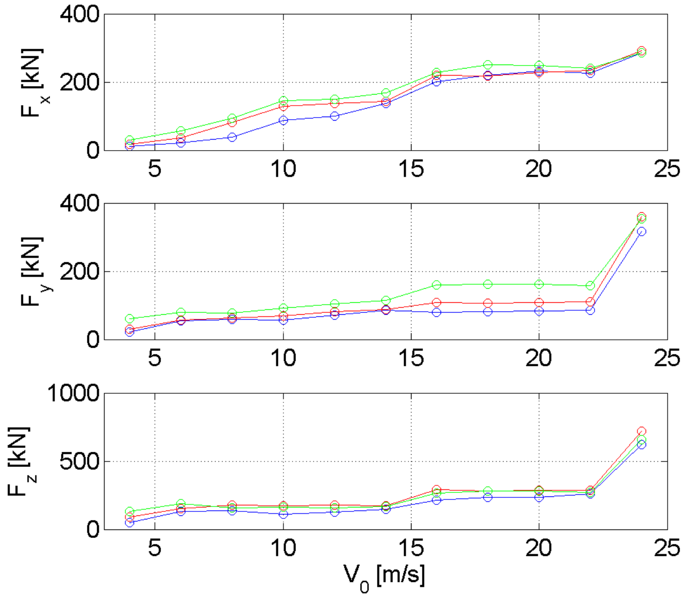


(b)

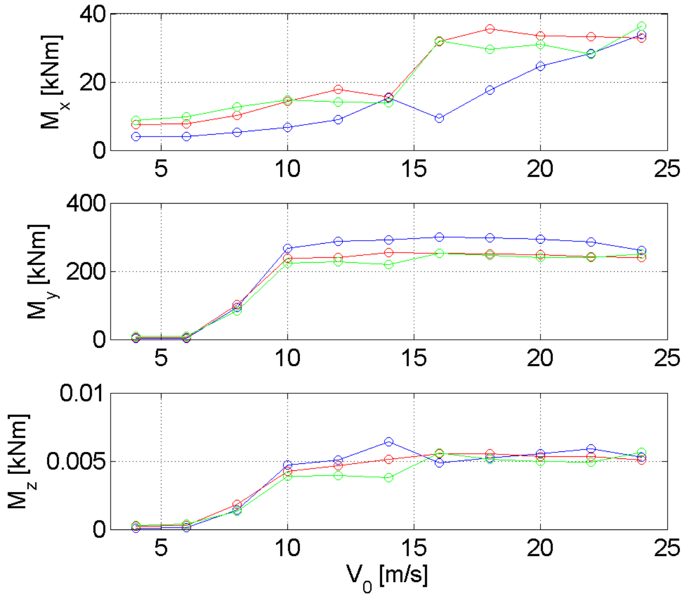
Figure 5.38.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.7. Arm 2

Plots of loads in the arm 2.



(a)

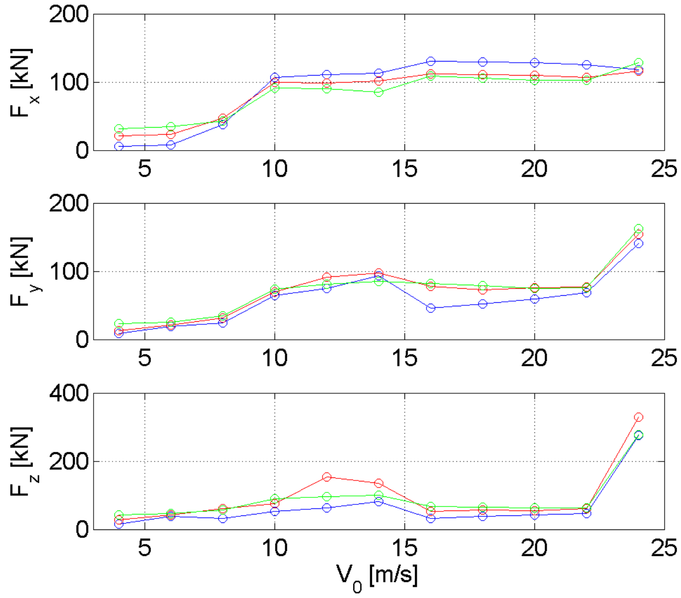


(b)

Figure 5.39.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.8. Arm 3

Plots of loads in the arm 3.



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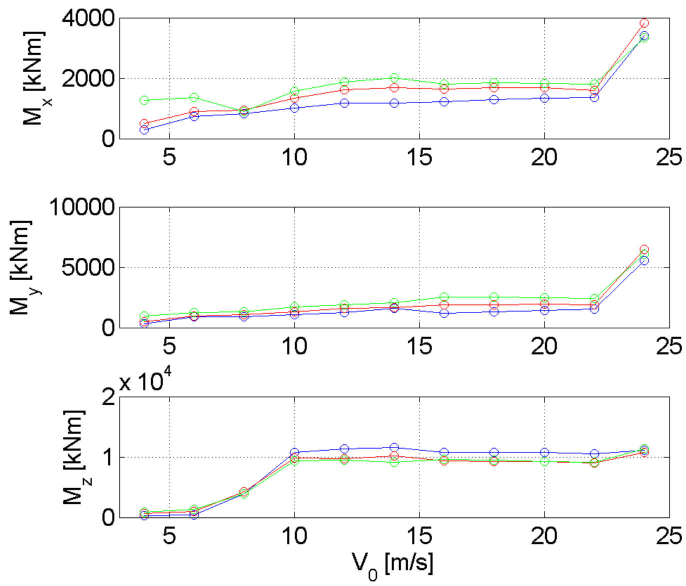
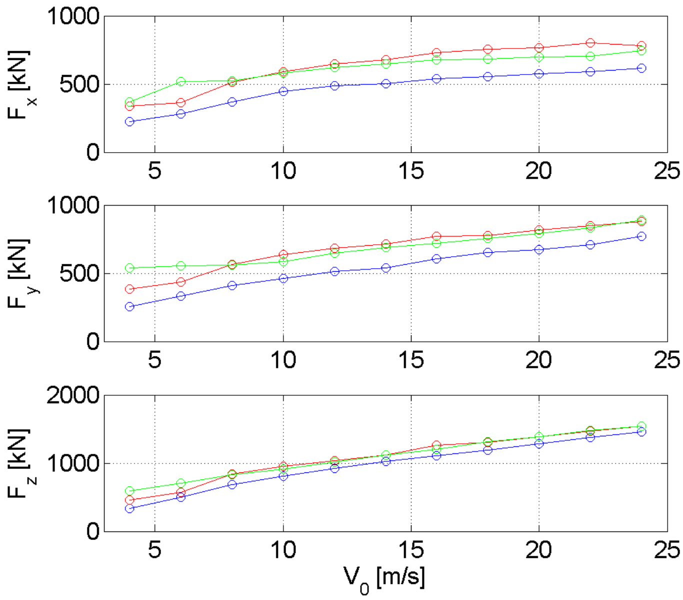


(b)

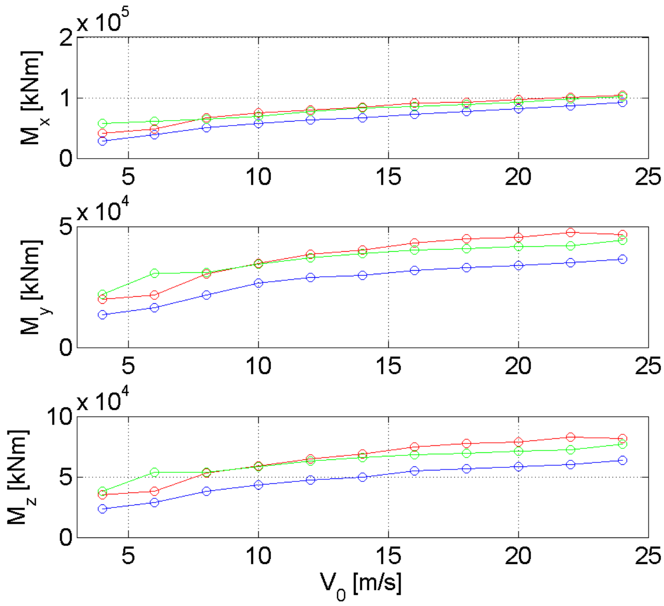
Figure 5.40.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.9. Blade 1, Point 1

Plots of loads in the blade point 1.



(a)

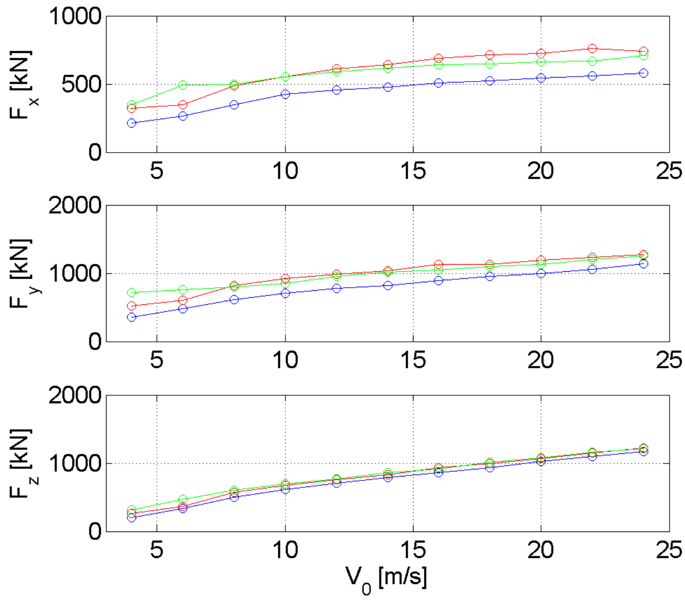


(b)

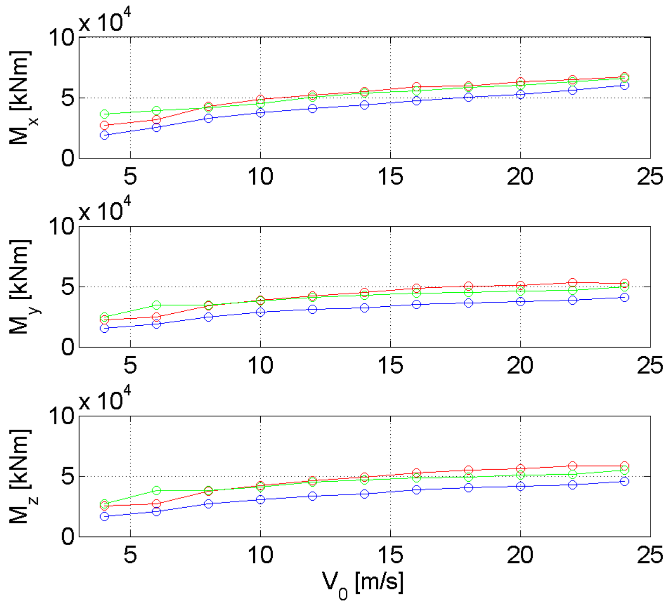
Figure 5.41.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.10. Blade 1, Point 2

Plots of loads in the blade point 2.



(a)

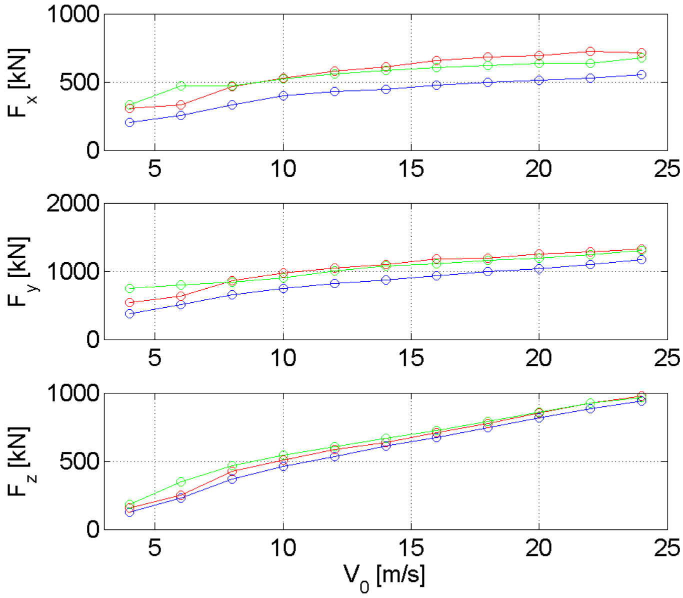


(b)

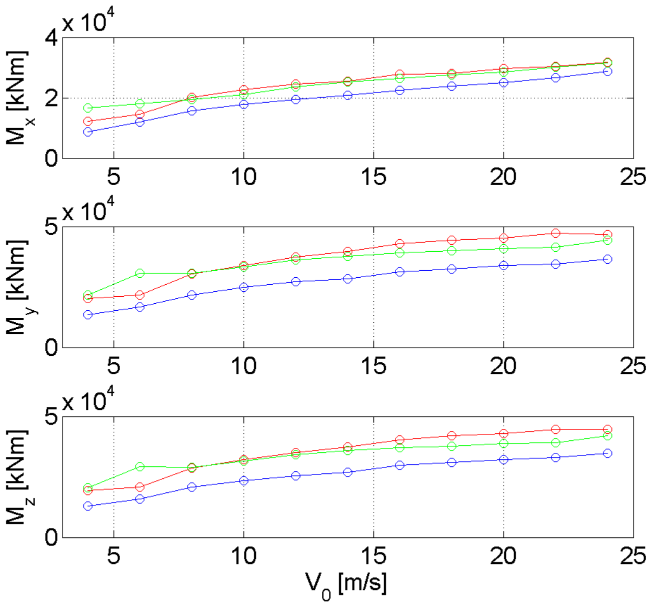
Figure 5.42.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.11. Blade 1, Point 3

Plots of loads in the blade point 3.



(a)

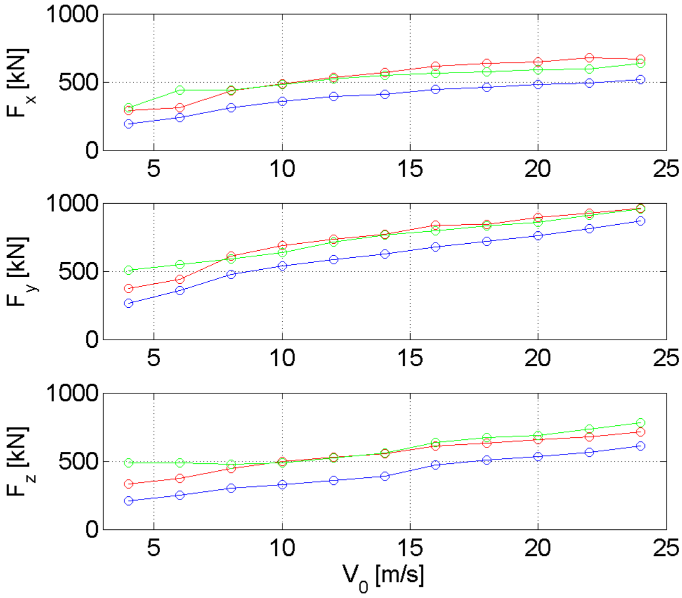


(b)

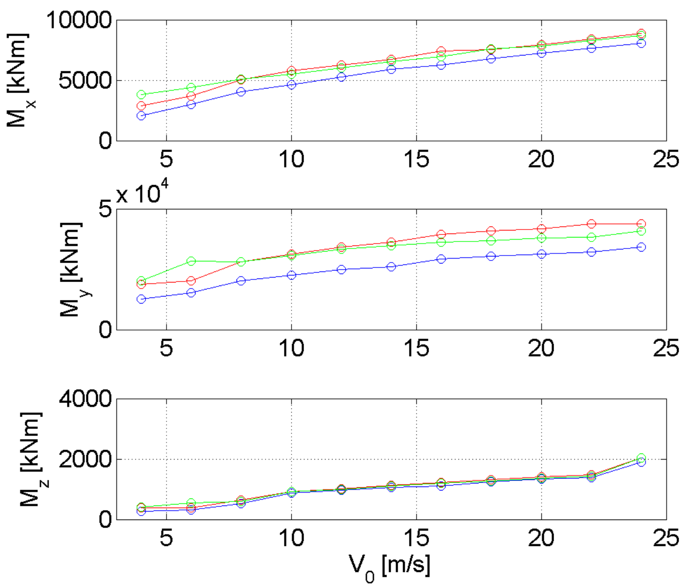
Figure 5.43.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.12. Blade 1, Point 4

Plots of loads in the blade point 4.



(a)

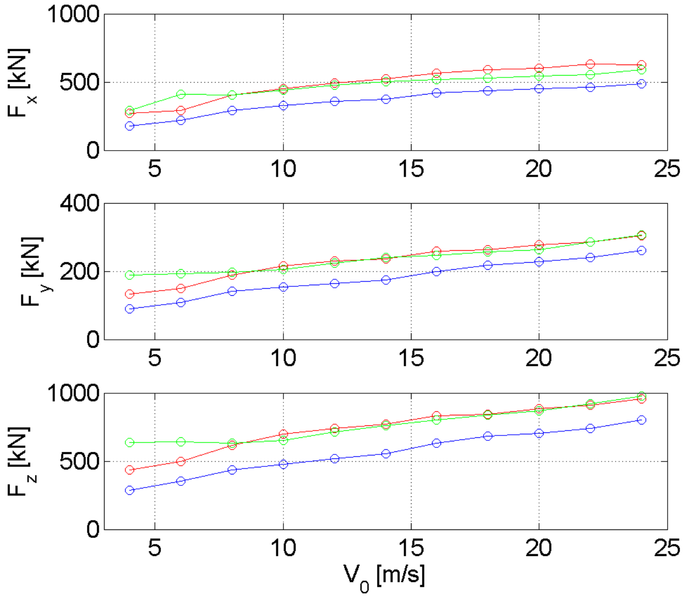


(b)

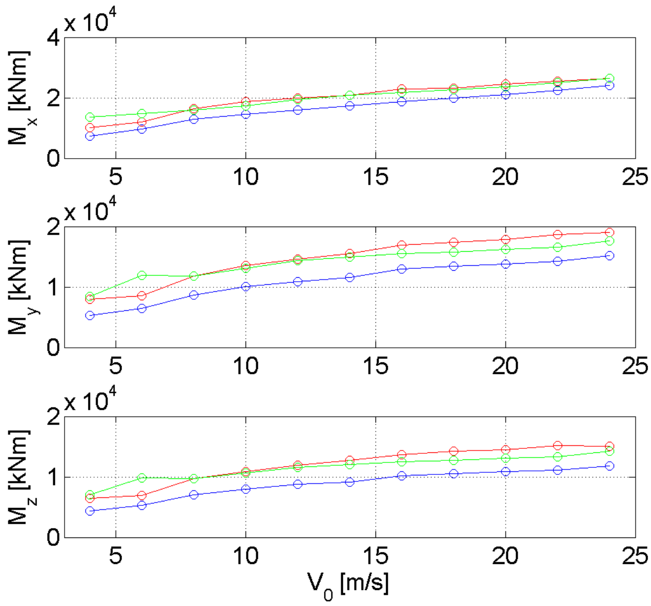
Figure 5.44.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.13. Blade 1, Point 5

Plots of loads in the blade point 5.



(a)

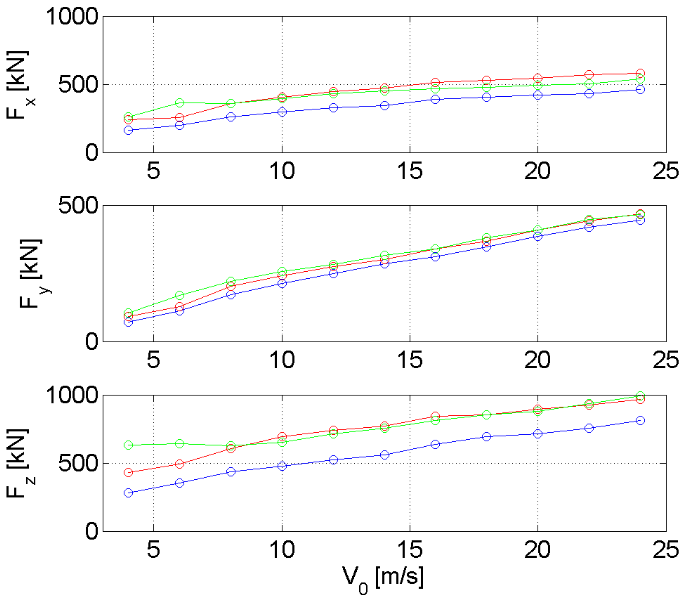


(b)

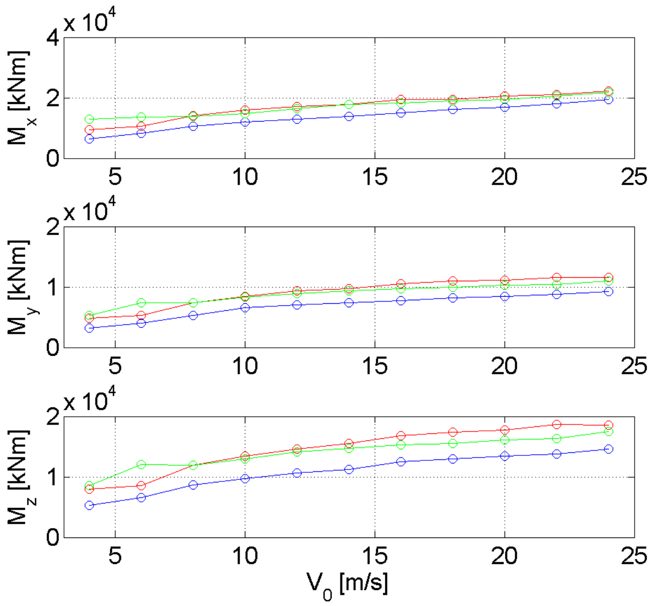
Figure 5.45.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.14. Blade 1, Point 6

Plots of loads in the blade point 6.



(a)

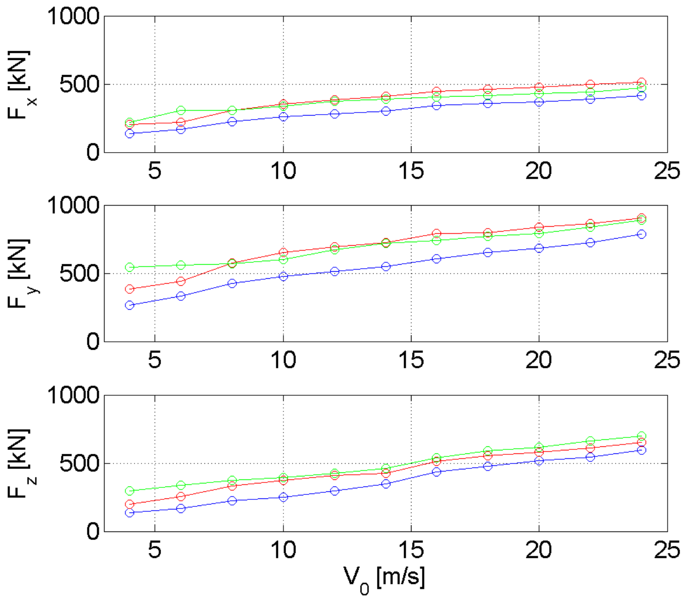


(b)

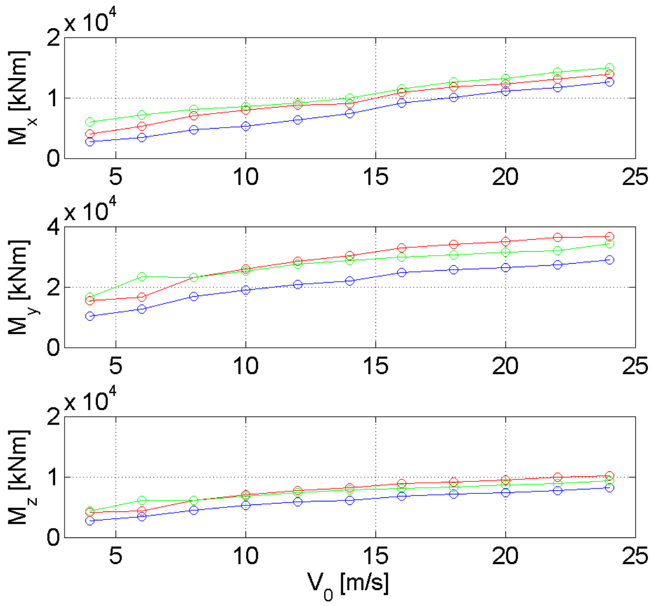
Figure 5.46.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

5.6.15. Blade 1, Point 7

Plots of loads in the blade point 7.



