Inch Cape Offshore Wind Farm

New Energy for Scotland

Offshore Environmental Statement:
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Annex 10A.5: Modelling of Structures Methodology

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ANNEX 10A.5 MODELLING OF STRUCTURES METHODOLOGY

TECHNICAL REPORT

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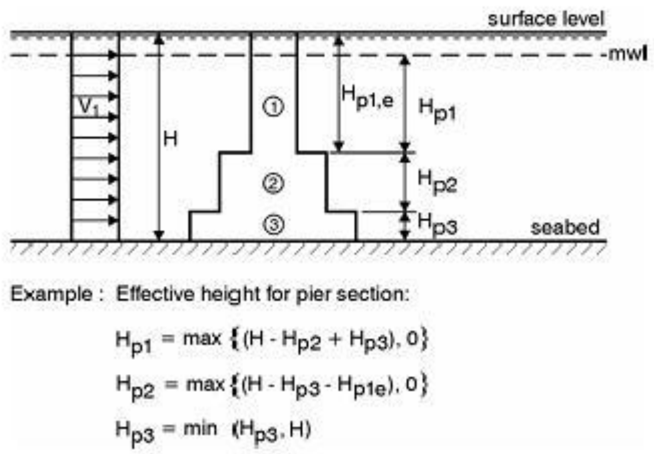
Installing any non-permeable or semi-permeable structure into the marine environment will have a hydraulic effect on the ambient current flow and wave energy by essentially blocking the area it occupies. The tower of a gravity-based structure acts on currents and waves in the same way as piers. Piers introduce a current-induced drag force on the pier itself, increasing the resistance to the flow and thereby altering the flow regime. Calculating the drag force is dependent on the size and geometry of the structure and the magnitude of the current. Piers also dissipate the energy travelling within a wave, initially reducing the wave height on the lee side of the structure.

Within the hydrodynamic model of the Forth and Tay Modelling System (FTMS), gravity bases are modelled using a sub-mesh technique as their size is smaller than that of the mesh elements in which they are located. This technique calculates the flow past the structure by considering the upstream and downstream water levels. Information about the structure is required, including its location, orientation, streamline factor (this is typically 1.02 for piers) and geometry. The gravity base structure is represented in the FTMS hydrodynamic model as a series of stepped sections. For circular structures, each section requires details on its height and diameter – see Figure 10A.5.1.

Figure 10A.5.1 - Schematic of structure in the water column. Source: DHI MIKE21 manuals



The effect of flow around each pier is modelled by calculating the current induced drag force on each individual pier.

The effective drag force, F, is determined from:

$$F = \frac{1}{2}\, \rho_w\, \gamma C_D A_e V^2$$

where ρ_w is the density of water, γ is the streamline factor, C_D is the drag coefficient, A_e is the effective area of the pier exposed to current and V is the current speed. The sign of F is such that a positive force acts against the current.

The FTMS spectral wave model also uses the sub-mesh technique, and applies a source term approach. The source term approach takes the effects of the structures into account by introducing a decay term to reduce the wave energy behind the structure. The FTMS is only capable of representing simple geometry types, so the gravity bases were represented by a circular structure, dimensioned so as to be representative of the proposed gravity base size. Therefore, the information required to model a gravity base structure is its location and representative diameter.

The source term due to the effect of a structure can be written;

$$s = -\frac{c}{A} c_g E(\sigma, \theta)$$

Where A is the area of the cell/element in the mesh in which the structure is located, c is the reflection factor, c_g is the group celerity and $E(\sigma, \theta)$ is the energy density.

The approaches as outlined above for representing marine structures in hydrodynamic and spectral wave models are in line with accepted industry standards best practice guidance, for example as outlined in Lambkin *et al*. (2009).

A.5.1 REFERENCES

Lambkin, D.O., Harris, J.M., Cooper, W.S. and Coates, T. 2009. Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment: Best Practice Guide. COWRIE.