WINDCRETE 15 MW PREDESIGN

# WindCrete for the 15MW EIA Reference Wind Turbine

The RNA characteristics used for design purpose:

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| --- | --- |
| **RNA** | |
| **Ø Rotor [m]** | 240 |
| **Mass RNA [kg]** | 1.45E+06 |
| **Hub Height [m]** | 150 |
| **Yaw Bearing Height** | 145 |
| **Thrust rated [N]** | 2.10E+06 |

Also a vertical force of -1.6·106N is applied to emulate the initial vertical force of the moorings. The values is obtained from the OC3 Hywind platform.

## Design targets

The properties of the design of the WindCrete for the 15MW EIA Reference Wind Turbine are set to fulfil the next design constraints:

1. Maximum tilt for the thrust at rated wind speed less than 4.5º
2. Heave and Pitch natural periods over 30s

The concrete considered for the predesign is a prestressed concrete with a compressive characteristic strength of 70 MPa. The properties are:

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| --- | --- |
| **70 MPa Concrete** | |
|  | 70 |
| **Density [kg/m3]** | 2500 |
| **E [N/mm2]** | 3.6318e+04 |

## WindCrete Characteristics

The WindCrete platform is a concrete monolithic spar platform. As made of concrete, the tower is different than the steel one. Moreover, for design purpose, the tower base is set to the MSL.

However, to implement the WindCrete in FAST, the WindCrete properties will be defined supposing the tower starts at 15m above MSL in Section 2.

### Tower

The tower is a hollow truncated cone with constant thickness.

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| --- | --- | --- |
| **Tower** | | |
| **Tower Base Height [m]** | 0 |
| **Top Tower Height [m]** | 145 |
| **Tower Base Outer Radius [m]** | 6.6 |
| **Tower Top Outer Radius [m]** | 3.35 |
| **Thickness tower [m]** | 0.4 |

### Substructure

The substructure has a draft of 160m and is divided in a taper section of 10m length at the top, a cylinder section in the mid of the buoy, and a hemi-sphere at the bottom of the buoy.

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| --- | --- | --- |
| **Substructure (Taper section + Cylinder + Hemisphere)** | | |
| **Draft [m]** | 160 |
| **Buoy Thickness [m]** | 0.5 |
| **Taper length [m]** | 10 |
| **Taper Top Outer Radius [m]** | 6.6 |
| **Taper Base Outer Radius [m]** | 9.3 |
| **Cylinder Length [m]** | 140.7 |
| **Cylinder Outer Radius [m]** | 9.3 |
| **Hemi-Sphere Outer Radius [m]** | 9.3 |

### Ballast

The ballast is placed at the bottom of the buoy and is made of aggregates. The ballast fills the hemi-sphere hollow and a part of the cylinder. The ballast is considered to have a bulk density of 2500 kg/m3.

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| --- | --- | --- |
| **Ballast** | | |
| **Ballast length [m] (Hemisphere + Cylinder)** | 45.28 |
| **Ballast density [kg/m3]** | 2500 |

## WindCrete Properties without the wind turbine

### Physic Properties

The physic properties of the WindCrete take into account the whole structure and the ballast.

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| --- | --- | --- |
| **WindCrete Properties** | | |
| **Mass [kg]** | 4.136e+07 |
| **CoG z direction [m]** | -99.56 |
| **Ixx [kg·m2] from CM** | 1.899e+11 |
| **Iyy [kg·m2] from CM** | 1.899e+11 |
| **Izz [kg·m2] from CM** | 1.972e+09 |

### Hydrostatic Properties

The Hydrostatic properties are assessed from the intersection between the platform axisymmetric axis and the MSL as a reference point. The Cxx are the coefficients of the linear-hydrostatic matrix.

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| **WindCrete Hydrostatic Properties** | |
| **Displacement [m3]** | 4.190e+04 |
| **CoB z direction [m]** | -79.79 |
| **C33 [N/m]** | 1.376e+06 |
| **C44 [N·m/rad]** | -3.360e+10 |
| **C55 [N·m/rad]** | -3.360e+10 |

# WindCrete FAST properties

## Tower

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| --- | --- | --- |
| **Tower** | | |
| **Tower Base Height [m]** | 15 |
| **Top Tower Height [m]** | 145 |
| **Tower Top Outer Radius [m]** | 3.35 |
| **Tower Base Outer Radius [m]** | 6.26 |
| **Thickness tower [m]** | 0.4 |

## SubStructure

|  |  |  |
| --- | --- | --- |
| **Substructure (Tapper section + Cylinder + Hemisphere)** | | |
| **Draft [m]** | 160 |
| **Substructure Top Height [m]** | 15 |
| **Buoy Thickness above MSL[m]** | 0.4 |
| **Buoy Thickness below MSL[m]** | 0.5 |
| **Taper1 length [m]** | 14 |
| **Taper1 Top Outer Radius [m]** | 6.26 |
| **Taper1 Base Outer Radius [m]** | 6.6 |
| **Taper2 length [m]** | 10 |
| **Taper2 Top Outer Radius [m]** | 6.6 |
| **Tapper2 Base Outer Radius [m]** | 9.3 |
| **Cylinder Length [m]** | 140.7 |
| **Cylinder Outer Radius [m]** | 9.3 |
| **Hemi-Sphere Outer Radius [m]** | 9.3 |

The substructure properties considering the ballast are the following:

|  |  |
| --- | --- |
| **WindCrete Substructure FAST Properties** | |
| **Mass [kg]** | 3.759e+07 |
| **CoG\_z [m]** | -116.858 |
| **Ixx [kg·m2]** | 6.127e+10 |
| **Iyy [kg·m2]** | 6.127e+10 |
| **Izz [kg·m2]** | 1.884e+09 |

# FAST Tower Modal Analysis

The first bending moment of the tower (of 130 m height and with the mass of RNA at 135 m) cuts the 3P rotor frequency between the cut-in and the rated wind speed.

|  |  |  |
| --- | --- | --- |
| No. | Mode | Frequency [Hz] |
| 1 | 1st Tower FA | 0.33 |
| 2 | 1st Tower SS | 0.33 |
| 3 | 2nd Tower FA | 2.06 |
| 4 | 2nd Tower SS | 2.06 |

# WindCrete Sketch