(a)



(b)

Figure 5.47.: a) 1 Hz damage equivalent forces, b) 1 Hz damage equivalent moments. Blue: Sea state 1, red: Sea state 2, green: Sea state 3.

Bibliography

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Appendix A.

Result Tables

A.1. Deterministic Inflow

A.1.1. Shaft Torque and Power

WSP [m/s]	Mean $Q[Nm]$	Std $Q[Nm]$
4	683613.65	114909.72
6	1524121.74	73905.59
8	2556778.48	92982.56
10	4394004.46	4018948.76
12	6451248.89	2884901.88
14	8001692.85	2586952.1
16	8556420.42	3811326.34
18	8790824.32	7667948.93
20	9148244.7	9547511.12
22	9537612.33	9501025.08
24	9619299.55	7652504.51

Table A.1.: Summary of torque calculated in the point entitled ”Generator”. Sea state 0

WSP [m/s]	Mean $P[MW]$	Std $P[MW]$
4	0.17	0.03
6	0.59	0.03
8	1.41	0.06
10	2.59	2.41
12	3.91	1.73
14	4.87	1.56
16	5.32	2.53
18	5.67	5.17
20	6.07	6.51
22	6.31	6.5
24	6.09	5.14

Table A.2.: Summary of power calculated in the point entitled "Generator". Sea state 0

A.1.2. Rotor thrust

WSP [m/s]	Mean $F[kN]$	Std $F[kN]$
4	146.27	2.51
6	333.69	20.13
8	626.25	51.67
10	876.84	85.66
12	998.55	87.09
14	1064.13	91
16	1119.13	139.47
18	1182.94	245.36
20	1251.77	294.71
22	1320.11	285.98
24	1382.78	216.03

Table A.3.: Summary of Resultant rotor thrust force at distance d calculated in the point entitled "Resultant rotor thrust force at distance d". Sea state 0

WSP [m/s]	Mean $F[kN]$	Max $F[kN]$
4	146.27	150.71
6	333.69	362.4
8	626.25	702.16
10	876.84	1021.38
12	998.55	1136.8
14	1064.13	1206.49
16	1119.13	1487.57
18	1182.94	1752.74
20	1251.77	1997.76
22	1320.11	2069.73
24	1382.78	2085.17

Table A.4.: Summary of Resultant rotor thrust force at distance d calculated in the point entitled "Resultant rotor thrust force at distance d". Sea state 0

WSP [m/s]	Mean $d[m]$	Max $d[m]$
4	68.1	68.5
6	68.09	67.56
8	68.15	68.32
10	68.1	70.25
12	68.11	70.06
14	68.31	70.6
16	68.32	70.69
18	68.65	69
20	68.89	70.6
22	69.07	71.28
24	69.22	72.25

Table A.5.: Summary of Distance d above tower base for thrust force calculated in the point entitled "Distance d above tower base for thrust force". Sea state 0

A.1.3. Tower Top

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-0.03	28.71	-0.02	2.82	-676.66	1.92
6	0.2	58.45	0.01	5.67	-646.3	4.67
8	0.4	104.65	0.03	13.48	-592.81	9.46
10	-0.29	146.35	0.03	26.55	-567.4	10.85
12	-0.55	168.43	-0.02	29.74	-565.89	15.81
14	0.39	183.72	-0.01	35.87	-566.7	23.78
16	0.53	196.49	-0.11	38.52	-566.95	39.88
18	0.63	214.49	-0.06	67.49	-567.14	64.71
20	0.17	231.07	-0.4	83.26	-566.6	78.53
22	-0.02	246.25	0.22	82.99	-568.65	80.77
24	-1.03	259.94	-0.1	66.36	-574.65	71.54

Table A.6.: Summary of forces calculated in the point entitled ”Tower Top”. Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	0.34	52.63	-0.51	578.36	0.03	1.45
6	-0.29	121.94	4.03	1178.97	0.16	3.24
8	-0.58	287.91	8.07	2114.28	0.34	5.15
10	-0.56	526.57	-5.79	2954.8	0.6	15.02
12	0.45	585.68	-11.24	3399.38	0.91	15.22
14	0.06	684.33	7.95	3702.28	1.1	16.65
16	2.21	774.34	10.8	3963.9	1.21	18.63
18	1.52	1339.7	12.69	4319.99	1.12	26.61
20	7.75	1645.84	3.44	4648.27	1.46	31.24
22	-4.5	1640.21	-0.28	4952.71	1.33	30.86
24	1.91	1314.15	-20.71	5230.69	1.16	26.75

Table A.7.: Summary of moments calculated in the point entitled ”Tower Top”. Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	0.3	87.44	0.44	66.53	-675.73	3.88
6	-0.05	102.4	-0.25	77.86	-645.8	6.27
8	1.04	132.71	0.88	102.28	-591.32	10.57
10	-0.2	170.65	0.56	99.59	-566.53	12.61
12	0.14	188.15	-0.14	99.64	-566.27	17.33
14	-0.18	200.04	-0.32	100.91	-567.61	24.61
16	-0.27	227.84	0.11	139.68	-565.38	30.64
18	-0.29	239.83	0.05	140.58	-567.49	36.39
20	0.18	251.78	-0.17	140.17	-569.75	42
22	0.13	265.49	-0.15	140.11	-572.33	47.12
24	-1.1	281.73	-0.59	140.79	-574.85	52.03

Table A.8.: Summary of forces calculated in the point entitled "Tower Top". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-8.41	1295.66	6.2	1731.53	0.03	1.84
6	4.84	1526.99	-1.28	2044.2	0.17	3.78
8	-16.84	2021.34	20.81	2672.13	0.34	5.95
10	-10.84	1974.29	-3.92	3436.82	0.6	16.58
12	2.71	1974.74	2.78	3788.74	0.9	18.35
14	6.37	1996.97	-3.5	4026.35	1.07	20.05
16	-2.25	2799.3	-5.54	4599.27	1.19	19.87
18	-1.16	2811.58	-5.86	4835.88	1.19	19.19
20	3.33	2806.19	3.63	5076.26	1.27	19.05
22	3.16	2808.73	2.77	5352.46	1.26	18.84
24	11.14	2823.66	-22.17	5678.96	1.33	18.1

Table A.9.: Summary of moments calculated in the point entitled "Tower Top". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	7.43	122.33	-34.57	119.75	-676.07	7.45
6	0.02	124.72	-1.95	175.59	-641.73	9.9
8	-0.19	188	1.17	161.68	-580.23	16.54
10	2.65	220.66	-0.68	175.91	-563.12	20.18
12	1.08	240.22	2.95	179.88	-563.22	23.89
14	1.68	250.37	-2.1	180.54	-564.66	28.23
16	-1.97	284.3	0.67	213.13	-561.6	34.01
18	2.4	292.32	1.67	212.53	-563.81	38.54
20	0.81	303.62	-0.77	213.56	-566.03	43.47
22	-1.55	315.59	-1.79	213.05	-568.9	48.38
24	-2.2	328.8	-2.09	212.96	-572.2	53.15

Table A.10.: Summary of forces calculated in the point entitled "Tower Top". Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	683.94	2339.33	148.58	2426.75	-0.04	2.2
6	38.52	3449.88	0.58	2485.56	0.14	4.76
8	-23.04	3186.33	-3.94	3762.69	0.33	8.75
10	13.37	3468.36	52.63	4423.14	0.6	17.99
12	-57.81	3545.26	21.75	4816.28	0.8	18.94
14	41.38	3556.07	33.3	5019.44	1.06	19.44
16	-13.45	4225.82	-38.93	5713.69	1.15	18.72
18	-32.29	4211.83	47.81	5872.81	1.21	18.22
20	15.17	4229.5	15.79	6098.88	1.24	17.51
22	34.94	4220.02	-31.25	6339.45	1.29	17.58
24	40.6	4218.76	-43.91	6605.63	1.33	17.98

Table A.11.: Summary of moments calculated in the point entitled "Tower Top". Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-0.65	171.1	1.42	175.82	-664.54	10.3
6	3.53	214.16	-0.47	216.26	-620.55	13.56
8	-0.79	214.11	-0.34	202.42	-567.43	14.71
10	1.63	235.85	0.58	194.14	-560.57	19.45
12	0.89	258.02	-0.33	203.22	-560.41	22.7
14	-0.5	272.76	-0.28	210.37	-561.61	26.8
16	-1.08	303.02	0.75	234.19	-560.43	32.57
18	1.57	311.1	-0.08	234.07	-562.41	38.02
20	-0.39	320.99	-0.6	232.87	-564.84	43.22
22	-1.5	332.06	0.34	230.95	-567.48	48.15
24	-1.09	344.7	0.41	229.42	-570.48	52.9

Table A.12.: Summary of forces calculated in the point entitled "Tower Top". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-27.63	3458.68	-13.17	3406.71	0.09	3.34
6	9.23	4259.12	70.09	4273.5	0.2	7.37
8	6.92	3996.85	-15.58	4296.66	0.41	10.11
10	-11.29	3836.39	32.65	4736.22	0.69	18.59
12	6.75	4015.2	17.99	5181.26	0.92	19.17
14	5.72	4151.94	-10.01	5474.54	1.06	18.86
16	-15.27	4647.62	-21.63	6097.68	1.18	19.2
18	1.99	4643.57	31.6	6258.87	1.24	18.65
20	12.09	4617.55	-8	6457.02	1.27	18.08
22	-6.91	4580.03	-30.14	6679.06	1.29	17.78
24	-8.61	4548.72	-21.95	6933.02	1.36	17.88

Table A.13.: Summary of moments calculated in the point entitled "Tower Top". Sea state 3

A.1.4. Tower Bottom

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	0.04	43.79	-0.05	5.78	2807.02	2.1
6	-0.31	89.63	-0.11	21.91	2835.58	4.85
8	-0.62	161.5	-0.13	47.06	2883.58	9.91
10	0.44	225.03	-0.09	67.73	2901.63	12.36
12	0.87	258.34	0.13	74.28	2898.72	17.62
14	-0.61	279.41	-0.08	75	2895.45	24.96
16	-0.82	299.69	0.14	83.86	2891.97	40.13
18	-0.95	323.99	0.38	111.87	2886.79	65.21
20	-0.28	346.47	0.51	127.34	2883.32	79.22
22	0	368.7	-0.47	125.56	2878.32	81.61
24	1.52	390.25	0.07	106.66	2870.22	72.21

Table A.14.: Summary of forces calculated in the point entitled "Tower Bottom". Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-0.98	135.29	-1.06	1227.52	0.04	4.31
6	-2.58	543.58	8.62	2508.68	0.18	9.63
8	-3.3	1190.81	17.31	4512.51	0.35	15.26
10	-2.24	1759.48	-12.35	6292.6	0.66	46.48
12	3.18	1927.65	-24.17	7227.12	0.85	46.15
14	-1.79	1979.58	16.93	7831.89	1.09	50.19
16	3.92	2182.92	23.02	8393.7	1.04	56.52
18	9	3046.52	26.7	9102.27	1.48	82.04
20	15.11	3522.54	7.58	9755.25	0.66	96.68
22	-12.87	3465.36	-0.18	10381.43	1.3	95.51
24	2.54	2868.76	-43.09	10971.87	1.86	82.51

Table A.15.: Summary of moments calculated in the point entitled "Tower Bottom". Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-0.5	122.18	-0.58	91.33	2804.61	14.16
6	0.2	149.51	0.4	112.06	2831.28	14.92
8	-1.49	202.38	-1.07	155.38	2877.12	16.39
10	0.25	259.99	-0.75	158.37	2894.09	19.72
12	-0.19	286.06	0.13	159.88	2890.62	23.41
14	0.22	303.08	0.44	160.8	2887.02	29.74
16	0.46	350.89	-0.12	227.46	2871	34.33
18	0.42	366.83	-0.17	226.22	2866.94	39.86
20	-0.29	384.36	0.2	225.45	2862.2	45.22
22	-0.24	404.7	0.28	225.61	2856.31	50.13
24	1.68	428.66	0.79	226.12	2849.53	54.82

Table A.16.: Summary of forces calculated in the point entitled "Tower Bottom". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-17.09	2649.13	13.66	3521.66	0.01	5.5
6	11.61	3195.98	-4.45	4246.71	0.18	11.28
8	-32.39	4366.8	42.78	5669.62	0.37	17.81
10	-22.1	4394.81	-7.61	7286.84	0.72	51.43
12	4.26	4424.08	5.58	8021.23	0.93	56.41
14	12.78	4451.19	-6.61	8504.32	1.18	61.41
16	-3.54	6225.51	-12.43	9786.94	1.28	60.93
18	-4.3	6200.08	-12.06	10249.12	1.41	58.89
20	5.87	6169.86	8.01	10744.34	1.32	58.49
22	7.46	6162.61	6.37	11317.57	1.5	57.76
24	23.95	6168.93	-46.91	11994.05	1.5	55.19

Table A.17.: Summary of moments calculated in the point entitled "Tower Bottom". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-10.89	172.3	51.26	167.46	2797.88	36.48
6	-0.1	180.69	2.86	250.24	2824.31	33.32
8	0.32	277.39	-1.64	236.73	2876.05	53.3
10	-3.68	327.9	1.21	259.66	2883.86	46.08
12	-1.62	356.99	-4.18	265.82	2878.35	54.48
14	-2.32	371.64	3.15	266.44	2874.71	48.94
16	2.65	427.88	-1.29	323.74	2855.11	49.57
18	-3.43	438.83	-2.11	321.86	2851.26	52.4
20	-0.98	454.97	1.36	321.8	2846.28	56.05
22	2.33	472.58	2.52	320.69	2840.07	60.24
24	3.2	492.34	2.81	320.23	2832.66	64.41

Table A.18.: Summary of forces calculated in the point entitled "Tower Bottom". Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	1453.54	4841.68	309.48	4955.12	0.16	6.7
6	81.42	7174.22	2.21	5143.32	0.21	14.28
8	-47.03	6726.14	-8.68	7857.24	0.45	26.05
10	33.76	7360.16	106.79	9266.27	0.66	55.13
12	-120.87	7532.74	45.69	10086.89	1.07	57.8
14	90.07	7551.24	67.44	10501.59	0.97	59.34
16	-35.32	9075.21	-77.78	12031.38	1.25	56.94
18	-63.27	9023.65	98.09	12345.66	1.38	55.38
20	38.14	9027.38	30.01	12804.11	1.45	53.13
22	73.5	8990.77	-65.48	13300.35	1.44	53.32
24	82.81	8972.43	-90.83	13854.98	1.52	54.46

Table A.19.: Summary of moments calculated in the point entitled "Tower Bottom". Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	1.04	245.83	-1.92	253.89	2795.94	40.79
6	-4.97	310.78	0.82	311.06	2825.77	45.55
8	1.08	320.52	0.46	298.17	2874.61	51
10	-2.41	353.99	-0.84	289.58	2876.04	58.5
12	-1.35	386.75	0.55	303.45	2868.81	59.17
14	0.76	407.45	0.62	312.39	2863.39	57.02
16	1.55	459.23	-1.33	358.15	2840.41	57.26
18	-2.37	470.53	0.18	357.2	2836.4	58.38
20	0.67	484.83	1.16	354.4	2831.49	61.66
22	2.25	500.89	-0.51	351.37	2825.74	65.41
24	1.63	519.5	-0.77	348.54	2818.8	69.25

Table A.20.: Summary of forces calculated in the point entitled "Tower Bottom". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-56.05	7254.03	-28.74	7023.32	0.14	9.95
6	23.38	8884.32	143.23	8853.84	0.17	21.81
8	12.95	8453.82	-31.41	9035.64	0.31	30.02
10	-24.29	8180.17	68.3	9970.45	0.52	56.85
12	15.11	8571.28	37.9	10897.43	0.77	58.24
14	16.64	8837.18	-21.25	11490.88	0.97	57.06
16	-35.94	10026.42	-44.37	12884.45	1.17	58.23
18	4.09	10000.6	66.58	13206.79	1.26	56.53
20	31.49	9923.62	-18.16	13610.81	1.32	54.82
22	-13.88	9832.03	-63.3	14065.17	1.39	53.86
24	-20.15	9749.06	-45.81	14589.44	1.38	54.03

Table A.21.: Summary of moments calculated in the point entitled "Tower Bottom". Sea state 3

A.1.5. Shaft

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	2.94	2.14	36.21	3.36	-1261.66	0.77
6	9.2	13.71	82.21	10.03	-1269.36	4.12
8	23.03	27.08	154.46	18.8	-1290.42	2.97
10	45.22	50.75	214.56	36.83	-1320.58	36.87
12	64.05	62.9	240.26	37.61	-1346.3	46.49
14	76.9	76.97	247.71	38.78	-1362.55	48.25
16	101.91	143.2	249.52	58	-1379.46	48.57
18	145.66	242.08	211.17	117.31	-1400.75	63.61
20	163.68	285.29	184.47	153.44	-1418.27	72
22	169.86	290.57	198.43	150.72	-1430.46	75.66
24	159.81	253.59	257.45	117.79	-1434.18	74.97

Table A.22.: Summary of forces calculated in the point entitled "Shaft". Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	481.3	12.51	-30.39	13.58	683.61	114.9
6	1097.81	52.85	-63.91	63.87	1524.12	73.86
8	2039.15	87.84	-109.51	97.16	2556.78	93.03
10	2849.17	312.06	-149.38	155.11	4394.01	4018.69
12	3230.24	352.5	-123.41	185.84	6451.25	2884.72
14	3402.85	345.27	-103.33	252.54	8001.7	2586.8
16	3597.06	396.47	-249.28	481.28	8556.43	3811.09
18	3718.86	408.07	-701.25	686.9	8790.83	7667.49
20	3825.77	406.74	-936.78	758.64	9148.25	9546.94
22	4042.82	459.9	-907.44	794.08	9537.61	9500.46
24	4348.74	623.13	-664.3	821.57	9619.3	7652.04

Table A.23.: Summary of moments calculated in the point entitled "Shaft". Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	421.72	28.52	50.5	26.25	-1306.89	28.52
6	637.72	21.9	72.81	16.95	-1360.39	29.82
8	906.72	51.09	112.19	33.08	-1447.2	35.96
10	1009.85	51.53	113.41	75.17	-1484.85	50.92
12	1015.21	64.96	79.81	67.25	-1494.17	53.13
14	1016.5	80.75	49.52	70.8	-1499.4	61.97
16	1942.53	73.31	35.61	113.22	-1890.31	42.75
18	1943.33	75.9	38.28	116.99	-1891.89	43.9
20	1944.17	77.25	43.26	122.86	-1894.35	46.53
22	1947.06	80.79	51.55	124.56	-1899.38	46.4
24	1954.32	84.71	61.02	118.46	-1909.2	45.16

Table A.24.: Summary of forces calculated in the point entitled "Shaft". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	645.54	39.34	-2937.01	61.37	691.74	162.9
6	1226.42	56.13	-4487.75	58.29	1517.49	185.16
8	2235.72	204.52	-6463.58	263.14	2556.69	173.78
10	3077.6	316.03	-7279.83	302.47	4383.11	4479.61
12	3423.15	248.38	-7291.12	344.72	6408.85	4252.41
14	3598.48	332.98	-7289.26	544.23	7877.74	4316.87
16	4970.04	333.07	-14162.54	383.77	8511.58	4138.14
18	5121.02	369.79	-14221.37	374.07	8698.13	4110.37
20	5304.05	385.9	-14302.02	353.2	8844.76	4248.72
22	5540.17	365.43	-14416.52	381.64	9014.59	4208.66
24	5823.01	357.32	-14572.29	414.11	9240.4	3762.07

Table A.25.: Summary of moments calculated in the point entitled "Shaft". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	397.28	54.55	46.79	59.79	-1298.19	34.73
6	661.16	45.35	92.54	49.19	-1365.46	32.34
8	949.62	114.54	172.45	106.1	-1461.42	70.42
10	1046.37	94.75	221.23	108.67	-1500.7	52.83
12	1045.4	118.42	184.91	120.47	-1509.74	74.49
14	1057.28	120.7	144.22	126.68	-1518.21	68.81
16	1984.92	114.25	155.77	156.56	-1907.86	58.32
18	1988.49	109.69	134.51	157.44	-1913.1	56.85
20	1991.56	106	138.86	154.33	-1917.89	55.76
22	1993.55	108.9	149.17	154.98	-1922.43	57.94
24	1994.65	112.81	161.11	155.55	-1927.28	60.38

Table A.26.: Summary of forces calculated in the point entitled ”Shaft”. Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	527.64	353.79	-2702.26	378.09	595.71	228.87
6	1367.98	316.76	-4642.51	324.38	1564.62	429.93
8	2691.73	564.48	-6736.81	690.98	2688.66	788.74
10	3737.65	569.98	-7432.32	670.94	4426.53	3922.41
12	4037.97	668.79	-7418.17	792.79	6201.5	3870.67
14	4136.45	664.42	-7507.33	794.67	7441.59	4046.78
16	5681.35	712.2	-14531.87	897.26	8241.21	3515.14
18	5777.18	696.58	-14622.48	872.1	8733.42	3376.55
20	5974.26	665.69	-14713.3	853.8	8954.98	3185.71
22	6218.26	666.56	-14811.72	870.87	9136.68	3273.5
24	6500.67	666.94	-14919.77	891.83	9363.71	3405.58

Table A.27.: Summary of moments calculated in the point entitled ”Shaft”. Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	535.93	121.98	71.57	109.99	-1332.89	35.67
6	815.01	76.17	212.26	90.27	-1410.13	35.62
8	975.36	109.21	351.04	84.37	-1488.64	50.79
10	933.99	97.48	377.52	99.03	-1500.53	68.85
12	944.65	106.86	365.56	105.14	-1523.53	74.54
14	972.92	107.02	312.27	110.81	-1532.38	76.68
16	1912.29	104.24	309.66	140.94	-1879.08	103.02
18	1933.44	104.45	279.73	144.44	-1894.17	101.62
20	1938.38	107.88	281.99	144.55	-1901.08	100.6
22	1937.24	111.85	286.28	144.64	-1907.16	100.13
24	1936.45	117.25	294.77	144.22	-1915.02	99.95

