CIVIL, ENVIRONMENTAL & GEOMATIC ENGINEERING DEPARTMENT, UCL
CEGE0023 OFFSHORE AND COASTAL ENGINEERING 2023-24

Design Project Brief

You are required to produce a preliminary design of a monopile substructure to support a Vestas V112 3MWt offshore wind turbine at particular locations for a planned extension of Rampion offshore wind farm. Turbine characteristics are specified in the "General Specification" document available on Moodle. Table 1 gives coordinates of turbine sites. Turbines positions are randomly distributed between project groups.

Identify your location on the Digimap online map and data service (https://digimap.edina.ac.uk). Use the Digimap Marine Roam application to plot the bathymetry around your location. You may use an online coordinates converter to convert the coordinates from UTM to degrees (e.g. https://www.movable-type.co.uk/scripts/latlong-utm-mgrs.html).

The design should be performed in accordance with BS EN 61400-3:2009 "Wind turbines – Part 3: Design requirements for offshore wind turbines" using load cases 1.1 and 6.1c.

Parameters you should specify in the process of design include:

1. Monopile diameter to provide safe mounting of the turbine tower on the substructure
2. Substructure height to provide safe operation for site water levels and wave conditions.
3. The height of the turbine tower to provide a safe gap between turbine rotor and water surface.

The substructure layout should include necessary operational elements such as work platform, J-tubes, boat landing and access ladders.

The following tasks are to be performed in the design process

1. Specification of design conditions for cases 1.1 and 6.1c, BS EN 61400-3:2009
   (a) Use the Digimap online map and data service to obtain bathymetric data for your site.
   (b) Search the sources of Metocean data to acquire suitable sets of wind, wave, current and tide data.
   (c) Use the data to calculate wind, wave, current and water level parameters for your design cases. Select one particular combination of waves, currents and water levels prescribed by the code for each design case.
   (d) Use the following additional considerations and assumptions[1]:
      i. Assume that current data are taken at the turbine site at the level 10m from the sea surface. For load case 6.1c use the maximal current speed in your data set.
      ii. Assume that the tide data is taken at the turbine site. Neglect the random water level component and use water levels of astronomical tides only. For load case 6.1c use Highest Astronomical Tide (HAT) and for load case 1.1 use Mean Low Water Neaps levels.
      iii. Assume that the wind data is taken at the turbine site at the height 20 m above the chart datum.
      iv. Use wave prediction charts (BS 6349-1-2:2016, Annexe C.4) to calculate wave conditions for load case 1.1.
      v. Use extreme values analysis (BS 6349-1-2:2016+A1:2017, Section 15 and Annex D) to

1 Assumptions made in the brief simplify the analysis to the level sufficient for educational purposes, but are not acceptable in the real design.

Site	WGS84 UTM Z30N		Group	Site	WGS84 UTM Z30N		Group
	Eastings	Northings			Eastings	Northings	
WF01	687210.72	5617101.8	Group 01	**WF07**	694247.80	5618054.52	Group 07
WF02	689607.51	5619065.43	Group 02	**WF08**	690038.49	5617186.22	Group 08
WF03	692003.15	5619686.77	Group 03	**WF09**	689380.88	5615509.29	Group 09
WF04	695312.51	5620004.21	Group 04	**WF11**	690692.37	5613937.55	Group 10
WF05	699970.07	5618924.75	Group 05	**WF15**	705429.02	5617852.65	Group 11
WF06	696906.86	5618723.20	Group 06	**WF16**	705103.77	5616054.42	Group 12

Table 1: Coordinates of proposed turbines sites

calculate wave conditions for load case 6.1c.

vi. 3rd-year students: Assume that the wave data is taken at the turbine site.

vii. MSc and 4th-year students: Assume that the wave data is taken in deep water.

viii. MSc and 4th-year students: Re-calculate wave height taking into account the difference in depths between the measurement site and the turbine site by applying shoaling consideration.

ix. MSc and 4th-year students: Define if your wave conditions correspond to breaking or non-breaking waves.