Table A.28.: Summary of forces calculated in the point entitled "Shaft". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	785.32	825.07	-3732.64	823.09	914.55	415.09
6	2235.23	731.39	-5627.99	608.33	1924.59	869.32
8	3943.52	603.32	-6967.03	902.7	2881.65	1093.75
10	4756.52	694.84	-6615.75	950.34	4684.54	3917.63
12	5152.13	760.33	-6619.44	1042.45	6397.47	3604.46
14	5142.23	755.57	-6836.72	1037.84	7565.77	3415.48
16	6630.61	771.75	-14198.94	1276.21	8337.56	3598.66
18	6684.43	748.02	-14437.81	1237.12	8757.3	3489.18
20	6865.01	743.14	-14536.84	1236.02	8944.29	3452.03
22	7071.57	748.86	-14610.17	1234.37	9134.03	3385.62
24	7334.62	752.45	-14691.4	1235	9364.71	3306.95

Table A.29.: Summary of moments calculated in the point entitled "Shaft". Sea state 3

A.1.6. Arm 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	14.55	4.59	398.86	0.76	1550.86	1.64
6	29.79	3.12	375.25	1.26	1590.23	2
8	43.38	1.67	342.34	4.66	1646.14	3.31
10	65.83	30.95	320.42	20.18	1681.61	25.46
12	90.8	25.2	311.6	26.15	1699.64	30.63
14	110.34	23.3	309.33	22.83	1704.7	26.43
16	115.86	48.48	305.59	21.99	1714.25	27
18	123.72	97.27	306.33	22.75	1716.14	31.03
20	131.66	121.36	306.87	20.55	1716.5	32.18
22	131.54	116.8	301.73	23.53	1722.65	35.4
24	121.44	87.14	291.76	32.05	1732.41	39.77

Table A.30.: Summary of forces calculated in the point entitled "Arm1". Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	3.23	0.18	-0.04	0.57	0	0
6	3.23	0.34	-0.08	1.71	0	0
8	3.22	0.62	-0.16	2.71	0	0
10	3.21	1.03	-0.21	98.11	0	0
12	3.2	1.1	-0.27	72.27	0	0
14	3.19	1.23	-0.18	65.99	0.01	0
16	3.1	1.38	-0.2	37.28	0.01	0
18	2.86	2.13	-0.15	40.06	0.01	0.01
20	2.75	2.64	0.04	30.09	0.01	0.01
22	2.76	2.73	-0.08	36.85	0.01	0.01
24	2.92	2.46	-0.3	78.19	0.01	0.01

Table A.31.: Summary of moments calculated in the point entitled "Arm1". Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	18.58	5.41	406.95	3.56	1526.03	13.77
6	35.08	4.76	399.55	4.41	1519.22	6.21
8	51.1	4.99	384.56	6.17	1514.65	5.78
10	76.62	36.2	362.89	24.74	1544.1	36.17
12	103.18	29.7	349.78	17.17	1573.53	24.62
14	121.8	28.81	343.19	18.37	1589.98	26.04
16	141.64	26.95	411.03	15.22	1292.08	25.28
18	142.68	26.42	404.86	16.34	1304.56	25.26
20	143.01	27.91	397.87	19.22	1318.83	28.76
22	142.91	29.95	389.18	20.74	1335.95	32.61
24	143.03	29.88	379.49	19.38	1354.93	34.86

Table A.32.: Summary of forces calculated in the point entitled "Arm1". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	3.23	1.85	0	1.29	0	0
6	3.23	1.89	-0.02	2	0	0
8	3.23	1.97	-0.07	3.62	0	0
10	3.21	2.07	-0.01	110.43	0	0
12	3.2	2.13	-0.08	107.76	0.01	0
14	3.2	2.21	-0.09	109.44	0.01	0
16	3.18	2.3	0	117.61	0.01	0
18	3.18	2.38	0.06	116.26	0.01	0
20	3.17	2.42	-0.11	119.45	0.01	0
22	3.17	2.47	-0.01	118.18	0.01	0
24	3.16	2.52	-0.12	105.78	0.01	0

Table A.33.: Summary of moments calculated in the point entitled "Arm1". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	15.47	7.62	409.42	17.33	1526.23	39.33
6	35.61	11.51	395.83	15.57	1528.91	26.04
8	51.47	15.17	370.55	21.22	1552.82	86.08
10	69.58	34.36	341.05	27.58	1613.84	49.45
12	89.9	33.53	329.76	32.18	1635.81	73.05
14	105.58	34.18	327.78	32.84	1636.05	60.21
16	127.9	31.44	387.47	29.04	1378.44	62.53
18	134.54	28.15	384.54	28.42	1378.89	60.29
20	135.24	26.18	377.32	26.82	1393.98	56.13
22	134.54	25.88	368.38	25.8	1414.34	54.84
24	133.72	26.31	357.93	25.36	1439.07	53.41

Table A.34.: Summary of forces calculated in the point entitled "Arm1". Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	3.3	4.45	0	4.26	0	0
6	3.34	4.33	-0.02	5.18	0	0
8	3.32	6.22	0.01	8.1	0	0
10	3.38	4.51	-0.18	94.5	0	0
12	3.35	5.53	-0.13	93.55	0.01	0
14	3.37	4.8	-0.16	98.73	0.01	0
16	3.37	4.71	-0.09	91.71	0.01	0
18	3.36	4.75	-0.06	92.12	0.01	0
20	3.35	4.8	-0.09	88.28	0.01	0
22	3.35	4.82	-0.1	91	0.01	0
24	3.34	4.86	-0.16	94.91	0.01	0

Table A.35.: Summary of moments calculated in the point entitled "Arm1". Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	24.9	11.5	410.62	37.15	1518.36	78.28
6	39.91	19.36	375.55	31.11	1583.42	54.06
8	48.61	22.41	329.5	22.47	1669.76	48.66
10	60.98	39.31	300.2	31.83	1731.74	45.71
12	73.71	38.32	289.99	35.15	1751.31	46.52
14	87.2	36.23	292.27	35.99	1741.09	47.84
16	113.18	35.69	340.62	28.16	1553.11	51.14
18	119.55	33.23	342.53	27.72	1536.97	50.44
20	119.57	32.66	336.85	27.17	1546.96	49.35
22	119.09	32.7	329.74	26.75	1560.93	49.6
24	117.95	33.02	320.81	27	1580.47	49.57

Table A.36.: Summary of forces calculated in the point entitled "Arm1". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	3.44	5.14	0.05	6.48	0	0
6	3.59	5.29	0.11	8.82	0	0
8	3.51	4.41	-0.12	10.61	0	0
10	3.48	4.4	-0.33	90.24	0	0
12	3.5	4.33	-0.39	83.16	0.01	0
14	3.5	4.31	-0.38	82.06	0.01	0
16	3.47	4.74	-0.31	95.55	0.01	0
18	3.45	4.74	-0.3	94.91	0.01	0
20	3.43	4.74	-0.26	94.41	0.01	0
22	3.42	4.71	-0.17	92.29	0.01	0
24	3.4	4.69	-0.31	89.89	0.01	0

Table A.37.: Summary of moments calculated in the point entitled "Arm1". Sea state 3

A.1.7. Arm 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	20.21	2.52	430.61	1	1497.88	1.86
6	47.01	2.48	447.42	4.48	1469.79	6.99
8	85.31	2.38	475.86	4.8	1419.8	3.21
10	145.13	23.57	506.63	17.35	1366.73	20.62
12	204.94	17.82	520.79	19.77	1351.83	24.6
14	247.95	18.11	528.65	25.35	1348.46	31.24
16	275.26	116.36	543.1	31.38	1326.78	52.26
18	308.26	252.57	570.35	37.57	1289	72.96
20	333	322.91	587.74	42.65	1272.93	79.59
22	348.26	321.06	595.23	44.25	1262.2	78.96
24	341.56	239.44	594.05	43.49	1250.44	71.97

Table A.38.: Summary of forces calculated in the point entitled "Arm2". Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	3.23	0.21	0.04	0.24	0	0
6	3.23	0.39	0.1	0.54	0	0
8	3.23	0.71	0.19	0.89	0	0
10	3.22	1.14	0.27	97.99	0	0
12	3.22	1.4	0.26	71.98	0	0
14	3.22	1.68	0.38	65.63	0.01	0
16	3.16	1.8	0.65	36.39	0.01	0
18	3.04	2.27	1.38	38.52	0	0
20	2.99	2.64	1.68	27.3	0	0
22	3	2.92	1.65	34.53	0.01	0
24	3.06	3.18	1.17	77.25	0.01	0

Table A.39.: Summary of moments calculated in the point entitled "Arm2". Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	26.29	6.6	552.61	5.57	1190.09	27.28
6	65.38	9.29	638.55	6.77	991.87	8.42
8	124.18	9.98	760.37	21.2	725.74	30.95
10	214.28	26.18	824.12	18.98	613.98	32.44
12	307.1	28.13	835.36	25.31	618.05	38.92
14	373.36	32.77	841.29	31.08	627.18	46.09
16	439.18	63.6	1251.46	25.96	-313.75	53.78
18	450.73	63.17	1257.47	25.92	-313.93	55.17
20	461.28	64.88	1265.57	26.25	-315.26	57.36
22	473.41	64.33	1276.68	26.51	-318.92	59.09
24	489.69	59	1291.37	26.31	-326.15	59.48

Table A.40.: Summary of forces calculated in the point entitled "Arm2". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	3.23	1.92	0.09	1	0	0
6	3.23	1.91	0.16	1.23	0	0
8	3.23	2	0.27	1.85	0	0
10	3.22	2.29	0.43	110.77	0	0
12	3.22	2.63	0.38	108.03	0	0
14	3.21	2.92	0.38	109.73	0	0
16	3.19	2.86	0.46	118.62	0	0
18	3.19	3.04	0.54	117.28	0	0
20	3.18	3.11	0.38	120.52	0	0
22	3.17	3.2	0.51	119.21	0	0
24	3.16	4.33	0.44	106.71	0	0

Table A.41.: Summary of moments calculated in the point entitled "Arm2". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	22.01	8.74	538.93	20.72	1216.62	58.95
6	67.93	12.74	649.12	20.87	965.65	41.54
8	132.19	31.99	784.49	43.31	670.06	115.14
10	222.04	54.44	847.97	40.75	557.6	101.39
12	304.88	59.76	857.19	48.49	568.58	111.65
14	362.13	64.47	866.23	48.9	568.4	108.64
16	437.05	88.14	1284.96	58.62	-364.88	143.94
18	462.52	72.01	1292.49	56.88	-365.22	137.88
20	477	63.85	1301.68	54.99	-367.49	132.01
22	490.37	63.47	1312.36	56.3	-370.16	132.53
24	506.87	63.05	1324.43	57.47	-371.78	132.94

Table A.42.: Summary of forces calculated in the point entitled "Arm2". Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	3.27	4.63	0.1	2.37	0	0
6	3.29	4.2	0.22	2.33	0	0
8	3.24	6	0.4	4.25	0	0
10	3.34	4.47	0.55	94.65	0	0
12	3.31	5.4	0.61	93.66	0	0
14	3.36	4.69	0.54	98.93	0	0
16	3.35	5.48	0.58	92.36	0	0
18	3.35	5.62	0.58	92.78	0	0
20	3.35	6.08	0.57	88.94	0	0
22	3.34	6.27	0.57	91.74	0	0
24	3.32	6.04	0.55	95.77	0	0

Table A.43.: Summary of moments calculated in the point entitled "Arm2". Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	34.33	15.99	593.35	47.22	1085.6	124.85
6	87.26	30.05	717.65	38.84	793.04	89.45
8	145.3	40.37	829.23	54.54	586.07	110.85
10	232.78	69.04	840.28	57.15	599.05	105.72
12	312.02	68.46	856.6	62.52	591.46	109.44
14	365.73	58.22	867.68	62.33	588.04	101.55
16	454.36	81.74	1284.3	89.35	-305.33	131
18	476.26	75.87	1299.65	87.56	-322.47	125.63
20	488.94	73.57	1309.63	87.04	-327.85	120.36
22	502.16	71.91	1318.95	86.99	-327.76	115.96
24	519.12	70.05	1330.35	87.11	-328.56	112.98

Table A.44.: Summary of forces calculated in the point entitled "Arm2". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	3.39	4.98	0.18	5.05	0	0
6	3.47	4.89	0.39	5.29	0	0
8	3.4	6.03	0.61	3.97	0	0
10	3.4	6.15	0.82	89.99	0	0
12	3.44	5.99	0.81	82.86	0	0
14	3.47	5.89	0.71	81.83	0	0
16	3.44	7.26	0.73	95.97	0	0
18	3.43	7.24	0.66	95.38	0	0
20	3.42	7.31	0.71	94.9	0	0
22	3.4	7.46	0.81	92.81	0	0
24	3.37	7.58	0.69	90.42	0	0

Table A.45.: Summary of moments calculated in the point entitled "Arm2". Sea state 3

A.1.8. Arm 3

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	10.49	1.38	428.4	0.84	1501.09	1.66
6	24.08	1.64	442.91	2.19	1475.9	3.41
8	40.55	1.84	468.43	3.47	1428.87	1.92
10	79.68	23.36	497.06	12.06	1375.16	11.57
12	131.28	16.72	514.01	14.28	1351.14	16.96
14	171.25	15.06	523.97	16	1340.81	21.34
16	175.74	79.65	527.94	18.03	1336.12	81
18	150.04	163.16	521.5	25.14	1351	151.15
20	140.36	200.76	521.09	26.09	1354.95	178.24
22	151.42	202.53	531.21	29.31	1338.28	178.38
24	174.95	160.46	548.89	38.78	1298.26	149.49

Table A.46.: Summary of forces calculated in the point entitled "Arm3". Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	481.3	12.51	-30.39	13.58	683.61	114.9
6	1097.81	52.85	-63.91	63.87	1524.12	73.86
8	2039.15	87.84	-109.51	97.16	2556.78	93.03
10	2849.17	312.06	-149.38	155.11	4394.01	4018.69
12	3230.24	352.5	-123.41	185.84	6451.25	2884.72
14	3402.85	345.27	-103.33	252.54	8001.7	2586.8
16	3597.06	396.47	-249.28	481.28	8556.43	3811.09
18	3718.86	408.07	-701.25	686.9	8790.83	7667.49
20	3825.77	406.74	-936.78	758.64	9148.25	9546.94
22	4042.82	459.9	-907.44	794.08	9537.61	9500.46
24	4348.74	623.13	-664.3	821.57	9619.3	7652.04

Table A.47.: Summary of moments calculated in the point entitled "Arm3". Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	0.98	4.23	343.59	2.44	1697.31	6.76
6	0.14	2.88	318.7	2.22	1753.51	1.67
8	-5.61	4.06	298.78	2.52	1795.89	1.78
10	-0.25	42.39	303.59	16.22	1784.83	13.51
12	14.85	39.92	314.19	15.85	1767.17	12.66
14	27.51	42.74	320.35	30.68	1756.58	26.04
16	-13.58	50.08	234.08	11.36	1918.21	7.3
18	-13.87	51.01	235.6	13.77	1914.45	8.84
20	-14.58	52.84	237.49	13.44	1909.52	9.63
22	-15.47	50.44	239.86	9.19	1903.61	8.53
24	-16.53	44.13	242.74	10.35	1896.89	8.7

Table A.48.: Summary of forces calculated in the point entitled "Arm3". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	645.54	39.34	-2937.01	61.37	691.74	162.9
6	1226.42	56.13	-4487.75	58.29	1517.49	185.16
8	2235.72	204.52	-6463.58	263.14	2556.69	173.78
10	3077.6	316.03	-7279.83	302.47	4383.11	4479.61
12	3423.15	248.38	-7291.12	344.72	6408.85	4252.41
14	3598.48	332.98	-7289.26	544.23	7877.74	4316.87
16	4970.04	333.07	-14162.54	383.77	8511.58	4138.14
18	5121.02	369.79	-14221.37	374.07	8698.13	4110.37
20	5304.05	385.9	-14302.02	353.2	8844.76	4248.72
22	5540.17	365.43	-14416.52	381.64	9014.59	4208.66
24	5823.01	357.32	-14572.29	414.11	9240.4	3762.07

Table A.49.: Summary of moments calculated in the point entitled "Arm3". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	1.91	11.1	346.94	12.03	1691.16	32.79
6	0.04	12.95	318.21	7.87	1753.93	14.04
8	-5.3	14.58	303.27	13.38	1785.14	69.51
10	2.32	39.95	316.84	21.89	1756.76	29.06
12	16.9	39.79	327.18	28.47	1737.24	59.35
14	26.3	40.44	329.88	29.17	1733.82	43.19
16	-15.23	40.43	240.36	17.73	1903.84	15.39
18	-14.71	40.39	241.07	17.46	1901.8	14.87
20	-15.1	39.01	243.35	19.18	1896.48	15.44
22	-15.62	40.73	246.5	21.52	1888.88	16.75
24	-16.07	41.94	250.24	23.57	1879.48	17.63

Table A.50.: Summary of forces calculated in the point entitled "Arm3". Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	527.64	353.79	-2702.26	378.09	595.71	228.87
6	1367.98	316.76	-4642.51	324.38	1564.62	429.93
8	2691.73	564.48	-6736.81	690.98	2688.66	788.74
10	3737.65	569.98	-7432.32	670.94	4426.53	3922.41
12	4037.97	668.79	-7418.17	792.79	6201.5	3870.67
14	4136.45	664.42	-7507.33	794.67	7441.59	4046.78
16	5681.35	712.2	-14531.87	897.26	8241.21	3515.14
18	5777.18	696.58	-14622.48	872.1	8733.42	3376.55
20	5974.26	665.69	-14713.3	853.8	8954.98	3185.71
22	6218.26	666.56	-14811.72	870.87	9136.68	3273.5
24	6500.67	666.94	-14919.77	891.83	9363.71	3405.58

Table A.51.: Summary of moments calculated in the point entitled "Arm3". Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	1.37	18.02	327.54	19.45	1730.79	41.36
6	0.11	20.81	316.57	13.7	1755.25	26.77
8	-2.86	19.1	330.92	19.47	1721.87	39.94
10	17.68	40.43	367.53	30.11	1642.95	43.02
12	39.51	37.32	384.01	30.54	1608.38	46.07
14	49.79	33.5	379.59	30.52	1620.75	43.35
16	-11.12	40.73	262.85	22.21	1854.1	23.65
18	-11.46	40.22	260.54	20.38	1857.95	21.92
20	-11.81	39.83	263.04	21.29	1851.96	22.64
22	-12.06	39.4	266.63	22.08	1843.42	23.46
24	-12.16	38.18	271.71	21.73	1831.61	24.03

Table A.52.: Summary of forces calculated in the point entitled "Arm3". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	785.32	825.07	-3732.64	823.09	914.55	415.09
6	2235.23	731.39	-5627.99	608.33	1924.59	869.32
8	3943.52	603.32	-6967.03	902.7	2881.65	1093.75
10	4756.52	694.84	-6615.75	950.34	4684.54	3917.63
12	5152.13	760.33	-6619.44	1042.45	6397.47	3604.46
14	5142.23	755.57	-6836.72	1037.84	7565.77	3415.48
16	6630.61	771.75	-14198.94	1276.21	8337.56	3598.66
18	6684.43	748.02	-14437.81	1237.12	8757.3	3489.18
20	6865.01	743.14	-14536.84	1236.02	8944.29	3452.03
22	7071.57	748.86	-14610.17	1234.37	9134.03	3385.62
24	7334.62	752.45	-14691.4	1235	9364.71	3306.95

Table A.53.: Summary of moments calculated in the point entitled "Arm3". Sea state 3

A.1.9. Blade 1, point 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-6.26	24.74	-808.93	17.82	52.23	49.11
6	-13.53	50.46	-790.71	46.28	129.56	117.42
8	-22.81	90.61	-754.47	90.53	266.72	223.68
10	-36.78	127.51	-731.54	129.59	331.12	314.79
12	-52.53	141	-727.66	151.4	335.26	363.01
14	-65.45	145.72	-724.2	166.83	332.43	395.15
16	-70.02	148.56	-719.45	178.09	333.13	432.66
18	-71.94	162.23	-713.89	196.03	334.74	486.1
20	-74.69	172.19	-705.52	212.91	335.87	536.03
22	-77.59	174.39	-696.49	226.86	331.9	567.23
24	-77.51	169.57	-688.77	238.18	322.42	579.89

Table A.54.: Summary of forces calculated in the point entitled ”BladeP1”. Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	34101.27	2928.8	-360.44	1458.58	651.55	2487.28
6	34915.18	7256.77	-817.88	2973.76	922.96	5059.95
8	36235.76	14013.08	-1390.67	5338.4	1265.61	9068.44
10	36692.38	19785.77	-2291.9	7519.66	1706.73	12594.95
12	36698.36	22667.71	-3309.43	8310.04	2218.37	14127.99
14	36500.28	24507.31	-4130.87	8589.3	2691.17	14849.5
16	36389.25	26141.74	-4419.73	8758.01	2845.48	15318.48
18	36308.39	28254.67	-4533.43	9599.22	2907.67	16517.85
20	36034.3	30487.21	-4709.81	10214.84	2970.01	17510.1
22	35640.73	32419.16	-4889.44	10345.75	3049.81	18103.4
24	35305.73	33963.28	-4878.4	10038.28	2985.49	18357.47

Table A.55.: Summary of moments calculated in the point entitled ”BladeP1”. Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-6.61	72.88	-807.81	63.35	53.01	74.92
6	-13.22	87.56	-790.83	82.27	130.05	130.95
8	-23.29	116.19	-752.31	124.34	266.97	236.4
10	-36.77	150.28	-730.02	152.27	329.35	320.64
12	-52.77	160.87	-726.94	170.58	330.05	365.77
14	-63.96	164	-724.36	184.03	328.03	396.94
16	-68.92	181.89	-718.36	210.09	327.07	429.22
18	-70.43	181.56	-713.59	220.93	323.08	456.92
20	-71.99	182.63	-707.79	231.36	320.45	485.36
22	-73.33	185.66	-699.89	243.65	317.78	517.89
24	-74.39	190.8	-690.25	258.49	317.2	555.35

Table A.56.: Summary of forces calculated in the point entitled "BladeP1". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	34064.47	6702.44	-380.93	4333.22	680.63	7581.28
6	34977.67	9757.77	-798.98	5179.46	897.3	8931.94
8	36148.06	16325.02	-1419.52	6848.75	1316.74	11594.24
10	36574.61	21104.84	-2290.84	8854.15	1709.04	14788.42
12	36527.5	23647.99	-3322.96	9469.99	2264.77	15954.66
14	36427.48	25339.51	-4039.76	9656.57	2609.24	16455.41
16	36188.85	27672.98	-4354.99	10684.27	2763.35	18356.66
18	35944.18	29113.44	-4445.89	10672.47	2803.84	18678.83
20	35733.17	30580.9	-4540.9	10734.21	2876.03	19061.87
22	35455.38	32330.29	-4621.22	10911.37	2911.3	19641.66
24	35211	34411.13	-4688.25	11214.7	2878.04	20463.48

Table A.57.: Summary of moments calculated in the point entitled "BladeP1". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-12.22	100.9	-836.51	113.86	81.85	122.17
6	-13.77	104.84	-788.31	153.53	135.82	181.87
8	-23.67	160.37	-744.97	164.71	289.06	264.46
10	-39.68	188.14	-729.16	192.07	335.13	338.44
12	-51.97	200.78	-719.88	208.27	328.2	383.06
14	-62.38	203.74	-721.58	220.41	332.12	416.44
16	-65.45	229.03	-708.62	249.17	325.58	455.29
18	-72.55	228.44	-704.91	259.56	324.58	480.91
20	-73.44	229.74	-700.97	269.94	326.47	511.09
22	-73.36	231.95	-692.75	280.68	322.15	543.66
24	-74.82	235.48	-682.46	293.35	317.79	578.28

Table A.58.: Summary of forces calculated in the point entitled "BladeP1". Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	37089.04	11801.68	-689.62	5995.36	1295.74	10523.46
6	35027.55	16434.52	-828.71	6220.6	916.2	10764.61
8	36281.98	19714.15	-1429.03	9493.85	1246.73	16344.76
10	36747.21	24002.75	-2452.49	11124.34	1964.42	19034.33
12	36073.32	26486.69	-3255.15	11870.22	2270.43	20412.06
14	36509.84	28265.77	-3922.49	12039.94	2666.13	20848.88
16	35684.9	31171.16	-4133.35	13508.75	2536.15	23455.16
18	35597.39	32528.03	-4572.05	13480.87	3013.16	23623.86
20	35699.9	34044.61	-4628.7	13562.18	2963.16	24021.48
22	35370.45	35676.96	-4624.13	13697.4	2823.51	24493.15
24	34973.67	37526.17	-4713.46	13911.07	2830.38	25089.6

Table A.59.: Summary of moments calculated in the point entitled "BladeP1". Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-7.75	142.83	-798.76	160.92	71.5	168.8
6	-20.1	179.75	-774.53	185.3	180.36	219.99
8	-24.91	182.61	-735.81	195.62	314.67	298.47
10	-40.91	200.7	-724.37	207.03	331.97	356.59
12	-53.48	215.36	-719.37	224.53	332.22	399.99
14	-61.41	221.98	-715.75	238.25	331.06	430.87
16	-67.13	244.12	-703.17	265.84	324.73	469.23
18	-72.4	243.91	-698.65	275.03	322.96	494.83
20	-72.35	244.21	-692.94	284.21	323.24	523.35
22	-73.26	245.8	-682.88	293.94	318.37	554.23
24	-75.65	248.97	-671.75	306.02	314.42	588.27

Table A.60.: Summary of forces calculated in the point entitled "BladeP1". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	34023.04	16509.88	-446.45	8448.55	654.16	14820.47
6	35343.09	19739.59	-1196.1	10660.47	1325.38	18552.64
8	36454.4	22918.24	-1507.99	10810.95	1255.95	18612.8
10	36381.62	25559.19	-2537.91	11867.45	1943.51	20334.7
12	36284	28133.6	-3354.81	12732.03	2317.18	21939.27
14	36199.37	29978.7	-3866.71	13125.89	2493.66	22800.45
16	35514.38	32807	-4234.38	14401.41	2645.51	25038.57
18	35378.94	34113.5	-4559.94	14394.99	2960.97	25230.21
20	35325.66	35506.12	-4560.45	14416.22	2845.04	25519.75
22	34862.77	37005.4	-4616.92	14516.95	2811.84	25928.54
24	34440.1	38784.74	-4760.87	14710.7	2910.68	26490.11

Table A.61.: Summary of moments calculated in the point entitled "BladeP1". Sea state 3

A.1.10. Blade 1, point 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	6.04	23.32	688.09	34.21	-245.63	38.14
6	13	47.54	698.56	85.23	-175.81	89.49
8	21.79	85.33	714.12	164.61	-50.64	169.46
10	35.38	120.08	717.22	233.4	10.5	238.02
12	50.89	132.9	716.5	268.97	15.32	275.36
14	63.52	137.34	713.56	291.71	13.88	301.35
16	67.82	139.7	710.95	310.44	15.94	334.54
18	69.41	152.56	707.99	334.44	19.19	383.49
20	71.88	161.94	702.63	360.11	22.77	427.07
22	74.36	163.83	695.51	382.73	22.42	451.38
24	73.89	158.89	688.52	401.45	17.28	456.82

Table A.62.: Summary of forces calculated in the point entitled ”BladeP2”. Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-12377.49	1966.99	402.15	1614.82	451.3	1753.82
6	-12950.75	4854.59	722.24	3287.25	531.97	3565.97
8	-13946.25	9371.16	1121.53	5894.16	635.4	6389.14
10	-14397.1	13205.82	1720.03	8217.99	708.9	8864.08
12	-14450.66	15080.96	2398.15	9171.19	805.44	9972.01
14	-14356.54	16269.23	2964.72	9577.2	938.84	10535.55
16	-14347.81	17376.07	3160.89	9826.9	975.38	10927.93
18	-14382.14	18817.58	3238.09	10633.65	991.96	11803.27
20	-14300.14	20325.88	3348.18	11272.83	985.56	12545.68
22	-14156.22	21604.78	3465.4	11560.02	994.43	13055.67
24	-14075.65	22587.84	3437.44	11542.92	941.18	13367.73

Table A.63.: Summary of moments calculated in the point entitled ”BladeP2”. Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	6.37	69.2	687.4	84	-244.55	46.29
6	12.72	82.83	699.05	119.48	-175.4	92.57
8	22.25	109.47	712.5	196.01	-49.61	172.63
10	35.37	141.51	715.29	252.07	9.56	238.56
12	51.12	151.52	713.87	283.39	11.22	274.23
14	62.09	154.38	711.93	304.24	10.29	299.69
16	66.71	170.53	707.12	334.08	11.51	323.33
18	67.94	169.94	702.69	351.16	9.62	346.39
20	69.2	170.56	698.08	368.2	9.4	370.08
22	70.23	173.09	691.97	388.55	9.9	396.54
24	71.02	177.68	685.57	412.9	12.82	426.63

Table A.64.: Summary of forces calculated in the point entitled "BladeP2". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-12363.01	4285.97	422.39	4886.45	470.56	5382.44
6	-13002.5	6350.13	703.57	5780.1	515.35	6316.34
8	-13912.6	10764.01	1154.65	7549.92	671.84	8156.3
10	-14339.05	13969.22	1720.24	9660.97	711.5	10392.08
12	-14354.21	15623.05	2421.58	10386.22	843.24	11237.13
14	-14327.5	16713.84	2890.93	10664.81	897.01	11634.36
16	-14245.35	18155.84	3100.84	11857.51	923.73	13011.51
18	-14150.01	19097.68	3159.8	11979.01	928.68	13327.39
20	-14099.86	20068.85	3233.85	12152.02	961.44	13675.26
22	-14034.87	21229.22	3286.61	12453.08	965.85	14159.43
24	-14023.4	22609.71	3307.8	12908.17	912.24	14813.81

Table A.65.: Summary of moments calculated in the point entitled "BladeP2". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	11.64	95.65	724.32	148.52	-230.21	66.35
6	13.24	99.2	698.93	204.47	-169.81	110.62
8	22.52	151.63	713.62	240.82	-28.8	186.25
10	38.13	177.69	716.79	291.18	14.76	244.53
12	50.18	189.64	706.86	320.7	12.06	280.24
14	60.36	192.32	711.21	341.91	14.76	307.76
16	63.25	215.65	698.27	378.43	13.51	334.9
18	69.91	214.9	695.84	394.65	14.03	356.33
20	70.58	215.92	694.83	412.33	17.03	381.78
22	70.24	217.81	688.07	431.25	16.13	408.83
24	71.37	220.97	679.87	452.73	16.02	437

Table A.66.: Summary of forces calculated in the point entitled "BladeP2". Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-14317.9	7514.57	789.25	6774.87	923.57	7477.96
6	-13064.09	10561.51	722.84	6965.37	521.97	7619.84
8	-14034.89	12857.2	1126.2	10587.27	604.3	11555.26
10	-14475.5	15727.6	1886.31	12345.3	887.5	13448.88
12	-14108.94	17381.5	2387.07	13212.74	873.9	14444.26
14	-14441.6	18553.6	2854.15	13453.92	992.89	14791.24
16	-14015.69	20386	2908.96	15118.13	796.63	16651.66
18	-14019.94	21269.63	3298.26	15173.21	1075.11	16827
20	-14185.04	22276.48	3307.57	15364.47	1009.52	17174.49
22	-14089.92	23363.08	3254.19	15607.06	884.28	17572.6
24	-13978.3	24595.53	3300.69	15933.51	859.5	18055.88

Table A.67.: Summary of moments calculated in the point entitled "BladeP2". Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	7.43	135.26	685.65	208.38	-226.02	89.97
6	19.17	170.13	702.11	246.2	-128.3	135.24
8	23.75	172.5	714.75	280.99	-4.68	206.55
10	39.37	189.43	711.67	311.08	13.56	256.02
12	51.71	203.26	708.65	341.74	15.5	290.1
14	59.44	209.5	706.23	363.72	15.79	314.86
16	64.93	229.73	693.89	399.43	14.81	341.56
18	69.81	229.34	690.64	414.69	14.81	363.23
20	69.56	229.43	687.61	430.81	17.12	387.54
22	70.17	230.78	679.15	448.16	16.47	413.65
24	72.15	233.66	670.63	468.81	16.97	441.67

Table A.68.: Summary of forces calculated in the point entitled "BladeP2". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-12391.79	10489.66	439.97	9527.87	422.35	10530.67
6	-13328.44	12666.58	1042.21	11975.93	763.47	13154.44
8	-14206.66	14903.53	1166.65	12058.86	583.55	13159.34
10	-14265.72	16718.88	1920.27	13186.18	836.79	14369.84
12	-14283.26	18432.15	2452.51	14195.98	880.15	15527.85
14	-14290.71	19650.63	2762.46	14706.65	854.81	16179.76
16	-13990.45	21432.27	2995.61	16136.02	860.24	17778.62
18	-13973.96	22296.9	3270.18	16209.13	1031.78	17967.05
20	-14044.92	23226.18	3229.33	16330.51	926.15	18237.78
22	-13869.67	24226.87	3245.66	16534.92	876.34	18588.82
24	-13746.82	25414.48	3352.8	16839.62	916.07	19045.54

Table A.69.: Summary of moments calculated in the point entitled "BladeP2". Sea state 3

A.1.11. Blade 1, point 3

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	5.5	22.12	542.43	37.64	-394.8	27.92
6	11.78	45.06	560.01	93.4	-345.69	64.01
8	19.67	80.83	589.94	180.5	-256.98	120.34
10	31.74	113.25	602.87	254.93	-211.95	168.63
12	45.38	125.63	603.82	291.47	-208.03	196.38
14	56.28	130.08	601.31	313.98	-208.99	217.21
16	59.66	132.47	600.29	334.29	-207.1	243.92
18	60.68	144.19	599.77	361.51	-203.97	282.13
20	62.53	152.98	597.25	389.93	-200.51	316.18
22	64.29	155.29	592.88	413.41	-199.45	335.73
24	63.35	151.71	588.7	430.96	-201.52	341.1

Table A.70.: Summary of forces calculated in the point entitled ”BladeP3”. Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	4192.9	970.01	348.44	1419.06	338.6	1337.95
6	4030.95	2380.47	502.55	2886.27	352.2	2719.86
8	3707.37	4595.14	695.21	5172.92	371.02	4872.65
10	3499.16	6450.13	947.89	7183.56	325.77	6760.32
12	3453.83	7326.22	1233.06	8059.81	289.02	7614.4
14	3475.92	7888.49	1495.63	8484.12	309.84	8065.54
16	3436.83	8454.78	1589.19	8775.31	309.13	8390.03
18	3356.53	9194.56	1633.22	9480.49	311.37	9076.53
20	3333.02	9959	1679.22	10068.02	286.01	9663.55
22	3321.71	10604.99	1737.24	10435.27	273.96	10085.34
24	3250.48	11094.82	1714.88	10618.31	231.23	10365.21

Table A.71.: Summary of moments calculated in the point entitled ”BladeP3”. Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	5.8	66.22	541.91	87.35	-393.72	28.66
6	11.53	78.86	560.65	126.63	-345.34	64
8	20.14	103.51	588.66	211.42	-255.63	120.35
10	31.76	133.1	600.99	272.52	-212.19	168.07
12	45.63	142.5	601.03	304.33	-210.6	195.05
14	54.98	145.3	599.69	324.73	-211.12	215.56
16	58.77	160.22	595.89	353.61	-209.01	234.78
18	59.34	160.24	592.93	370.63	-209.86	254
20	60.08	161.3	590.53	387.89	-209.04	273.66
22	60.56	164.16	587.47	408.83	-207.29	294.95
24	60.76	169.06	585.11	434.08	-203.47	318.75

Table A.72.: Summary of forces calculated in the point entitled "BladeP3". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	4191.76	1955.31	364.58	4341.59	352.87	4116.17
6	3995.21	2984.83	487.22	5102.25	340.26	4823.58
8	3702.9	5167.37	724.45	6615.53	398.87	6214.26
10	3506.75	6742.58	948.52	8430.86	328.23	7919.28
12	3476.17	7518.13	1259.25	9096.05	320.21	8573.14
14	3460.66	8036.41	1449.74	9396.68	284.6	8893.45
16	3427.78	8688.26	1544.37	10503.53	272	9959.07
18	3422.35	9160.92	1577.41	10723.38	267.11	10232.85
20	3377.85	9661.3	1630.72	10971.73	285.31	10527.63
22	3319.04	10256.22	1663.04	11329.68	280.93	10924.96
24	3213.28	10958.76	1656.3	11824.5	228.3	11451.07

Table A.73.: Summary of moments calculated in the point entitled "BladeP3". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	10.75	91.54	580.29	153.81	-389.52	30.01
6	11.9	94.51	561.38	214.63	-341.11	66.82
8	20.02	144.4	591.96	256.05	-240.19	127.61
10	34.13	168.71	602.7	310.97	-208.23	170.2
12	44.53	180.1	594.45	342.38	-208.39	197.12
14	53.39	182.62	600.46	364.26	-207.17	219.13
16	55.46	204.55	589.41	400.84	-205.64	239.32
18	61.21	204.16	588.27	416.76	-204.53	257.32
20	61.31	205.49	590.05	434.78	-201.85	278.48
22	60.42	207.71	586.36	454.17	-201.25	300.46
24	60.94	211.12	581.89	476.41	-199.51	322.88

Table A.74.: Summary of forces calculated in the point entitled ”BladeP3”. Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	3261.02	3407.9	703.05	6030.93	709.28	5720.86
6	3944.13	4866.36	495.55	6165.5	343	5818.79
8	3650.75	6072.92	677.36	9344.23	341.4	8821.98
10	3417.99	7480.7	1086.8	10875.93	462.43	10268.37
12	3537.21	8289.81	1261.66	11666.96	356.64	11037.27
14	3347.19	8858.86	1485.42	11925.56	381.6	11317.83
16	3447.87	9701.62	1417.55	13425.46	188.95	12746
18	3397.25	10140.55	1699.79	13546.71	378.07	12900.57
20	3244.3	10656.27	1680.54	13800.43	316.57	13190.46
22	3197.75	11216.61	1611.88	14094.45	211.04	13518.28
24	3138.11	11850.86	1628.34	14458.22	180.74	13909.96

Table A.75.: Summary of moments calculated in the point entitled ”BladeP3”. Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	6.46	129.41	542.08	215.42	-379.02	41.08
6	17.03	162.59	568.71	257.76	-310.77	84.26
8	21.05	164.42	596.45	297.89	-222.68	139.93
10	35.12	180.07	597.97	331.48	-208.38	177.19
12	45.9	193.31	597.16	364.15	-206.17	202.64
14	52.36	199.39	596.18	387.1	-205.36	222.35
16	56.82	218.17	586.8	422.47	-203.34	241.88
18	60.85	218.05	585.29	437.96	-202.71	260.01
20	60.12	218.5	585.06	454.5	-199.99	280.26
22	60.2	220.19	579.71	472.27	-198.74	301.76
24	61.56	223.31	575.07	493.65	-196.48	324.23

Table A.76.: Summary of forces calculated in the point entitled "BladeP3". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	4150.97	4734.73	345.47	8467.25	304.81	8061.35
6	3842.21	5821.48	720.66	10620.54	508.96	10054.8
8	3565.98	7005	680.77	10646.67	313.96	10045.76
10	3493.56	7926.73	1075.46	11624.49	408.69	10970.73
12	3425.56	8761.85	1286.99	12546.13	350.67	11864.24
14	3373.46	9358.12	1385.83	13050.81	270.29	12378.02
16	3379.03	10176.19	1476.85	14339.05	232.94	13607.25
18	3331.75	10615.91	1666.78	14472.28	343.46	13770.87
20	3218.46	11095.04	1612.05	14662.07	253.85	14002.38
22	3206.75	11612.93	1605.51	14920.04	205.72	14292.99
24	3152.05	12225.05	1675.02	15263.06	224.34	14663.67

Table A.77.: Summary of moments calculated in the point entitled "BladeP3". Sea state 3

A.1.12. Blade 1, point 4

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	3.41	20.48	35.64	29.1	-598.08	7.96
6	7.12	41.67	48.04	71.47	-580.76	22.83
8	11.82	74.7	71.1	138	-548.63	46.95
10	18.44	103.95	83.5	193.76	-530.66	68.04
12	25.58	116.07	84.68	219.86	-528.76	81.11
14	31.18	121.27	83.63	236.73	-528.02	94.11
16	32.76	124.67	84.58	254.06	-526.64	104.51
18	33.5	134.99	86.69	277.04	-524.83	123.83
20	34.46	143.22	87.4	300.63	-521.7	139.67
22	35.54	147.52	87.24	319.92	-518.6	149.95
24	35.03	148.59	88.05	334.17	-517.4	156

Table A.78.: Summary of forces calculated in the point entitled "BladeP4". Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	11153.79	254.37	335.18	1295.26	3.1	25.9
6	11742.32	615.46	293.41	2632.3	-60.43	55.68
8	12760.39	1174.76	241.43	4715.81	-141.5	102.93
10	13219.3	1666.08	86.17	6545.89	-273.44	228.52
12	13229.42	1926.8	-73.08	7386.67	-410.21	214.97
14	13188.11	2091.28	-135.67	7862.86	-507.99	234.07
16	13160.71	2296.05	-145.91	8234.48	-544.22	292.69
18	13128.14	2634.16	-138.27	8945.29	-560.69	451.89
20	13100.53	2922.13	-166.82	9559.33	-590.7	545.15
22	13029	3056.1	-176.33	10027.69	-619.56	561.96
24	12899.61	3043.49	-196.17	10368.53	-627.49	507.07

Table A.79.: Summary of moments calculated in the point entitled "BladeP4". Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	3.65	62.19	35.59	58.92	-596.99	56.71
6	6.87	73.37	48.77	89.79	-581.01	68.37
8	12.23	95.24	70.86	155.2	-546.81	94.34
10	18.42	121.63	82.65	202.38	-529.48	102.15
12	25.85	130.77	83.16	225.45	-528.5	110.18
14	30.26	134.36	83.11	241	-528.17	118.92
16	31.93	149.45	83.09	260.38	-524.58	146.09
18	32.3	151.76	82.67	274.62	-523.61	153.56
20	33	154.58	83.44	289.72	-521.86	160.66
22	33.52	159.06	84.56	307.66	-519.21	168.21
24	33.64	165.53	87.06	328.82	-515.81	176.87

Table A.80.: Summary of forces calculated in the point entitled ”BladeP4”. Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	11149.46	469.75	348.44	4005.11	2.8	59.98
6	11730.16	745.85	281.98	4678.25	-59.06	78.97
8	12739.31	1288.4	268.25	6018.11	-140.98	107.81
10	13180.11	1727.36	88.59	7671.2	-272.29	247.14
12	13168.18	1965.19	-40.01	8320.05	-406.59	256.42
14	13126.62	2120.97	-150.7	8668.05	-499.55	276.72
16	13044.18	2292.07	-177.15	9753.02	-541.26	297.05
18	12982.71	2419.59	-167.83	10083.21	-554.89	324.18
20	12921.17	2544.97	-136.68	10423.79	-567.08	356.41
22	12848.64	2692.09	-129.98	10858.42	-582.1	385.18
24	12775.57	2866.11	-175.2	11414.23	-603.18	406.65

Table A.81.: Summary of moments calculated in the point entitled ”BladeP4”. Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	8.46	86.22	63.05	102.81	-622.48	101.68
6	7.07	88.25	50.25	146.84	-579.16	143.55
8	11.69	134.36	73.93	182.8	-539.6	139.14
10	20.35	156.42	84.79	224.97	-528.19	155.75
12	25.25	167.36	80.77	249.26	-522.73	163.81
14	30.04	170.48	85.97	266.23	-526.64	170.18
16	29.89	191.51	81.7	291.41	-518.57	195.98
18	34.19	192.63	82.68	304.49	-517.19	202.19
20	34.01	195.59	86.7	320.03	-517.34	208.35
22	33.1	199.23	87.32	336.95	-515.14	213.61
24	33.5	203.92	88.26	356.06	-511.62	220.21

Table A.82.: Summary of forces calculated in the point entitled ”BladeP4”. Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	11290.96	804.04	691.56	5574.81	28.99	86.74
6	11737.33	1115.7	281.1	5663.54	-61.39	98.72
8	12873.41	1520.21	204.84	8561.41	-148.14	155.87
10	13171.36	1898.98	215.96	9967.08	-268.25	245.89
12	13098.71	2125.91	16.87	10730.48	-389.78	265.98
14	13095.89	2278.74	-24.28	11035.21	-469.79	291.69
16	12962.2	2483.97	-240.98	12450.68	-527.3	307.54
18	12917.23	2596.25	-61.67	12646.12	-556.94	330.59
20	12877.01	2730.79	-114.94	12977.03	-574.86	355.23
22	12791.85	2877.44	-208	13339.5	-592.8	385.38
24	12694.38	3034.78	-229.96	13760.36	-613.19	416.18

Table A.83.: Summary of moments calculated in the point entitled ”BladeP4”. Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	3.62	121.65	37.6	143.46	-587.92	147.51
6	10.8	152.37	56.66	175.86	-565.79	175.33
8	12.12	153.19	78.37	210.97	-532.52	170.99
10	20.59	167.25	82.1	238.5	-525.24	170.46
12	25.95	180	83.61	263.52	-523.69	181.73
14	28.73	186.61	84.56	281.42	-522.76	191.95
16	30.81	204.6	82.59	305.83	-515.6	213.94
18	33.7	205.88	83.53	318.99	-514.57	218.98
20	32.95	207.96	86.34	333.38	-513.11	223.85
22	32.96	211.08	86.04	348.97	-509.19	228.43
24	34.14	215.47	86.96	367.37	-505.22	234.22

Table A.84.: Summary of forces calculated in the point entitled ”BladeP4”. Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	11223.44	1119.2	290.91	7826.43	-11.75	143.88
6	12020.66	1368.78	420.59	9777.07	-82.45	165.95
8	13028.97	1731.81	164.26	9750.14	-163.66	181.47
10	13127.36	2031.76	149.31	10649.08	-288.48	249.02
12	13087.19	2244.8	-2.37	11535.21	-402.07	263.32
14	13041.35	2382.46	-137.3	12068.18	-478.57	283.13
16	12881.43	2581.89	-202.53	13292.83	-531.62	317.22
18	12831.92	2691.95	-95.4	13496.37	-558.4	340.38
20	12780.87	2819.04	-172.12	13768.06	-574.41	367.92
22	12693.37	2957.01	-209.86	14093.46	-592.82	393.53
24	12600.97	3112.15	-184.94	14492.82	-613.39	420.58

Table A.85.: Summary of moments calculated in the point entitled ”BladeP4”. Sea state 3