Produce a Design Conditions Report describing the data, methods of calculation of design conditions and summarising these conditions for your design cases. The report should include plots of wind and current profiles and wave velocity profiles in combinations required for calculating loads. The report word limit is 2500 words excluding bibliography.

2. Calculate wind, wave and current loads on the wind-turbine installation for the specified load cases. Loads must include: (i) Horizontal force and (ii) Mud-line overturning moment. Use the following additional considerations and assumptions:

   (a) For wind load use rotor trust and tower load for case 1.1 and tower load for case 6.1c.

   (b) Assume unidirectional waves co-directional with currents for both design cases.

   (c) For case 1.1, calculate loads for one selected combination of waves, currents and water levels prescribed by the code.

   (d) For case 6.1c calculate loads corresponding to HAT conditions.

   (e) MSc and 4th-year students: For cases with breaking waves include breaking impact loads to your load calculations.

   (f) Compare loads for both cases and specify ultimate design loads.

   (g) For calculating waves and current loads use the method for slender structures. Discuss the applicability of this approximation for your structure and wave-current conditions. Discuss alternative methods of calculating wave-current loads. You can use Figure 7-1 from DNV-RP-C205 to help you in your discussion.

3. For the surficial seabed sediments at your site calculate if the seabed is mobile and find the critical velocity for bed sediment movement. Specify if scour occurs around the installed substructure and calculate the depth of the scour hole. If required, suggest measures for scour protection. Sediment parameters for your site are specified in EON (2012), including particle size distribution

(EON 2012, Appendix H, Table 1), summary statistics (EON 2012, Appendix H, Table 2) and particles description (EON 2012, Appendix H, Table 3). Use the following additional considerations and assumptions:

(a) Assume that the surficial sediment thickness is greater than the depth of scour formed around the foundation.

(b) For sediment transport and scour analysis assume wave and current conditions corresponding to the design case 6.1c. Use the water level corresponding to Lowest Astronomic Tide (LAT).

(c) 3rd-year students: Neglect the effect of waves on scour and consider scour by current only.

(d) Use any appropriate method for predicting scour around a cylindrical structure. Refer to slides and recommended reading of the course lecture on scour and scour protection.

Final Design Report should include:

1. Introduction summarising aims and objectives the project and its context.
2. Brief summary of design conditions.
3. Description of methods for load calculation and summary of calculated loads.
4. Values of design parameters and their justification.
5. Results of sediment transport and scour analysis and description of the methods used for this analysis. Summary of recommendations for scour protection.
6. A3 drawing of the proposed design.
7. Appropriate referencing should be used in the report and a list of references should be provided.

The report word limit is 2500 words excluding bibliography

Selected sources of Metocean data

British Oceanographic Data Centre: http://www.bodc.ac.uk/

WaveNet: http://wavenet.cefas.co.uk/Map

Channel Coastal Observatory: http://www.channelcoast.org/

Marine Environmental Data and Information Network (MEDIN): http://www.oceannet.org/

National Oceanography Centre: http://www.pol.ac.uk/

National Data Buoy Center (NDBC): http://www.ndbc.noaa.gov/maps/United_Kingdom.shtml

National Tidal and Sea Level Facility: https://www.ntslf.org/

Cefas Wavenet Wave Hindcast: https://wavenet.cefas.co.uk/hindcast

Recommended codes

BS EN 61400-3:2009 Wind turbines. Design requirements for offshore wind turbines
Available on: https://bsol.bsigroup.com/Bibliographic/BibliographicInfoData/000000000030170387

BS 6349-1-2:2016+A1:2017 Maritime works. General. Code of practice for assessment of actions
Available on: https://bsol.bsigroup.com/Bibliographic/BibliographicInfoData/000000000030361856

Other references

EON (2012) Rampion Offshore Wind Environmental Statement. Section 7 – Benthos and Sediment Quality. Appendix 7.2. December 2012.
Available on Moodle