A.1.13. Blade 1, point 5

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	0.98	18.71	-218.7	5.85	-479.33	15.99
6	1.68	38.04	-234.96	15.44	-455.18	43.35
8	2.63	68.2	-262.96	31.09	-411.34	86.8
10	3.04	94.55	-275.87	42.59	-388.75	123.32
12	3.22	106.47	-275.95	47.79	-386.93	141.28
14	3.68	112.98	-275.23	52.77	-385.95	155.45
16	4.04	118.29	-274.35	59.41	-384.78	167.87
18	4.64	128.53	-273.02	71.24	-383.68	190.33
20	4.85	137.29	-272.71	80.2	-380.43	209.36
22	5.39	144.03	-271.36	85.6	-377.57	222.5
24	5.51	149.17	-267.42	87.65	-378.19	230.42

Table A.86.: Summary of forces calculated in the point entitled "BladeP5". Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	6193.66	794.29	222.18	539.81	-127.04	449.71
6	6751.18	1948.74	85.17	1095.78	-160.99	914.31
8	7752.88	3760.59	-89.8	1961.35	-207.76	1638.75
10	8243.02	5279.02	-398.61	2757.06	-246.84	2274.2
12	8274.54	6005.31	-714.99	3117.25	-285.92	2563.03
14	8232.48	6478.71	-905.43	3367.79	-330.01	2719.41
16	8241.78	6967.12	-957.04	3594.93	-340.47	2835.12
18	8274.23	7623.65	-978.19	3996.67	-347.42	3075.52
20	8276.17	8290.99	-1034.17	4336.42	-350.19	3280.61
22	8238.48	8816.86	-1079.9	4587.57	-356.89	3429.06
24	8199.25	9190.36	-1094.51	4753.72	-344.9	3531.62

Table A.87.: Summary of moments calculated in the point entitled "BladeP5". Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	1.17	57.54	-218.76	20.37	-478.26	72.03
6	1.47	67.35	-234.22	26.53	-455.91	90.38
8	2.97	86.8	-262.78	41.76	-409.69	133.9
10	3.02	110.59	-275.18	48.85	-387.76	154.1
12	3.57	119.78	-274.76	52.6	-387	166.86
14	3.3	124.58	-273.55	56.68	-386.91	177.62
16	3.46	140.31	-271.55	64.2	-384.07	206.26
18	3.93	145.1	-270.11	68.47	-383.28	215.23
20	4.78	150.06	-268.4	73.15	-382.21	224.14
22	5.41	156.41	-266.51	78.39	-380.37	234.41
24	5.44	164.52	-264.15	84.33	-378.17	246.54

Table A.88.: Summary of forces calculated in the point entitled "BladeP5". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	6190.41	1597.34	227.15	1689.32	-132.12	1389.4
6	6761.93	2441.59	82.93	1960.43	-155.92	1623.04
8	7735.53	4214.52	-77.44	2500.94	-216.97	2102.04
10	8205.06	5507.14	-395.17	3227.62	-247.1	2675.23
12	8209.77	6152	-693.27	3518.47	-295.05	2897.54
14	8190.57	6590.69	-893.58	3707.39	-316.75	3009.74
16	8154.31	7123.14	-959.62	4194.3	-324.71	3379.88
18	8116.56	7522.17	-969.54	4394.19	-327.26	3480.77
20	8105.41	7941.32	-970.83	4593.31	-337.94	3588.34
22	8095	8436.86	-989.57	4824.9	-342.76	3730.18
24	8116.98	9020.52	-1042.09	5100.01	-333.43	3915.19

Table A.89.: Summary of moments calculated in the point entitled "BladeP5". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	5.92	80.09	-206.4	37.47	-513.44	130.21
6	1.51	81.43	-234.14	53.62	-454.19	184.23
8	2.11	123.33	-266.9	56.3	-400.85	185.88
10	4.67	143.52	-274.02	65.55	-387.26	212.78
12	3.89	154.4	-274.72	70.02	-380.79	226.16
14	4.72	158.72	-271.75	73.14	-386.67	235.35
16	2.52	179.21	-270.91	81.9	-378.03	266.46
18	5.67	182.02	-269.44	85.38	-377.28	274.33
20	5.39	186.79	-266.67	89.44	-379.06	282.4
22	4.57	192.1	-264.45	93.78	-377.63	290.02
24	4.89	198.23	-262.02	99	-375.08	299.74

Table A.90.: Summary of forces calculated in the point entitled "BladeP5". Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	6911.82	2783.08	392.66	2356.16	-232.61	1935.89
6	6799.32	3961.05	77.37	2378.75	-157.75	1978.13
8	7867.37	4962.29	-115.41	3585.48	-201.36	2977.07
10	8253.02	6115.38	-336.12	4196.32	-290.68	3464.4
12	8121.39	6784.47	-628.86	4540.13	-301.54	3724.87
14	8242.24	7258.14	-786.59	4707.82	-336.74	3822.46
16	8080.99	7946.57	-964.99	5316.15	-293.53	4314.46
18	8083.17	8310.42	-934.02	5440.74	-368.12	4372.36
20	8157.66	8743.09	-981.28	5626.86	-351.77	4478.44
22	8131.55	9214.99	-1044.54	5823.24	-322.57	4596.28
24	8106.21	9742.25	-1084.47	6041.64	-320.77	4735.73

Table A.91.: Summary of moments calculated in the point entitled "BladeP5". Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	0.56	112.62	-221.71	53.65	-468.04	187.8
6	3.88	140.74	-242.6	65.33	-437.35	223.8
8	1.87	140.57	-271.29	68.3	-392.03	225.83
10	4.12	153.42	-274.44	71.24	-383.61	230.82
12	3.88	166.05	-273.01	76.86	-382.86	248.07
14	3.23	173.67	-271.44	81.44	-382.62	261.88
16	3.16	191.41	-268.75	88.99	-376.15	288.97
18	5.22	194.32	-267.14	92.26	-375.74	295.9
20	4.59	198.27	-264.85	95.93	-375.58	302.64
22	4.58	203.04	-263.25	99.74	-372.06	309.18
24	5.59	208.85	-261.07	104.53	-368.94	317.87

Table A.92.: Summary of forces calculated in the point entitled "BladeP5". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	6271.5	3897.45	179.71	3306.51	-122.59	2692.49
6	7076.68	4753.95	94.65	4113.53	-225.26	3394.59
8	8039.25	5724.06	-162.2	4077.66	-199.45	3393.41
10	8167.16	6487.97	-399.84	4474.42	-280.88	3704.05
12	8181.78	7171.11	-662.43	4869.38	-302.81	4007.89
14	8182.19	7661.63	-846.49	5129.73	-302.82	4185.36
16	8061.11	8330.93	-957.06	5666.94	-309.53	4609.12
18	8060.5	8695.8	-949.52	5794.11	-356	4670.35
20	8101.38	9096.53	-1002.43	5955.66	-330.51	4755.18
22	8052.82	9531.35	-1044.01	6133.67	-321.77	4861.92
24	8029.71	10039.81	-1065.64	6341.08	-336.92	4994.37

Table A.93.: Summary of moments calculated in the point entitled "BladeP5". Sea state 3

A.1.14. Blade 1, point 6

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-0.94	16.59	-324.79	12.15	-298.43	16
6	-2.67	33.7	-356.76	28.51	-249.83	43.34
8	-5.01	60.35	-414.33	54.34	-162.5	86.87
10	-8.98	84.18	-441.98	75.85	-119.93	123.05
12	-12.51	96.22	-443.02	88.17	-117.33	141.77
14	-13.92	104.43	-441.97	97.85	-116.52	157.46
16	-14.16	111.41	-442.44	111.69	-114.97	175.57
18	-14.18	121.93	-443.17	133.58	-113.67	210.61
20	-14.78	131.34	-444.52	151.48	-109.31	236.41
22	-15.1	139.48	-444.22	159.85	-106.8	249.11
24	-15.35	146.29	-441.51	159.55	-110.44	249.39

Table A.94.: Summary of forces calculated in the point entitled ”BladeP6”. Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-6518.37	571.72	157.92	344.01	-185.29	548.75
6	-6877.95	1440.97	39.65	700.19	-175.95	1115.08
8	-7499.98	2817.5	-114.24	1257.93	-169.09	1997.55
10	-7780.26	3938.39	-335.29	1777.91	-110.08	2774.13
12	-7764.59	4461.87	-557.34	1978.42	-45.89	3134.46
14	-7760.58	4825.52	-718.15	2086.44	-18.51	3340.68
16	-7734.87	5187.87	-770.88	2189.83	-3.45	3499.37
18	-7686.24	5701.4	-805.79	2442.83	3.96	3805.15
20	-7691.24	6197.9	-851.05	2636.83	26.26	4069.82
22	-7679.83	6623.29	-900.55	2741.09	43.44	4272.82
24	-7580.83	6958.68	-911.27	2779.56	67.87	4422.55

Table A.95.: Summary of moments calculated in the point entitled ”BladeP6”. Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-0.75	51.38	-324.84	14.74	-297.3	70.83
6	-2.75	59.87	-356.11	29.43	-251.03	89.22
8	-4.59	76.99	-413.61	54.92	-161.21	132.95
10	-8.86	98.66	-440.25	75.83	-119.77	152.95
12	-11.94	108.16	-439.92	87.74	-119.06	166.4
14	-13.96	114.39	-438.8	97.35	-119.49	178.54
16	-14.34	129.98	-437.22	105.74	-117.7	207.67
18	-14.23	136.34	-435.98	114.75	-117.5	217.68
20	-13.86	142.68	-435.28	124.01	-117.13	227.75
22	-13.89	150.04	-434.7	134.04	-115.96	239.03
24	-14.73	158.83	-434.98	145.21	-114.21	252.04

Table A.96.: Summary of forces calculated in the point entitled "BladeP6". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-6520.64	1458.28	153.72	1038.72	-191.13	1703.91
6	-6841.72	2053.83	45.59	1225.44	-170.9	1985.94
8	-7492.75	3394.08	-119.96	1603.28	-180.83	2560.32
10	-7764.97	4257.93	-333.38	2078.59	-111.36	3262.03
12	-7741.09	4696.47	-558.49	2240.08	-59.39	3540.9
14	-7707.73	5018.34	-695.67	2321.01	-10.13	3690.04
16	-7656.58	5514.23	-752.97	2605.2	11.83	4151.26
18	-7631.8	5813.83	-776.27	2681.37	20.72	4294.28
20	-7587.7	6133.39	-807.53	2768.08	20.06	4443.41
22	-7538.65	6512.3	-840.98	2880.22	29.79	4633.27
24	-7463.84	6957.95	-872.42	3021.93	62.35	4874.87

Table A.97.: Summary of moments calculated in the point entitled "BladeP6". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	3.8	71.82	-327.68	21.8	-334.78	128.45
6	-2.73	72.85	-357.06	34.72	-248.28	183.05
8	-5.52	109.76	-421.3	60.16	-146.15	184.97
10	-7	128.41	-440.23	78.96	-119.24	212.86
12	-10.7	139.3	-438.79	90.78	-113.07	226.56
14	-12.03	144.66	-438.81	100.32	-119.62	236.33
16	-15.1	163.95	-435.96	109.67	-111.84	267.54
18	-12.88	168	-435.44	117.85	-111.73	276.26
20	-13.76	173.96	-435.68	127.63	-114.04	285.11
22	-15.12	180.24	-434.54	137.91	-113.51	293.54
24	-15.58	187.19	-433.64	148.45	-111.96	304.06

Table A.98.: Summary of forces calculated in the point entitled ”BladeP6”. Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-5745.24	2617.82	90.66	1447.95	-326.54	2374.62
6	-6816.25	3712.56	39.23	1489.44	-170.91	2417.57
8	-7576.5	4224.16	-112.95	2254.55	-157.35	3638.52
10	-7690.66	5064.93	-359.38	2645.41	-166.42	4236.1
12	-7780.82	5526.29	-534.68	2841.43	-81.9	4561.88
14	-7620.63	5851.76	-674.65	2916.38	-58.53	4693.12
16	-7669.13	6475.52	-717.94	3292.01	39.15	5298.43
18	-7621.02	6745.21	-818.89	3335.42	-25.29	5382.14
20	-7500.07	7056.49	-835.51	3415.06	11.47	5526.75
22	-7448.37	7394.16	-843.57	3510.14	64.18	5684.6
24	-7392.79	7788.21	-879.12	3622.52	86.67	5868.26

Table A.99.: Summary of moments calculated in the point entitled ”BladeP6”. Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-1.61	100.56	-330.56	28.52	-282.41	185.75
6	-1.35	125.63	-373.24	43.87	-218.5	222.86
8	-6.34	124.99	-430.49	67.27	-129.76	225.31
10	-8.12	137.15	-438.57	83.85	-115.68	230.95
12	-11.15	149.66	-438.33	94.58	-115.32	248.65
14	-13.49	157.82	-437.6	102.89	-115.79	262.83
16	-14.62	174.85	-433.71	112.01	-111.3	289.72
18	-13.3	178.99	-433.21	120.23	-111.41	297.4
20	-14.42	184.15	-433.43	129.62	-111.88	304.99
22	-15.08	189.9	-432.75	139.57	-109.04	312.29
24	-14.96	196.53	-432.39	150.03	-106.66	321.78

Table A.100.: Summary of forces calculated in the point entitled "BladeP6". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	-6583.72	3716.78	142.55	2024.31	-168.54	3309.79
6	-6993.31	4472.31	-39.89	2557.77	-235.72	4156.63
8	-7658.68	4986.25	-134.79	2577.45	-142.71	4143.78
10	-7736.97	5416.24	-381.28	2829.95	-138.39	4526.09
12	-7684.31	5925.97	-555.85	3055.44	-72.78	4904.83
14	-7633.02	6307.03	-660.03	3185.87	-11.06	5133.29
16	-7591.71	6890.11	-737.29	3518.04	24.01	5656.06
18	-7544.42	7153.35	-811.89	3564.3	-9.26	5743.59
20	-7459.44	7437.33	-819.86	3630.37	36.77	5862.57
22	-7444.28	7739.76	-844.36	3716.28	65.09	6006.06
24	-7399.86	8110.56	-893.46	3821.07	67.38	6180.98

Table A.101.: Summary of moments calculated in the point entitled "BladeP6". Sea state 3

A.1.15. Blade 1, point 7

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	1.55	14.36	338.09	21.22	58.3	7
6	4.1	29.24	322.84	54.21	127.06	16.54
8	7.83	52.36	296.06	106.45	251.15	31.99
10	12.63	73.53	283.51	149.27	311.23	47.45
12	16.58	84.4	283.34	169.9	315.05	66.52
14	18.55	92.03	283.01	185.11	315.65	86.7
16	19.37	98.57	283.39	199.84	318.42	120.46
18	20.05	108.25	284.42	221.36	321.34	177.2
20	21.26	116.98	283.53	242.09	327.22	212.11
22	22.4	124.58	283.51	260.02	330.34	220.3
24	23.48	130.98	287.24	274.83	326.99	203.11

Table A.102.: Summary of forces calculated in the point entitled "BladeP7". Sea state 0

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	18765.92	143.12	-0.8	1074.41	-252.54	289.49
6	20275.55	341.32	7.68	2184.86	-212.22	589.93
8	22984.61	670.79	15.18	3914.69	-170.85	1058.01
10	24273.59	972.72	-11.06	5446.36	-76.29	1489.02
12	24314.43	1392.41	-21.11	6190.14	41.85	1706.55
14	24288.01	1835.16	13.56	6643.2	141.38	1856.73
16	24305.01	2591.96	18.9	7005.76	180.54	1990.75
18	24316.01	3850.12	22.23	7620.06	205.9	2187.09
20	24393.78	4612.04	5.54	8162.18	235.44	2360.91
22	24404.62	4780.78	-0.32	8608.58	269.56	2509.31
24	24266.26	4379.7	-35.58	8972.21	281.09	2637.55

Table A.103.: Summary of moments calculated in the point entitled "BladeP7". Sea state 0

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	1.4	43.73	337.41	60.85	59.15	34.13
6	4.17	51.22	323.48	82.82	125.69	43.24
8	7.49	66.38	294.97	133.52	251.45	60.62
10	12.54	85.69	282.72	164.34	309.87	68.85
12	16.05	94.4	283.12	181.01	311.03	83.05
14	18.5	100.35	283.99	194.08	310.81	99.57
16	19.57	114.24	282.84	216.01	311.6	124.22
18	20.09	120.24	283.48	228.43	312.02	136.85
20	20.46	126.27	284.84	241.51	313.31	149.37
22	21.26	133.16	286.25	256.87	315.69	161.37
24	22.86	141.31	288.59	274.85	319.98	173.65

Table A.104.: Summary of forces calculated in the point entitled "BladeP7". Sea state 1

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	18767.98	674.15	11.28	3304.66	-248.77	865.77
6	20221.9	862.58	-1.99	3864.1	-215.13	1022.32
8	22948.4	1217.04	38.86	4998.13	-164.22	1336.45
10	24193.36	1401.69	-7.97	6385.14	-75.47	1730.3
12	24176.01	1723.25	5.11	6964.57	47.61	1904.65
14	24126.97	2096.46	-7.45	7302.22	129.78	2023.28
16	24039.51	2610.39	-9.96	8253.06	173.14	2307.57
18	24000.22	2892.25	-11	8582.34	194.47	2425.96
20	23971.62	3171.96	5.88	8921.14	221.37	2546.26
22	23951.4	3439.14	3.98	9335.39	246.54	2683.95
24	23955.45	3709.91	-39.53	9848.94	265.26	2846.36

Table A.105.: Summary of moments calculated in the point entitled "BladeP7". Sea state 1

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	-2.47	61.21	368.9	109.91	39.71	60.36
6	4.32	62.37	322.57	155.55	129.33	90.46
8	8.36	94.07	289.33	170.89	270.72	91.75
10	10.96	110.58	283.19	202.49	311.07	109.02
12	15.02	120.34	278.64	220.08	314.42	118.59
14	16.92	125.45	284.93	232.75	311.45	128.82
16	20.3	142.36	279.02	259.04	315.47	150.15
18	19.04	146.37	280.52	270.05	316.49	160.7
20	20.56	152.12	285.04	282.7	317.47	171.54
22	22.52	158.14	286.63	296.28	319.03	181.7
24	23.8	164.82	288.22	312.25	321.84	192.17

Table A.106.: Summary of forces calculated in the point entitled "BladeP7". Sea state 2

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	18336.77	1227.26	274.11	4613.21	-183.63	1213.25
6	20242.22	1796.27	0.25	4702	-211.62	1243.28
8	23306.92	1887.67	-7.5	7087.19	-175.53	1882.42
10	24139.83	2246.63	99.64	8273.64	-47.67	2218.41
12	24161.45	2458.88	38.33	8939.68	43.84	2414.91
14	24063.98	2667.76	64.06	9232.86	126.47	2517.09
16	24006.83	3107.65	-75.27	10448.61	145.64	2862.39
18	23977.72	3342.24	85.17	10651.56	227.08	2941.65
20	23935.51	3581.91	30.59	10975.18	237.23	3053.73
22	23893.87	3807.91	-55.12	11325.45	239.96	3174.69
24	23864.76	4039.66	-77.93	11724.17	264.26	3307.93

Table A.107.: Summary of moments calculated in the point entitled "BladeP7". Sea state 2

WSP [m/s]	Mean $F_x[kN]$	Std $F_x[kN]$	Mean $F_y[kN]$	Std $F_y[kN]$	Mean $F_z[kN]$	Std $F_z[kN]$
4	2.41	85.57	331.08	156.49	76.42	89.82
6	3.46	107.16	311.61	187.74	168.1	114.45
8	9.36	107.13	283.58	203.04	292.7	114.82
10	12.05	118.19	279.54	216.95	311.98	120.98
12	15.5	129.24	280.44	236.96	313.12	131.78
14	18.22	136.58	281.7	252.56	313.17	141.84
16	19.99	151.74	279.32	276.41	315.2	159.76
18	19.5	155.8	280.87	287.03	316.17	168.83
20	21.17	160.79	283.8	298.33	318	178.58
22	22.53	166.34	283.92	310.33	321.38	188.25
24	23.3	172.73	285.1	325.21	325.16	198.17

Table A.108.: Summary of forces calculated in the point entitled "BladeP7". Sea state 3

WSP [m/s]	Mean $M_x[kNm]$	Std $M_x[kNm]$	Mean $M_y[kNm]$	Std $M_y[kNm]$	Mean $M_z[kNm]$	Std $M_z[kNm]$
4	19036.24	1793.75	-24.98	6443.24	-248.4	1703.43
6	20991.75	2304.13	133.04	8084.36	-165.46	2137.35
8	23718	2361.88	-30.25	8075.7	-173.15	2149.97
10	24103.01	2542.84	61.34	8844.07	-40.94	2373.84
12	24070.04	2761.28	32.43	9612	54.25	2595.89
14	24021.55	2953.02	-20.05	10088.53	112.02	2742.19
16	23878.65	3317.86	-39.36	11151.4	160.5	3053.75
18	23851.16	3513.51	56.74	11360.98	221.19	3134.44
20	23830.61	3735.46	-16.01	11633.35	225.69	3232.91
22	23831.89	3951.08	-54.21	11953.46	241.06	3344.66
24	23830.03	4169.86	-37.52	12333.35	275.84	3471.22

Table A.109.: Summary of moments calculated in the point entitled "BladeP7". Sea state 3

A.2. Turbulent Inflow

A.2.1. Tower Top

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	175.26	154.59	13.46
6	218.07	161.85	21.07
8	293.54	188.77	34.95
10	344.98	198.87	42.16
12	383.55	206.33	51.41
14	406.77	212.56	65.84
16	468.89	295.29	77.16
18	489.84	297.1	91.02
20	511.82	304.4	104.38
22	540.53	307.13	117.73
24	564.14	319.31	125.7

Table A.110.: Summary of forces calculated in the point entitled "Tower Top". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	3017.18	3468.31	5.35
6	3189.49	4345.27	9.06
8	3764.74	5872.78	19.18
10	3949.57	6907.9	43.35
12	4098.5	7684.95	50.37
14	4223.54	8139.12	53.68
16	5913.94	9405.14	52.49
18	5955.37	9853.44	52.03
20	6110.01	10285.11	51.73
22	6205.03	10854.4	51.57
24	6496.91	11339.97	53.42

Table A.111.: Summary of moments calculated in the point entitled "Tower Top". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	252.44	228.02	18.1
6	264.03	243.39	27.31
8	372.77	296.03	44.16
10	435.29	328.74	55.13
12	476.66	342.13	62.85
14	506.56	348.34	73.04
16	566.75	407.77	83.75
18	590.86	415.17	96.54
20	608.83	413.99	107.27
22	643.83	428.5	122.87
24	650.08	419.95	132.13

Table A.112.: Summary of forces calculated in the point entitled "Tower Top". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	4477.05	5017.02	6.97
6	4798.81	5274.7	11.95
8	5840.68	7455.56	24.59
10	6488.5	8711.29	44.18
12	6760.46	9534.8	46.94
14	6847.9	10118.24	49.47
16	8079.53	11342.09	48.13
18	8248.79	11808.2	48.25
20	8239.9	12176.37	48.94
22	8499.25	12869.51	49.68
24	8356.04	13014.81	54.21

Table A.113.: Summary of moments calculated in the point entitled "Tower Top". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	260.87	299.79	22.23
6	355.61	331.17	33.4
8	411.02	369.72	42.45
10	451.32	385.87	52.21
12	492.04	412.64	62.24
14	518.82	436.77	73
16	565.66	508.95	84.79
18	588.3	515.28	99.95
20	608.74	511.85	109.48
22	633.36	523.9	123.96
24	655.52	518.26	131.7

Table A.114.: Summary of forces calculated in the point entitled ”Tower Top”. Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	5900.45	5207.94	8.93
6	6533.12	7097.48	15.87
8	7332.28	8219.02	25.17
10	7640.3	9048.12	43.28
12	8198.9	9874.03	46.87
14	8637.14	10382.41	47.67
16	10104.57	11364.29	49.31
18	10256.53	11814.33	48.98
20	10196.21	12223.32	48.81
22	10391.78	12689.01	49.93
24	10330.46	13141.95	54.89

Table A.115.: Summary of moments calculated in the point entitled ”Tower Top”. Sea state 3

A.2.2. Tower Bottom

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	242.54	216.02	28.27
6	312.7	240.56	34.68
8	429.8	294.31	46.52
10	505.13	310.99	53.82
12	556.51	320.03	63
14	590.73	323.89	77.41
16	685.98	437.49	84.87
18	716.7	439.81	98.87
20	750.42	447.5	113.1
22	789.84	451.52	124.04
24	829.62	482.61	135.01

Table A.116.: Summary of forces calculated in the point entitled "Tower Bottom". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	6262.68	7007.19	15.89
6	6879.41	8965.72	27.08
8	8368.21	12228.18	58.41
10	8854.53	14373.53	134.05
12	9130	15908.72	155.09
14	9264.5	16880.22	165.17
16	12400.24	19491.66	161.29
18	12484.24	20393.64	159.91
20	12703.89	21378.97	158.59
22	12845.2	22483.55	157.77
24	13605.88	23557.4	163.36

Table A.117.: Summary of moments calculated in the point entitled "Tower Bottom". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	357.68	326.09	59.69
6	383.47	356.38	64.76
8	545.69	436.33	91.19
10	633.5	486.6	98.09
12	692.18	503.55	118.36
14	732.76	512.55	116.04
16	823.66	587.41	111.38
18	858.25	592.79	125.47
20	881.08	590.97	135.64
22	924.33	605.11	150.39
24	943.49	608.96	156.79

Table A.118.: Summary of forces calculated in the point entitled "Tower Bottom". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	9370.83	10254.84	20.91
6	10141.08	10906.58	35.75
8	12467.58	15544.28	74.53
10	13953.67	18082.15	136.18
12	14451.6	19758.62	143.94
14	14673.61	20929.42	151.64
16	16771.42	23494.56	147.08
18	16925.31	24472.44	147.2
20	16901.39	25131.66	149.03
22	17381.02	26433.69	150.77
24	17252.16	26857.24	166.27

Table A.119.: Summary of moments calculated in the point entitled "Tower Bottom". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	381.38	435.69	71.01
6	516.36	480.18	82.95
8	604.5	537.38	98
10	665.62	553.65	107.11
12	723.88	591.75	113.49
14	758.64	616.06	120.4
16	839.51	729.53	126.84
18	866.84	738.62	138.07
20	896.13	733.4	146.7
22	926.98	743.63	158.69
24	955.49	742.87	165.93

Table A.120.: Summary of forces calculated in the point entitled "Tower Bottom". Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	12437.46	10814.94	26.54
6	13666.52	14693.04	47.26
8	15331.3	17155.04	76.17
10	15887.26	18913.72	132.69
12	16958.14	20536.33	143.32
14	17719.81	21544.42	145.46
16	20802.53	23775.2	150.6
18	20899.02	24623.18	149.08
20	20894.36	25503.29	148.22
22	21174.43	26398.14	151.58
24	21061.84	27205.75	168.6

Table A.121.: Summary of moments calculated in the point entitled "Tower Bottom". Sea state 3

A.2.3. Shaft

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	64.37	55.42	55.96
6	146.72	120.91	67.65
8	154.03	146.71	81.88
10	157.75	203.74	136
12	205.12	224.84	156.43
14	234.23	234.09	182.52
16	248.11	345.15	130.59
18	263.45	367.86	133.78
20	281.99	371.08	141.12
22	295.78	375.95	148.07
24	749.16	509.74	314.59

Table A.122.: Summary of forces calculated in the point entitled "Shaft". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	285.75	341.94	265.73
6	730.73	881.56	386.98
8	814.88	889.51	3861.77
10	1015.92	1078.69	10750.61
12	1178.51	1265.62	11366.03
14	1177.78	1574.96	11568.54
16	1229.56	1215.67	10754.47
18	1302.18	1331.14	10779.99
20	1341.36	1421.37	10754.58
22	1369.99	1549.9	10487.11
24	3406.68	5549.35	11139.75

Table A.123.: Summary of moments calculated in the point entitled "Shaft". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	89.12	104.79	54.12
6	151.2	142.54	66.35
8	176.49	180.18	90.16
10	193.25	248.29	149.67
12	235.59	274.33	203.22
14	247.82	292.67	208.56
16	251.02	379.65	149.39
18	253.89	397.63	151.88
20	262.58	409.46	150.96
22	283.69	406.64	156.43
24	832.98	527.1	325.66

Table A.124.: Summary of forces calculated in the point entitled "Shaft". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	505.6	490.81	603.48
6	883.94	953.66	993.12
8	945.49	1074.65	4251.24
10	1339.03	1324.65	9826.25
12	1612.94	1621.81	9757.87
14	1676.42	1669.28	10216.79
16	1629.13	1912.11	9365.57
18	1684.23	1872.45	9222.11
20	1695.1	1939.76	9290.87
22	1604.48	1868.09	9037.59
24	3836.98	6501.42	10805.7

Table A.125.: Summary of moments calculated in the point entitled "Shaft". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	127.2	155.31	56.39
6	167.47	180.2	75.66
8	169.36	150.57	91.7
10	183.71	212.75	157.73
12	203.06	235.63	185.3
14	235.25	261.83	194.57
16	250.71	362.58	226.95
18	278.71	379.43	224.42
20	297.34	386.49	222.98
22	303.18	380.93	222.12
24	765.58	475.05	341.04

Table A.126.: Summary of forces calculated in the point entitled "Shaft". Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	1265.15	954.51	899.56
6	1360.35	1247.44	1393.66
8	898.1	1290.52	3888.53
10	1559.24	1720.77	9361.25
12	1882.47	1914.59	9439.37
14	2000.83	2038.8	9165.98
16	1812.94	2531.79	9547.58
18	1843.16	2520.67	9430.59
20	1816.43	2464.36	9194.26
22	1811.36	2434.72	9117.37
24	3334.74	6102.51	11377.52

Table A.127.: Summary of moments calculated in the point entitled "Shaft". Sea state 3

A.2.4. Arm 1

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	7.15	12.98	28.74
6	10.84	27.66	72.97
8	31.24	32.11	77.77
10	82.25	64.87	96.32
12	85.31	75.97	109.87
14	85.53	72.69	105.43
16	82.59	65.53	137.82
18	87.32	69.47	152.53
20	87.99	69.67	147.34
22	89.04	70.81	163.17
24	131.42	105.75	322.43

Table A.128.: Summary of forces calculated in the point entitled "Arm1". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	3.62	3.89	0
6	3.74	5.86	0
8	4.45	93.13	0
10	5.22	266.71	0
12	5.72	286.23	0
14	6.18	291.14	0
16	6.49	298.37	0
18	6.73	295.17	0.01
20	7.01	292.11	0.01
22	7.28	284.17	0.01
24	7.51	258.61	0.01

Table A.129.: Summary of moments calculated in the point entitled "Arm1". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	14.93	26.2	43.09
6	22.16	38.23	78.21
8	41.71	42.55	98.02
10	85.02	84.73	120.43
12	84.39	99.35	178.36
14	86.43	103.94	170.88
16	81.28	79.23	142.12
18	80.83	84.8	163.69
20	82.65	81.28	158.88
22	81.77	78.22	159.09
24	131.74	110.6	293.23

Table A.130.: Summary of forces calculated in the point entitled "Arm1". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	7.46	8.99	0
6	7.58	11.45	0
8	9.24	103.55	0
10	9.95	238.56	0
12	13.21	240.19	0
14	12.26	255.09	0
16	10.61	250.31	0.01
18	11.06	248.49	0.01
20	11.3	247.25	0.01
22	11.63	240.47	0.01
24	11.5	238.27	0.01

Table A.131.: Summary of moments calculated in the point entitled "Arm1". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	28.25	58.04	98.62
6	32.46	57.41	99.23
8	49.7	44.67	71.93
10	91.93	91.54	108.61
12	96.8	110.66	126.97
14	97.29	112.88	130.68
16	93.25	81.66	125.87
18	91.62	82.89	131.61
20	89.01	80.69	130.71
22	89.36	83.13	132.13
24	133.93	101.46	214.28

Table A.132.: Summary of forces calculated in the point entitled "Arm1". Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	8.45	13.6	0
6	8.59	17.8	0
8	8.14	85.21	0
10	8.89	224.46	0
12	9.13	227.47	0
14	9.25	220.73	0
16	10.19	251.25	0.01
18	10.41	244.77	0.01
20	10.49	239.67	0.01
22	10.75	239.18	0.01
24	11.19	250.09	0.01

Table A.133.: Summary of moments calculated in the point entitled "Arm1". Sea state 3

A.2.5. Arm 2

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	10.67	22.5	49.34
6	21.36	54.2	132.74
8	38.62	58.98	135.23
10	88.17	56.93	110.73
12	101.01	70.86	126.42
14	137.28	84.77	144.65
16	201.7	79.32	214.25
18	219.53	80.54	234.85
20	231.92	84.1	235.17
22	226.13	86.07	260.51
24	286.02	316.99	623.7

Table A.134.: Summary of forces calculated in the point entitled "Arm2". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	3.92	2.25	0
6	4	3.59	0
8	5.3	93.07	0
10	6.77	267.65	0
12	9.01	286.84	0.01
14	15.29	292.04	0.01
16	9.42	300.96	0
18	17.67	297.41	0.01
20	24.64	294.1	0.01
22	28.32	286.22	0.01
24	33.89	260.11	0.01

Table A.135.: Summary of moments calculated in the point entitled "Arm2". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	18.32	30.85	89.6
6	36.93	57.41	149.69
8	81.34	62.79	180.14
10	128.82	68.76	170.35
12	136.36	81.82	178.36
14	143.2	86.78	171.24
16	219.66	109.26	293.31
18	216.91	105.62	280.57
20	226.98	108.9	287.73
22	234.66	111.31	286.47
24	291.67	360.68	718

Table A.136.: Summary of forces calculated in the point entitled "Arm2". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	7.58	4.79	0
6	7.7	5.4	0
8	10.29	103.01	0
10	14.43	239.01	0
12	17.87	240.66	0
14	15.61	255.49	0.01
16	31.95	251.96	0.01
18	35.47	250.18	0.01
20	33.42	248.67	0.01
22	33.21	241.97	0.01
24	32.98	240.17	0.01

Table A.137.: Summary of moments calculated in the point entitled "Arm2". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	30.11	60.94	132.47
6	55.74	79.28	186
8	94.76	76.61	155.31
10	145.43	91.89	161.36
12	150.35	103.98	157.87
14	167.58	113.74	168.96
16	227.46	160.32	267.17
18	249.89	161.97	279.11
20	248.5	162.17	282.93
22	240.78	158.62	268.29
24	285.95	354.07	655.66

Table A.138.: Summary of forces calculated in the point entitled "Arm2". Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	8.66	9.75	0
6	9.75	10.18	0
8	12.6	84.29	0
10	14.65	224.36	0
12	14.16	227.25	0
14	13.88	220.03	0
16	32.13	252.18	0.01
18	29.66	245.59	0.01
20	30.97	241.16	0
22	28.09	240.21	0
24	36.39	251.06	0.01

Table A.139.: Summary of moments calculated in the point entitled "Arm2". Sea state 3

A.2.6. Arm 3

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	5.95	8.59	16.45
6	7.65	19.04	39.13
8	38.12	24.19	32.54
10	106.9	64.35	53.24
12	110.7	74.26	63.84
14	112.85	93.81	81.25
16	130.81	45.77	32.16
18	129.66	52.15	37.33
20	128.13	59.75	42.6
22	125.15	68.23	47.27
24	117.68	141.19	275.07

Table A.140.: Summary of forces calculated in the point entitled "Arm3". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	285.75	341.94	265.73
6	730.73	881.56	386.98
8	814.88	889.51	3861.77
10	1015.92	1078.69	10750.61
12	1178.51	1265.62	11366.03
14	1177.78	1574.96	11568.54
16	1229.56	1215.67	10754.47
18	1302.18	1331.14	10779.99
20	1341.36	1421.37	10754.58
22	1369.99	1549.9	10487.11
24	3406.68	5549.35	11139.75

Table A.141.: Summary of moments calculated in the point entitled "Arm3". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	20.64	13.07	28.02
6	22.9	21.14	42.6
8	46.45	31.25	61.46
10	98.99	69.45	75.33
12	98.2	91.22	153.31
14	101.34	97.52	135.92
16	111.94	77.48	52.56
18	110.42	72.91	56.11
20	109.85	75.67	54.74
22	106.42	76.69	61.13
24	116.28	154.4	328.06

Table A.142.: Summary of forces calculated in the point entitled "Arm3". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	505.6	490.81	603.48
6	883.94	953.66	993.12
8	945.49	1074.65	4251.24
10	1339.03	1324.65	9826.25
12	1612.94	1621.81	9757.87
14	1676.42	1669.28	10216.79
16	1629.13	1912.11	9365.57
18	1684.23	1872.45	9222.11
20	1695.1	1939.76	9290.87
22	1604.48	1868.09	9037.59
24	3836.98	6501.42	10805.7

Table A.143.: Summary of moments calculated in the point entitled "Arm3". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=4)	DEL $F_y[kN]$ (m=4)	DEL $F_z[kN]$ (m=4)
4	31.86	23.27	42.91
6	34.17	25.31	45.61
8	42.58	34.69	57.28
10	90.95	73.74	89.58
12	90.38	80.55	95.21
14	85.02	84.82	100.67
16	108.86	82.08	67.51
18	105.84	78.41	64.3
20	102.67	74.62	63.28
22	102.73	75.3	63.63
24	128.3	162.38	277.25

Table A.144.: Summary of forces calculated in the point entitled "Arm3". Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=4)	DEL $M_y[kNm]$ (m=4)	DEL $M_z[kNm]$ (m=4)
4	1265.15	954.51	899.56
6	1360.35	1247.44	1393.66
8	898.1	1290.52	3888.53
10	1559.24	1720.77	9361.25
12	1882.47	1914.59	9439.37
14	2000.83	2038.8	9165.98
16	1812.94	2531.79	9547.58
18	1843.16	2520.67	9430.59
20	1816.43	2464.36	9194.26
22	1811.36	2434.72	9117.37
24	3334.74	6102.51	11377.52

Table A.145.: Summary of moments calculated in the point entitled "Arm3". Sea state 3

A.2.7. Blade 1, point 1

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	226.41	256.99	335.44
6	278.5	330.07	495.46
8	366.71	411.83	689.75
10	447.69	462.76	813.96
12	486.54	511.88	920.54
14	504.6	537.19	1025.49
16	537.15	607.26	1108.74
18	553.83	650.42	1192.06
20	572.72	674.5	1281.97
22	588.77	707.43	1372.65
24	615.15	768.26	1454.89

Table A.146.: Summary of forces calculated in the point entitled "BladeP1". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	29012.98	13439.56	23661.13
6	39071.87	16534.57	29010.33
8	50645.95	21801.33	38001.51
10	57681.22	26542.32	43416.54
12	63089.14	28861.42	47620.73
14	67297.79	29896.01	49547.3
16	72979.02	31750.66	54662.23
18	77621.83	32888.35	56630.26
20	81526.08	33941.88	58682.16
22	86420.57	35037.79	60277.48
24	92942.48	36371.73	63452.64

Table A.147.: Summary of moments calculated in the point entitled "BladeP1". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	337.5	385.97	460.59
6	365.28	436.36	577.32
8	515.43	562.47	838.28
10	587.91	638.8	955.17
12	649.22	680.98	1035.24
14	679.47	713.73	1122.77
16	730.26	771.61	1259.05
18	756.1	777.76	1305.87
20	767.96	818	1389.37
22	799.32	846.44	1474.1
24	782.37	877.41	1537.87

Table A.148.: Summary of forces calculated in the point entitled "BladeP1". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	41790.73	20031.92	35218.27
6	48796.62	21659.04	38008.09
8	66481.12	30511.1	52921.08
10	75102.49	34817.78	59255.79
12	80122.58	38416.01	64990.28
14	84485.41	40369.35	69085.16
16	91265.61	43289.89	74625.85
18	91984.85	45036.23	77466.8
20	97330.84	45592.04	78753.97
22	100010.74	47558.85	82578.16
24	103732.07	46516.33	81497.36

Table A.149.: Summary of moments calculated in the point entitled "BladeP1". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	368.17	540.26	589.98
6	520.46	552.19	707.41
8	522.96	561.07	828.04
10	581.58	583.34	916.47
12	621.97	644.55	1020.17
14	649.12	689.88	1123.17
16	677.5	721	1204.48
18	684.94	756.33	1310.61
20	698.24	789.03	1383.31
22	704.04	832.71	1477.91
24	745.33	890.21	1538.64

Table A.150.: Summary of forces calculated in the point entitled ”BladeP1”. Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	57162.79	21864.46	37968.73
6	60842.52	30755.2	53639.32
8	64624.14	31063.91	53620.2
10	69385.9	34591.78	58371.34
12	77042.32	36980.38	63228.63
14	82682.33	38684.75	65970.07
16	85603.1	40322.02	68358.94
18	89497.3	40824.74	69497.55
20	92230.29	41770.46	71384.41
22	97787.56	42095.24	72257.15
24	102003.47	44424.56	77013.83

Table A.151.: Summary of moments calculated in the point entitled ”BladeP1”. Sea state 3

A.2.8. Blade 1, point 2

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	214.85	358.51	204.63
6	263.76	482.59	331.84
8	348.14	616.83	500.55
10	422.91	702.95	613.34
12	458.37	776.63	701.35
14	475.72	820.43	791.18
16	508.17	894.54	856.87
18	523.57	954.9	934.5
20	541.76	999.11	1022.42
22	557.85	1055.66	1102.14
24	580.5	1137.24	1170.38

Table A.152.: Summary of forces calculated in the point entitled "BladeP2". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	18739.51	15227.17	16826.87
6	25346.53	18650.04	20600.44
8	33133.34	24453.32	26991.32
10	37740.57	28712.11	30526.18
12	41068.01	31296.21	33454.06
14	43808.45	32411.76	34956.25
16	47350.04	35214.37	38885.62
18	50424.38	36570.89	40411.65
20	52848.01	37764.58	41709.44
22	56054.28	38903.92	42720.62
24	60355.18	40798.65	45356.22

Table A.153.: Summary of moments calculated in the point entitled "BladeP2". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	320.38	520.23	266.51
6	346.37	606.49	365.55
8	487.23	818.03	576.83
10	554.49	920.76	676.44
12	612.46	989.03	753.76
14	642.5	1040.14	828.12
16	689.04	1124.77	930.48
18	716.11	1130.96	991.13
20	726.36	1189.81	1072.12
22	759.48	1229.22	1154.43
24	742.12	1270.6	1218.62

Table A.154.: Summary of forces calculated in the point entitled "BladeP2". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	26829.46	22641.23	25078.19
6	31451.53	24515.64	27044.1
8	42930.02	34184.45	37513.79
10	48698.98	38576.73	42013.34
12	52203.99	42344.21	45987.88
14	54879.28	44808.43	48966.4
16	59264.61	48454.09	52785.87
18	59514.96	50212.77	54741.77
20	63005.14	50891.16	55993.78
22	64857.75	53282.04	58511.74
24	67304.21	52420.45	58212.38

Table A.155.: Summary of moments calculated in the point entitled "BladeP2". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	348.33	715.77	318.51
6	492.06	757.14	470.78
8	495.2	799.37	601.86
10	551.79	854.41	691.07
12	588.68	949.08	769.48
14	613.62	1012.82	858.62
16	641.05	1049.1	917.24
18	649.29	1097.8	1011.19
20	663.58	1130.1	1082.27
22	667.64	1196.95	1163.09
24	706.29	1249.88	1211.57

Table A.156.: Summary of forces calculated in the point entitled "BladeP2". Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	36518.43	24508.66	26941.81
6	39122.98	34610.46	38124.11
8	41809.99	34611.78	37930.56
10	45124.58	37994.54	41201.99
12	50109.12	41049.94	45007.75
14	53965.74	42918.66	46952.27
16	55732.92	44536.63	48494.08
18	58339.61	45200.6	49287.39
20	60000.65	46427.32	50671.31
22	63368.32	46821.33	51394.59
24	66065.89	49711.16	54729.71

Table A.157.: Summary of moments calculated in the point entitled "BladeP2". Sea state 3

A.2.9. Blade 1, point 3

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	205.81	377	125.7
6	252.73	509.9	229.88
8	330.76	658.2	367.63
10	397.08	744.84	461.77
12	430.51	815.21	535.29
14	447.2	865.99	611.3
16	478.67	936.21	671.62
18	496.82	990.83	742.47
20	514.33	1034.9	817.5
22	530.59	1094.55	886.42
24	554.2	1174.89	942.17

Table A.158.: Summary of forces calculated in the point entitled "BladeP3". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	8747.79	13545.35	12887.8
6	11879.04	16603.34	15759.79
8	15715.18	21775.56	20656.19
10	17895.52	24860.83	23304.12
12	19364.36	27220.73	25466.15
14	20718.53	28350.86	26771.33
16	22363.26	31288.49	29871.83
18	23798.01	32500.74	30944.03
20	24956.77	33772.37	32059.48
22	26697.05	34494.1	32865.91
24	28648.53	36443.67	34666.68

Table A.159.: Summary of moments calculated in the point entitled "BladeP3". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	307.24	542.04	159.44
6	330.94	638.15	251.47
8	465.98	862.11	426.81
10	528.01	975.58	510.14
12	579.93	1045.09	583.92
14	612.32	1096.42	637.69
16	656.32	1182.39	707.7
18	681.66	1187.06	778.31
20	692.68	1252.19	854.44
22	725.33	1282.22	927.6
24	711.4	1327.16	979.07

Table A.160.: Summary of forces calculated in the point entitled "BladeP3". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	12319.9	20149.78	19204.8
6	14546.35	21738.1	20674.86
8	20080.59	30251.79	28771.17
10	22758	33965.58	32173.63
12	24461.44	37216.64	35061.81
14	25549.75	39554.27	37357.84
16	27751.25	42733.68	40368.01
18	28028.78	44459.79	41948.24
20	29652.61	45200.45	42851.06
22	30367.75	47323.96	44734.81
24	31664.3	46753.69	44616.84

Table A.161.: Summary of moments calculated in the point entitled "BladeP3". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	332.77	744.2	181.45
6	471.02	796.01	350.4
8	473.19	839.55	464.5
10	524.35	903.64	545.27
12	561.66	1005.73	605.02
14	585.43	1072.51	668.3
16	608.23	1111.63	721.95
18	619.01	1159.09	791.27
20	634.68	1187.05	857.19
22	637.85	1247.21	923.92
24	679.1	1301.46	968.25

Table A.162.: Summary of forces calculated in the point entitled ”BladeP3”. Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	16633.83	21773.18	20622.32
6	18093.58	30714.68	29148.14
8	19455.91	30662.42	29029.9
10	21123.08	33363.88	31454.54
12	23570.93	36157.51	34241.68
14	25322.58	37777.63	35857.67
16	26469.31	39190.25	36984.67
18	27587.28	39877.12	37671.02
20	28420.8	40986.22	38678.44
22	30016.06	41496.47	39194.08
24	31487.9	44284.69	41882.5

Table A.163.: Summary of moments calculated in the point entitled ”BladeP3”. Sea state 3

A.2.10. Blade 1, point 4

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	194.08	267.45	210.71
6	237.62	358.42	252.21
8	310.7	476.02	302.86
10	360.63	539.76	326.22
12	393.69	584.59	358.2
14	408.49	626.45	387.26
16	444.12	677.58	471.49
18	461.5	720.15	507.15
20	482.57	758.33	535.66
22	493.73	810.04	565.54
24	517.46	869.27	612.96

Table A.164.: Summary of forces calculated in the point entitled "BladeP4". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	2061.59	12528.31	277.06
6	2992.17	15342.95	317.79
8	4066.86	20200.36	533.01
10	4649.08	22665.66	877.25
12	5277.49	24902.2	954.35
14	5873.45	26070.15	1067.53
16	6264.38	29340.62	1111.68
18	6750.08	30447.39	1245.43
20	7216.49	31380.27	1327.53
22	7619.71	32160.42	1375.59
24	8050.18	34067.83	1886.82

Table A.165.: Summary of moments calculated in the point entitled "BladeP4". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	289.31	374.71	330.29
6	312.02	442.82	372.93
8	434.28	608.55	443.48
10	487.32	686.32	499.61
12	535.68	735.23	529.44
14	567.17	770.37	553.07
16	613.79	835.68	611.63
18	637.75	844.76	630.34
20	647.07	895.68	654.71
22	679.12	923.51	680.16
24	667.91	959.4	715.33

Table A.166.: Summary of forces calculated in the point entitled "BladeP4". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	2891.06	18672.01	378.41
6	3675.98	20092.43	394.45
8	5052.04	27941.59	631.55
10	5774.17	31388.18	912.6
12	6229	34206.96	1012.57
14	6710.35	36313.43	1123.28
16	7404.27	39402.98	1212.45
18	7504.91	40819.8	1303.18
20	7930.31	41681.45	1410.51
22	8392.89	43733.89	1472.26
24	8845.05	43611.39	2031.88

Table A.167.: Summary of moments calculated in the point entitled "BladeP4". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	311.42	506.07	488.29
6	442.73	547.42	486.9
8	441.48	589.31	474.45
10	482.06	637.89	487.49
12	523.47	713.76	525.45
14	548.49	766.5	557.87
16	565.2	795.33	634.95
18	574.49	831.63	672.72
20	591.39	859.29	686.41
22	597.15	907.44	734.13
24	636.16	954.38	780.06

Table A.168.: Summary of forces calculated in the point entitled "BladeP4". Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	3813.69	20086.73	406.52
6	4410.15	28344.15	539.27
8	5067.42	28140.62	596.58
10	5487.68	30667.24	907.8
12	6018.52	33420.73	988.15
14	6522.25	34776.89	1093.28
16	6944.31	36092.17	1186.59
18	7564.24	36654.08	1266.09
20	7795.63	37796.64	1350.85
22	8289.79	38339.56	1434.52
24	8694.46	40973.6	2041.2

Table A.169.: Summary of moments calculated in the point entitled "BladeP4". Sea state 3

A.2.11. Blade 1, point 5

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	180.2	90.01	286.78
6	220.91	108.37	354.59
8	290.91	141.54	434.34
10	328.91	153.65	477.93
12	359.7	163.05	520.14
14	375.54	174.99	554.64
16	418.4	198.31	630.82
18	435.99	216.63	685.16
20	451.57	226.98	702.96
22	460.9	240.54	737.73
24	487.52	260.05	800.02

Table A.170.: Summary of forces calculated in the point entitled "BladeP5". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	7212.91	5317.81	4325.26
6	9744.44	6483.44	5307
8	12859.44	8616.85	7026.19
10	14604.77	10026.21	7961.79
12	15973.24	10873.1	8732.18
14	17249.1	11569.07	9074.36
16	18659.7	12946.56	10121.89
18	19866.03	13403.77	10534.21
20	20996.13	13770.94	10884.49
22	22421.56	14207.4	11094.38
24	24045.66	15212.65	11762.81

Table A.171.: Summary of moments calculated in the point entitled "BladeP5". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	268.49	132.37	437.3
6	289.36	150.07	496.35
8	402.45	189.54	614.25
10	450.78	214.6	699.27
12	492.49	228.94	739.17
14	523.89	235.68	770.75
16	566.96	258.26	832.54
18	589.34	262.32	842.96
20	600.72	276.39	886.09
22	629.75	286.42	911.28
24	626.7	304.98	956.03

Table A.172.: Summary of forces calculated in the point entitled "BladeP5". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	10178.75	7916.87	6439.42
6	11967.56	8491.76	6967.78
8	16472.74	11830.58	9706.67
10	18641.82	13520.21	10855.24
12	19902.72	14612.66	11934.76
14	20901.44	15556.82	12705.9
16	22793.08	16890.4	13701.89
18	23088.68	17400.97	14230.78
20	24452.7	17826.31	14485.85
22	25495.43	18668.16	15219.86
24	26475.47	18957.43	15044.66

Table A.173.: Summary of moments calculated in the point entitled "BladeP5". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	288.93	189.3	635.66
6	407.36	192.55	639.25
8	405.78	196.79	629.02
10	439.57	205.24	650.56
12	479.25	224.12	715.36
14	501.04	239.58	758.75
16	518.78	247	803.38
18	526.94	257.01	836.61
20	545.42	263.72	868.63
22	553.24	285.24	917.97
24	590.03	306.08	977.91

Table A.174.: Summary of forces calculated in the point entitled "BladeP5". Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	13619.6	8444.88	7002.07
6	14787.51	11896.94	9811.34
8	15999.15	11782.07	9757.85
10	17301.26	13068.97	10612.53
12	19354.59	14310.13	11513.34
14	20758.7	14973.09	12082.74
16	21652.42	15466.63	12524.69
18	22704.55	15717.98	12776.8
20	23560.9	16271.39	13139.01
22	24926.3	16592.78	13340.77
24	26280.53	17653.96	14196.52

Table A.175.: Summary of moments calculated in the point entitled "BladeP5". Sea state 3

A.2.12. Blade 1, point 6

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	161.27	71.33	283.01
6	197.53	112.41	352
8	262.1	172.06	433.61
10	296.86	212.05	476.64
12	325.92	247.61	522.26
14	344.21	283.67	560.12
16	390.9	311.11	638.34
18	406.45	346.31	695.34
20	418.52	384.02	714.79
22	432.11	418.04	752.98
24	461.86	444.44	813.25

Table A.176.: Summary of forces calculated in the point entitled "BladeP6". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	6408.22	3230.62	5323.11
6	8254.63	4003.99	6519.51
8	10652.11	5338.67	8617.73
10	11954.06	6514.97	9699.16
12	12912.9	7069.49	10645.55
14	13732.5	7328.01	11171.04
16	15091.39	7784.73	12530.97
18	16154.07	8237.85	13002.5
20	16912.61	8461.28	13388.79
22	17979.48	8752.37	13750.61
24	19364.17	9241.66	14586.05

Table A.177.: Summary of moments calculated in the point entitled "BladeP6". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	240.11	92.05	432.98
6	257.43	128.68	493.77
8	359.76	202.49	607.66
10	406.71	240.77	693.29
12	443.35	273.7	737.59
14	472.71	300.37	769.8
16	513.48	339.28	840.54
18	528.53	367.45	852.42
20	543.13	407.43	895.82
22	570.07	441	924.27
24	578.1	468.61	968

Table A.178.: Summary of forces calculated in the point entitled "BladeP6". Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	9317.91	4818.26	7913.15
6	10685.87	5235.72	8527.51
8	14149.7	7325.61	11872.05
10	15996.17	8411.98	13388.93
12	17165.02	9328.46	14591.88
14	17840.03	9741.53	15479.87
16	19360.78	10471.43	16809.54
18	19490.43	10956.94	17357.9
20	20571.83	11099.69	17761.81
22	21135.36	11555.2	18634.95
24	22130.42	11584.69	18594.91

Table A.179.: Summary of moments calculated in the point entitled "BladeP6". Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	258.4	105.04	632
6	361.3	169.79	639.84
8	359.37	221.41	625.1
10	392.45	255.88	651.28
12	430.36	282.86	713.04
14	450	315.74	756.19
16	467.28	339.46	813.05
18	475.66	380.41	850.54
20	492.03	407.97	880.38
22	502.85	446.45	937.38
24	537.4	464.68	993.4

Table A.180.: Summary of forces calculated in the point entitled "BladeP6". Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	12880.27	5275.1	8567.15
6	13519.96	7367.91	12005.19
8	13929.65	7388.48	11945.23
10	14786.96	8274.33	13013.15
12	16464.2	8902.24	14142.55
14	17685.41	9398.9	14741.93
16	18210.79	9720.22	15299.79
18	18976.32	9942.7	15581.34
20	19505.94	10238.19	16097.32
22	20644.81	10395.71	16337.41
24	21684.43	10957.08	17454.89

Table A.181.: Summary of moments calculated in the point entitled "BladeP6". Sea state 3

A.2.13. Blade 1, point 7

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	137.48	264.22	135.09
6	169.19	332.93	165.98
8	225.6	424.32	222.2
10	258.89	474.47	248.06
12	282.21	513.64	298.24
14	303.73	546.52	348.37
16	345.07	607.33	433.04
18	358.67	651.54	476.68
20	370.35	682.65	520.08
22	386.83	725.88	544.07
24	415.6	785.08	595.45

Table A.182.: Summary of forces calculated in the point entitled "BladeP7". Sea state 1

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	2758.18	10329.15	2720.58
6	3409.63	12699.7	3373.14
8	4655.83	16815.01	4518.5
10	5242.58	19003.98	5297.44
12	6295.24	20911.86	5831.88
14	7418.9	21893.21	6087.1
16	9151.97	24729.87	6782.21
18	10099.52	25605.45	7137.88
20	11137.38	26496.41	7405.49
22	11636.74	27217.84	7704.69
24	12664.73	29014.97	8255.49

Table A.183.: Summary of moments calculated in the point entitled "BladeP7". Sea state 1

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	205.32	386.25	197.82
6	221.26	439.26	256.57
8	308.29	573.66	332.07
10	353.11	650.15	375.3
12	382.71	691.67	407.27
14	409.27	722.29	424.26
16	445.5	789.13	514.5
18	460.09	795.51	551.84
20	475.35	839.52	578.07
22	497.11	863.86	610.68
24	512.44	905.21	653.44

Table A.184.: Summary of forces calculated in the point entitled ”BladeP7”. Sea state 2

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	4000.11	15387.11	4072.99
6	5318.11	16571.99	4402.51
8	6986.34	23040.7	6116.64
10	7939.5	26039.76	6982.36
12	8773.74	28420.27	7706.23
14	9023.44	30260.13	8172.22
16	10916.6	32804.17	8857.41
18	11792.77	34034.04	9184.82
20	12312.56	34907.88	9491.97
22	13134.53	36507.49	9886.59
24	13841.4	36557.46	10119.1

Table A.185.: Summary of moments calculated in the point entitled ”BladeP7”. Sea state 2

WSP [m/s]	DEL $F_x[kN]$ (m=10)	DEL $F_y[kN]$ (m=10)	DEL $F_z[kN]$ (m=10)
4	220.45	543.1	298.14
6	308.51	559.39	338.67
8	307.12	568.18	375.13
10	337.63	598.03	396.3
12	371.45	670.44	425.78
14	388.31	718.32	461.44
16	402.59	740.25	538.96
18	414.94	770.03	588.72
20	429.03	792.11	613.97
22	441.97	838.14	660.21
24	472.97	887.53	698.55

Table A.186.: Summary of forces calculated in the point entitled "BladeP7". Sea state 3

WSP [m/s]	DEL $M_x[kNm]$ (m=10)	DEL $M_y[kNm]$ (m=10)	DEL $M_z[kNm]$ (m=10)
4	6025.37	16639.39	4404.29
6	7109.86	23336.96	6139.87
8	8057.96	23166.25	6162.7
10	8516.85	25257.79	6783.42
12	9154.71	27501.84	7417.06
14	9949.48	28799.35	7844.96
16	11504.57	29847.65	8120.04
18	12629.11	30501.96	8335.3
20	13230.4	31430.81	8646.23
22	14188.61	32043.55	8840.03
24	14890.14	34227.36	9379.31

Table A.187.: Summary of moments calculated in the point entitled "BladeP7". Sea state 3

Appendix B.

HAWC2 Cross Sectional Beam Parameters

B.1. Floater

r [m]	x_cg [m]	y_cg [m]	x_sh [m]	y_sh [m]	x_e [m]	y_e [m]	k_x [−]	k_y [−]	pitch [deg]
0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
1.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
5.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
10.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
15.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
20.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
27.04000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
27.05000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
30.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
40.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
50.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
60.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
70.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
80.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
90.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
91.55000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
91.56000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
96.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
100.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
101.55000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
101.56000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
108.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
108.10000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
110.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
116.55000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0

Table B.1.: HAWC2 cross sectional parameters for body: floater

r $[m]$	m $[kg/m]$	$m(ri_x)^2$ $[kgNm^2]$	$m(ri_y)^2$ $[kgNm^2]$	EI_x $[Nm^2]$	EI_y $[Nm^2]$	EA $[N]$	GJ $[\frac{Nm^2}{rad}]$
0.0	1.4925e+05	1.2698e+06	1.2698e+06	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
1.00000	1.4925e+05	1.2698e+06	1.2698e+06	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
5.00000	1.4925e+05	1.2698e+06	1.2698e+06	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
10.00000	1.4925e+05	1.2698e+06	1.2698e+06	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
15.00000	1.4925e+05	1.2698e+06	1.2698e+06	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
20.00000	1.4925e+05	1.2698e+06	1.2698e+06	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
27.04000	1.4925e+05	1.2698e+06	1.2698e+06	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
27.05000	1.0100e+04	8.5932e+04	8.5932e+04	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
30.00000	1.0100e+04	8.5932e+04	8.5932e+04	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
40.00000	1.0100e+04	8.5932e+04	8.5932e+04	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
50.00000	1.0100e+04	8.5932e+04	8.5932e+04	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
60.00000	1.0100e+04	8.5932e+04	8.5932e+04	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
70.00000	1.0100e+04	8.5932e+04	8.5932e+04	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
80.00000	1.0100e+04	8.5932e+04	8.5932e+04	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
90.00000	1.0100e+04	8.5932e+04	8.5932e+04	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
91.55000	1.0100e+04	8.5932e+04	8.5932e+04	2.3154e+12	2.3154e+12	2.7214e+11	1.7862e+12
91.56000	1.0100e+04	8.5890e+04	8.5890e+04	2.3137e+12	2.3137e+12	2.7207e+11	1.7849e+12
96.00000	9020.00000	6.1094e+04	6.1094e+04	1.6446e+12	1.6446e+12	2.4281e+11	1.2687e+12
100.00000	7550.00000	3.5838e+04	3.5838e+04	9.6485e+11	9.6485e+11	2.0327e+11	7.4432e+11
101.55000	7660.00000	3.7429e+04	3.7429e+04	1.0077e+12	1.0077e+12	2.0623e+11	7.7737e+11
101.56000	7660.00000	3.7405e+04	3.7405e+04	1.0067e+12	1.0067e+12	2.0617e+11	7.7663e+11
108.00000	7660.00000	3.7405e+04	3.7405e+04	1.0067e+12	1.0067e+12	2.0617e+11	7.7663e+11
108.10000	7660.00000	3.7405e+04	3.7405e+04	1.0067e+12	1.0067e+12	2.0617e+11	7.7663e+11
110.00000	7660.00000	3.7405e+04	3.7405e+04	1.0067e+12	1.0067e+12	2.0617e+11	7.7663e+11
116.55000	7660.00000	3.7405e+04	3.7405e+04	1.0067e+12	1.0067e+12	2.0617e+11	7.7663e+11

Table B.2.: HAWC2 cross sectional parameters for body: floater

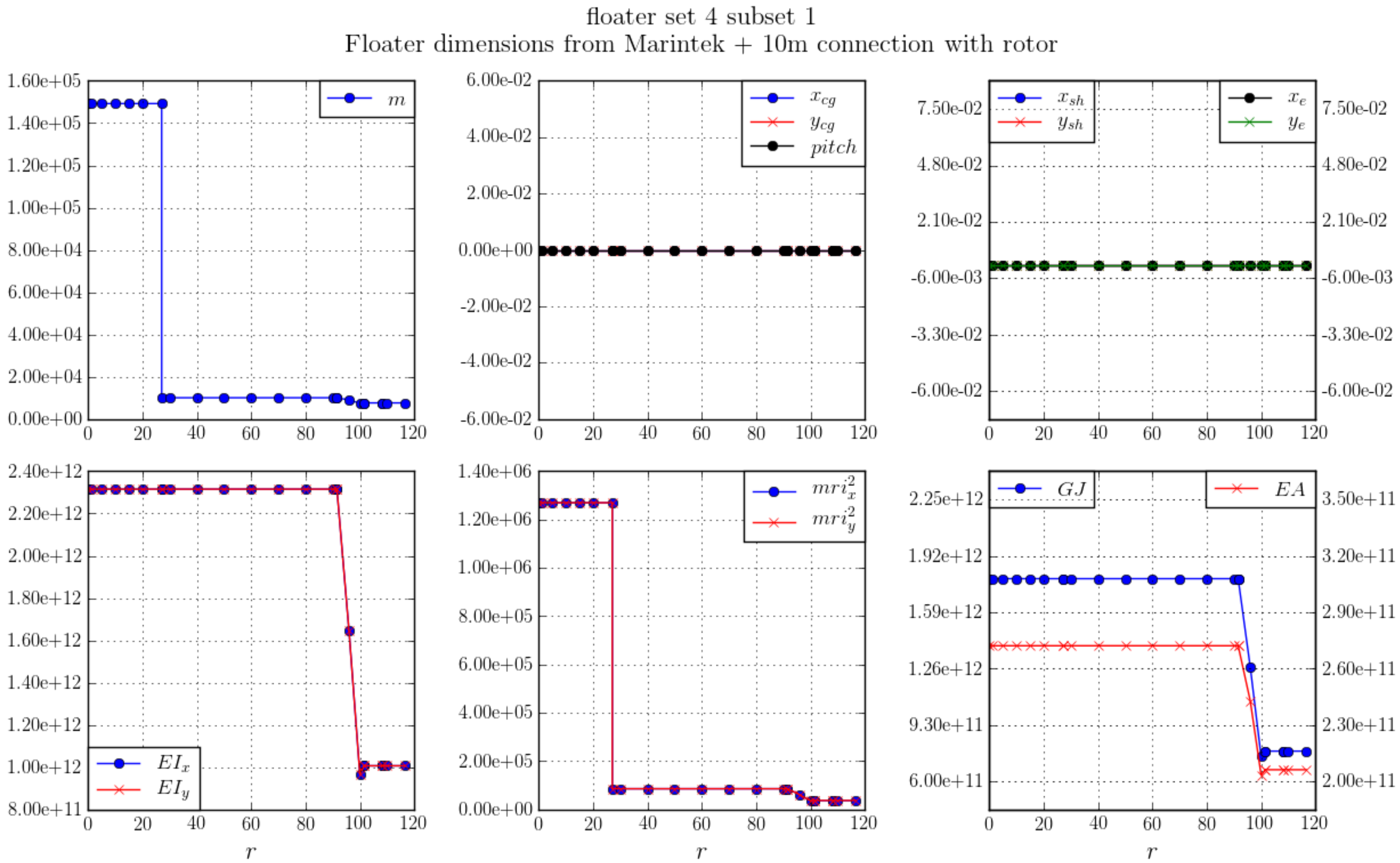

Figure B.1.: HAWC2 cross sectional data for body: floater

B.2. Tower

r $[m]$	x_cg $[m]$	y_cg $[m]$	x_sh $[m]$	y_sh $[m]$	x_e $[m]$	y_e $[m]$	k_x $[-]$	k_y $[-]$	$pitch$ $[deg]$
0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
35.65000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
35.75000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
71.40000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
71.50000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
107.15000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
107.25000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
143.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0

Table B.3.: HAWC2 cross sectional parameters for body: tower

r $[m]$	m $[kg/m]$	$m(ri_x)^2$ $[kgNm^2]$	$m(ri_y)^2$ $[kgNm^2]$	EI_x $[Nm^2]$	EI_y $[Nm^2]$	EA $[N]$	GJ $[\frac{Nm^2}{rad}]$
0.0	3436.74151	1.7596e+04	1.7596e+04	4.6860e+11	4.6860e+11	9.2469e+10	3.6149e+11
35.65000	3436.74151	1.7596e+04	1.7596e+04	4.6860e+11	4.6860e+11	9.2469e+10	3.6149e+11
35.75000	2577.55614	1.0989e+04	1.0989e+04	2.9294e+11	2.9294e+11	6.9350e+10	2.2598e+11
71.40000	2577.55614	1.0989e+04	1.0989e+04	2.9294e+11	2.9294e+11	6.9350e+10	2.2598e+11
71.50000	2217.60062	7845.39379	7845.39379	2.0907e+11	2.0907e+11	5.9667e+10	1.6128e+11
107.15000	2217.60062	7845.39379	7845.39379	2.0907e+11	2.0907e+11	5.9667e+10	1.6128e+11
107.25000	1699.24505	4533.68927	4533.68927	1.2080e+11	1.2080e+11	4.5719e+10	9.3188e+10
143.00000	1699.24505	4533.68927	4533.68927	1.2080e+11	1.2080e+11	4.5719e+10	9.3188e+10

Table B.4.: HAWC2 cross sectional parameters for body: tower

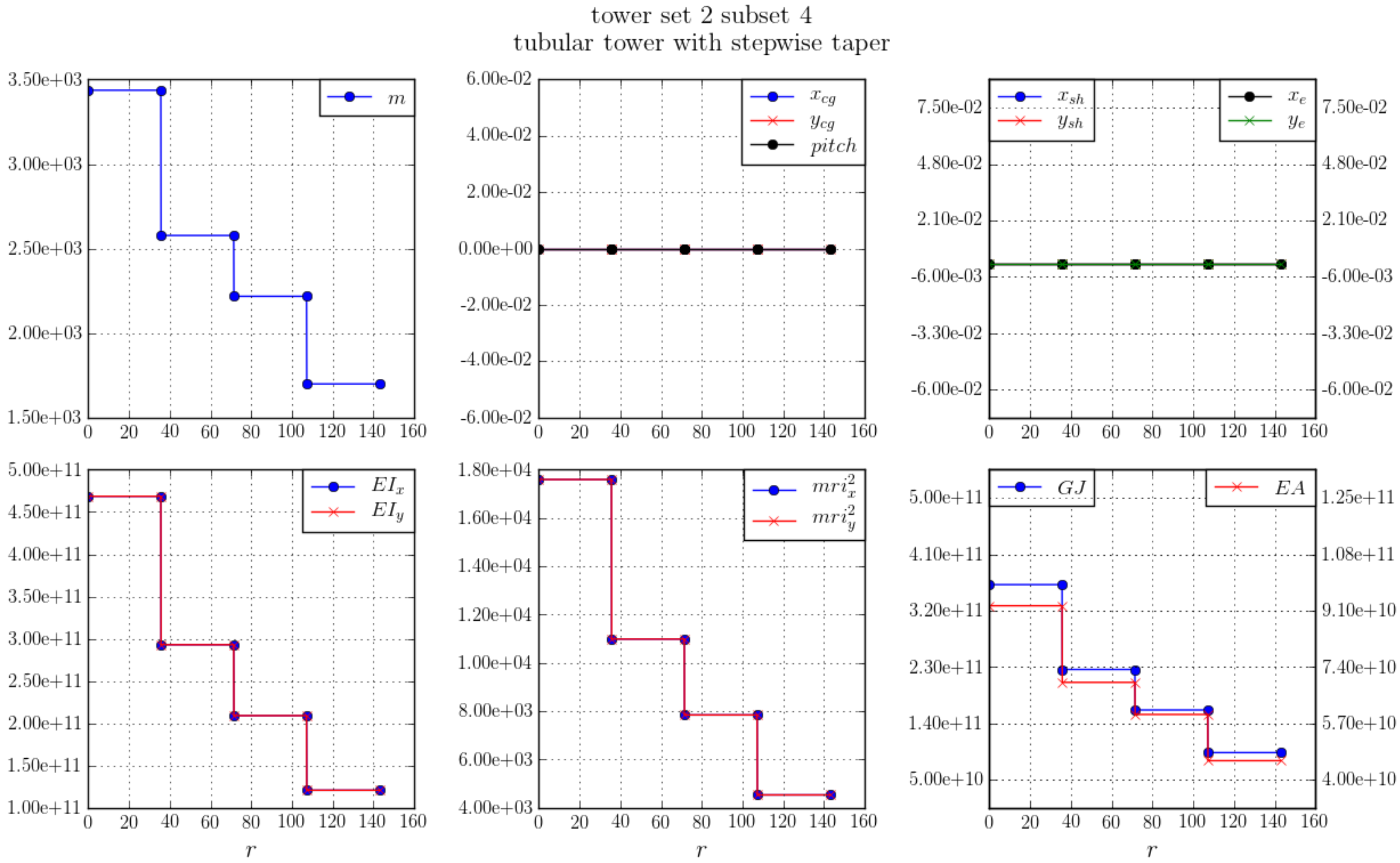

Figure B.2.: HAWC2 cross sectional data for body: tower

B.3. Generator

r $[m]$	x_cg $[m]$	y_cg $[m]$	x_sh $[m]$	y_sh $[m]$	x_e $[m]$	y_e $[m]$	k_x $[-]$	k_y $[-]$	$pitch$ $[deg]$
0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
2.60800	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0

Table B.5.: HAWC2 cross sectional parameters for body: generator

r $[m]$	m $[kg/m]$	$m(ri_x)^2$ $[kgNm^2]$	$m(ri_y)^2$ $[kgNm^2]$	EI_x $[Nm^2]$	EI_y $[Nm^2]$	EA $[N]$	GJ $[\frac{Nm^2}{rad}]$
0.0	1.1120e+05	7.8090e+05	7.8090e+05	1.3014e+18	1.3014e+18	1.8532e+17	1.0039e+20
2.60800	1.1120e+05	7.8090e+05	7.8090e+05	1.3014e+18	1.3014e+18	1.8532e+17	1.0039e+20

Table B.6.: HAWC2 cross sectional parameters for body: generator

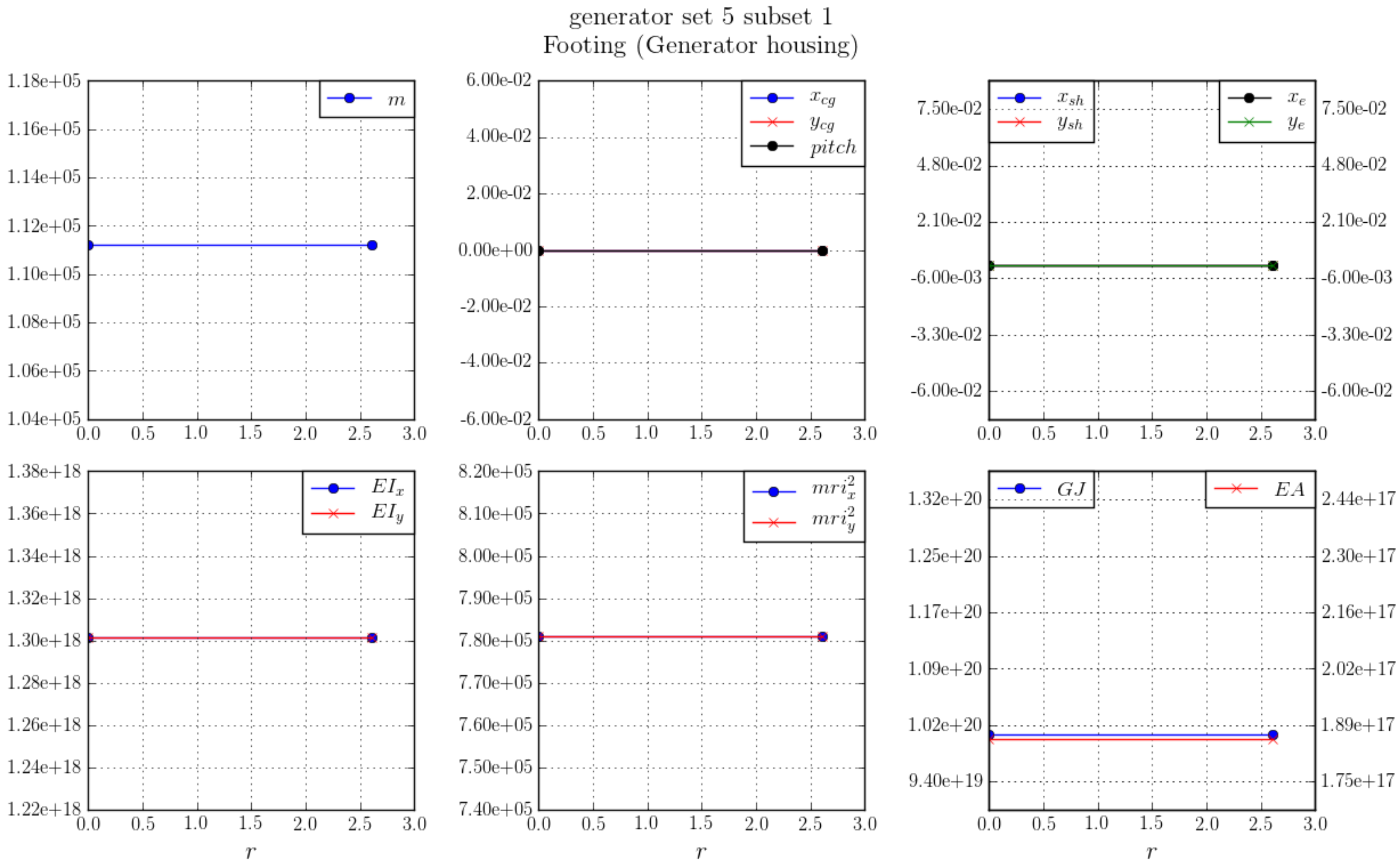

Figure B.3.: HAWC2 cross sectional data for body: generator

B.4. Arm

r $[m]$	x_cg $[m]$	y_cg $[m]$	x_sh $[m]$	y_sh $[m]$	x_e $[m]$	y_e $[m]$	k_x $[-]$	k_y $[-]$	$pitch$ $[deg]$
0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
20.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0

Table B.7.: HAWC2 cross sectional parameters for body: arm

r $[m]$	m $[kg/m]$	$m(ri_x)^2$ $[kgNm^2]$	$m(ri_y)^2$ $[kgNm^2]$	EI_x $[Nm^2]$	EI_y $[Nm^2]$	EA $[N]$	GJ $[\frac{Nm^2}{rad}]$
0.0	1899.10000	570.91110	570.91110	1.5370e+10	1.5370e+10	5.1129e+10	1.1858e+10
20.00000	1899.10000	570.91110	570.91110	1.5370e+10	1.5370e+10	5.1129e+10	1.1858e+10

Table B.8.: HAWC2 cross sectional parameters for body: arm

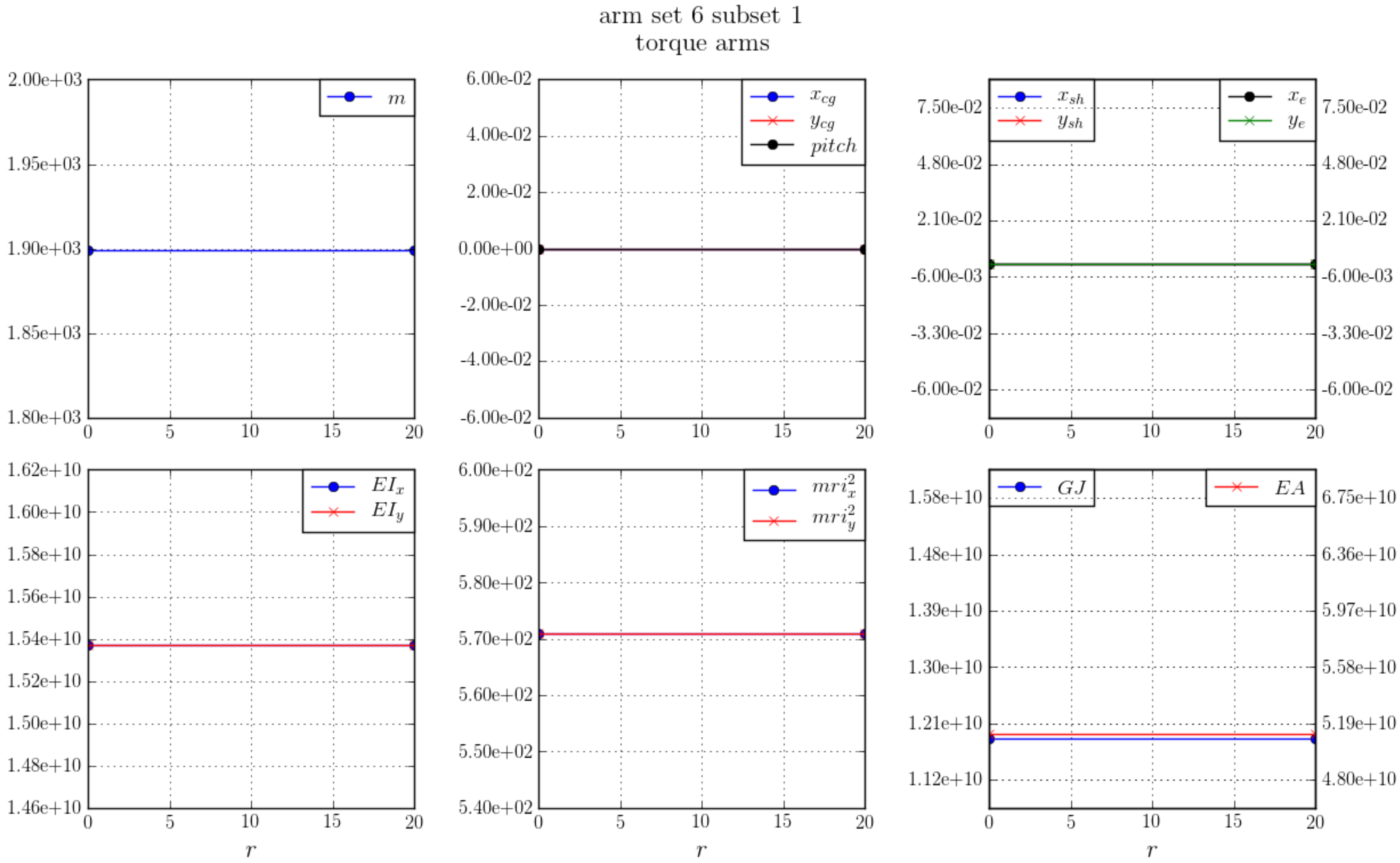

Figure B.4.: HAWC2 cross sectional data for body: arm

B.5. Bearing

r $[m]$	x_cg $[m]$	y_cg $[m]$	x_sh $[m]$	y_sh $[m]$	x_e $[m]$	y_e $[m]$	k_x $[-]$	k_y $[-]$	$pitch$ $[deg]$
0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0
1.00000	0.0	0.0	0.0	0.0	0.0	0.0	50.00000	50.00000	0.0

Table B.9.: HAWC2 cross sectional parameters for body: bearing

r $[m]$	m $[kg/m]$	$m(ri_x)^2$ $[kgNm^2]$	$m(ri_y)^2$ $[kgNm^2]$	EI_x $[Nm^2]$	EI_y $[Nm^2]$	EA $[N]$	GJ $[\frac{Nm^2}{rad}]$
0.0	1.0100e+04	8.5932e+04	8.5932e+04	2.3154e+17	2.3154e+17	2.7214e+16	1.7862e+17
1.00000	1.0100e+04	8.5932e+04	8.5932e+04	2.3154e+17	2.3154e+17	2.7214e+16	1.7862e+17

Table B.10.: HAWC2 cross sectional parameters for body: bearing

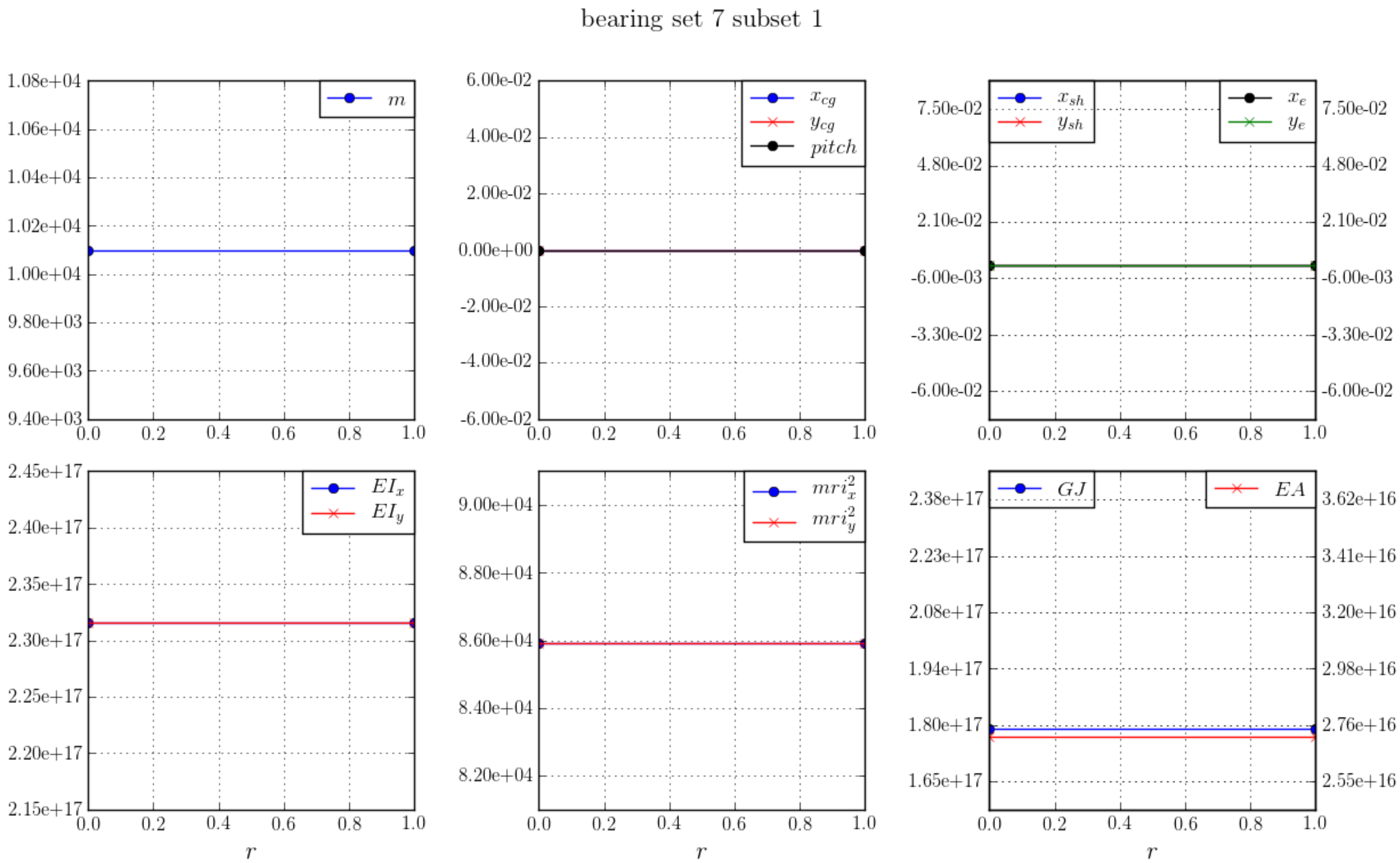

Figure B.5.: HAWC2 cross sectional data for body: bearing

B.6. Blades

r $[m]$	x_cg $[m]$	y_cg $[m]$	x_sh $[m]$	y_sh $[m]$	x_e $[m]$	y_e $[m]$	k_x $[-]$	k_y $[-]$	$pitch$ $[deg]$
0.0	0.22010	0.0	0.69100	0.0	0.0	0.0	50.00000	50.00000	0.0
17.68420	0.22010	0.0	0.69100	0.0	0.0	0.0	50.00000	50.00000	0.0
21.80870	0.22010	0.0	0.69100	0.0	0.0	0.0	50.00000	50.00000	0.0
29.44430	0.22010	0.0	0.69100	0.0	0.0	0.0	50.00000	50.00000	0.0
29.54430	0.16720	0.0	0.68730	0.0	0.0	0.0	50.00000	50.00000	0.0
168.18210	0.16720	0.0	0.68730	0.0	0.0	0.0	50.00000	50.00000	0.0
168.28210	0.22010	0.0	0.69100	0.0	0.0	0.0	50.00000	50.00000	0.0
184.93060	0.22010	0.0	0.69100	0.0	0.0	0.0	50.00000	50.00000	0.0
188.00000	0.22010	0.0	0.69100	0.0	0.0	0.0	50.00000	50.00000	0.0
200.42890	0.22010	0.0	0.69100	0.0	0.0	0.0	50.00000	50.00000	0.0

Table B.11.: HAWC2 cross sectional parameters for body: blade

r $[m]$	m $[kg/m]$	$m(ri_x)^2$ $[kgNm^2]$	$m(ri_y)^2$ $[kgNm^2]$	EI_x $[Nm^2]$	EI_y $[Nm^2]$	EA $[N]$	GJ $[\frac{Nm^2}{rad}]$
0.0	275.61000	49.36127	572.69615	4.8128e+13	4.6315e+14	2.1168e+14	4.8718e+13
17.68420	275.61000	49.36127	572.69615	4.8128e+13	4.6315e+14	2.1168e+14	4.8718e+13
21.80870	275.61000	49.36127	572.69615	4.8128e+13	4.6315e+14	2.1168e+14	4.8718e+13
29.44430	275.61000	49.36127	572.69615	4.8128e+13	4.6315e+14	2.1168e+14	4.8718e+13
29.54430	223.32000	21.53034	459.67387	1.9472e+13	4.0173e+14	1.9472e+14	2.5726e+13
168.18210	223.32000	21.53034	459.67387	1.9472e+13	4.0173e+14	1.9472e+14	2.5726e+13
168.28210	275.61000	49.36127	572.69615	4.8128e+13	4.6315e+14	2.1168e+14	4.8718e+13
184.93060	275.61000	49.36127	572.69615	4.8128e+13	4.6315e+14	2.1168e+14	4.8718e+13
188.00000	275.61000	49.36127	572.69615	4.8128e+13	4.6315e+14	2.1168e+14	4.8718e+13
200.42890	275.61000	49.36127	572.69615	4.8128e+13	4.6315e+14	2.1168e+14	4.8718e+13

Table B.12.: HAWC2 cross sectional parameters for body: blade

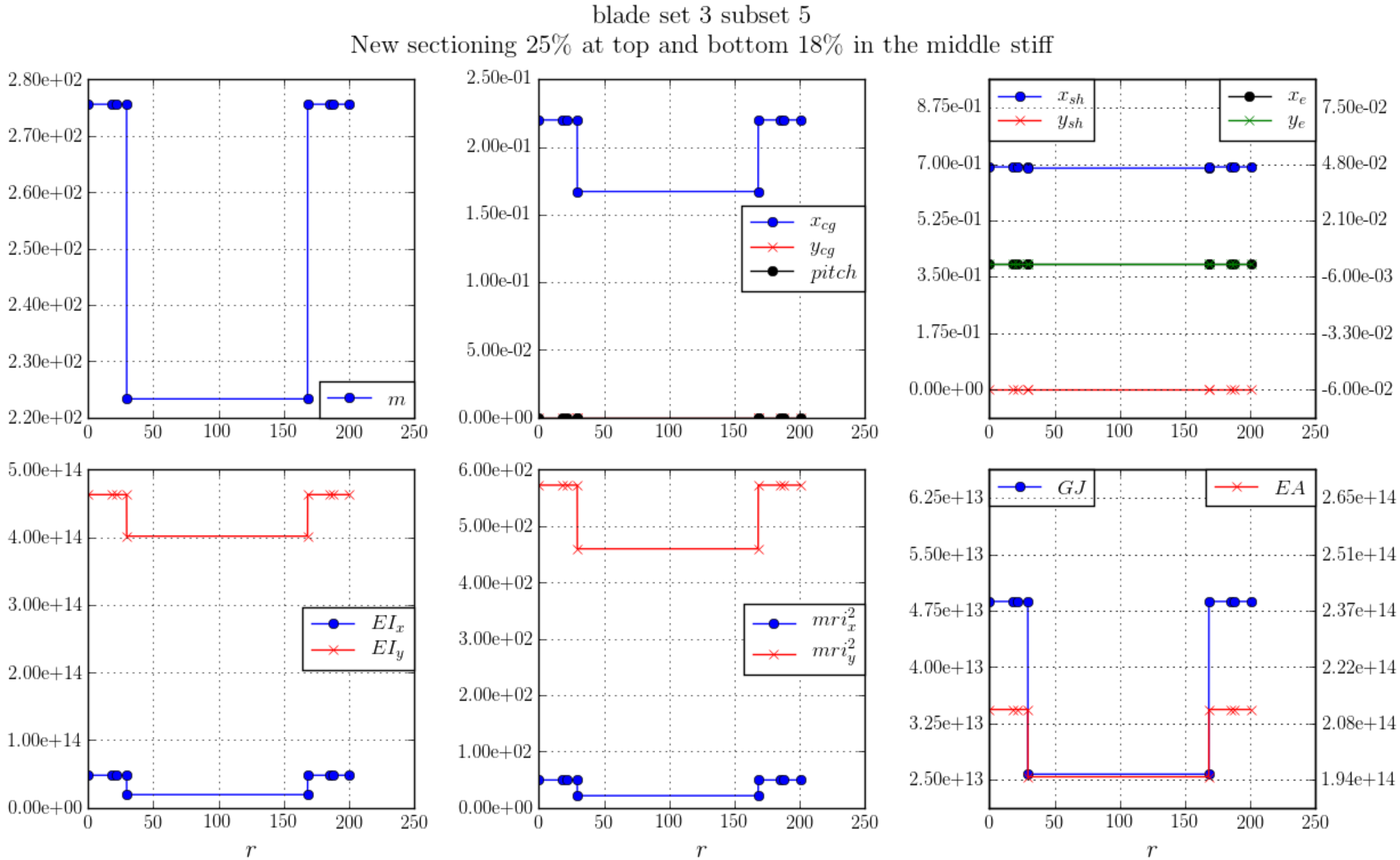

Figure B.6.: HAWC2 cross sectional data for body: blade