



OFFSHORE WIND ACCELERATOR (OWA)

DONISIS Interim Workshop Proceedings

Design of Offshore Monopiles Including Seismic Interaction with Soil (DONISIS) Project

Summary of findings and discussions

4 June 2026



THE DESIGN OF OFFSHORE MONOPILES INCLUDING SEISMIC INTERACTION WITH SOIL PROJECT

The Design of Offshore Monopiles Including Seismic Interaction with Soil (DONISIS) project is an international research and development project led by Delft University of Technology and set up in collaboration with the Carbon Trust's Offshore Wind Accelerator (OWA) programme. It aims to improve understanding of seismic soil–structure interaction in monopile-supported offshore wind turbines and translate this knowledge into practical design methods. DONISIS brings together universities, research institutes, certification bodies, technology providers and offshore wind developers. It is funded through the Dutch Research Council's Open Technology Programme (NWO OTP) and co-funded by participating research and industry partners.

THE OFFSHORE WIND ACCELERATOR

The Offshore Wind Accelerator (OWA) is the Carbon Trust's flagship collaborative research, development and demonstration programme. The joint initiative, which has been running since 2008, is a collaboration between the Carbon Trust and nine offshore wind developers. Its aim is to reduce the cost of offshore wind to be competitive with conventional energy generation, to accelerate the deployment of offshore wind globally, and to drive industry standards and best practice.

ACKNOWLEDGEMENTS

The successful delivery of the DONISIS Interim Workshop was made possible by the commitment and expertise of the project's international research and industry community. The Carbon Trust and TU Delft sincerely thank all DONISIS partners for supporting the project through research, funding, technical input, industry evidence and in-kind contributions.

We are especially grateful to the research team for sharing the project's interim findings and explaining how physical testing, numerical modelling, and the development of practical engineering methods are being connected. We also thank the presenters, panellists and moderators who contributed perspectives from research, offshore wind development, engineering design, site characterisation, certification and standardisation.

Finally, we thank everyone who attended the workshop and participated in the discussions. Their questions, experience and constructive input will help the project continue bridging the gap between advanced research and practical, certifiable seismic design methods for offshore wind.

PROJECT PARTNERS



Design of Offshore Monopiles Including Seismic Interaction with Soil (DONISIS)

Interim Workshop – Proceedings Summary

Yokohama, Japan | 4 June 2026

This document provides a concise summary of the principal discussion points and takeaways from the DONISIS Interim Workshop. It should be read alongside the [workshop presentation pack](#), which contains the detailed technical material presented during the sessions. It is not intended to provide a verbatim record of the discussions.

OVERVIEW

The DONISIS Interim Workshop brought together offshore wind developers, certification bodies, regulators, academics and engineering consultants to review progress in the project and discuss how improved methods for seismic design of monopile-supported offshore wind turbines can be translated into engineering practice. Across the workshop, the central challenge was clear: offshore wind is expanding into seismically active markets, while much current monopile design practice has developed in regions where seismic loading has not governed design. The workshop therefore focused on the topic of reducing uncertainty in seismic soil–structure interaction, developing and validating practical design approaches while identifying credible pathways towards certification and future guidance.

SESSION 1 – WHY DONISIS IS NEEDED AND CURRENT PRACTICE

Purpose

The purpose of Session 1 was to establish the technical and commercial need for DONISIS. Large diameter monopiles have been developed primarily through European offshore wind projects, while seismic design in emerging markets often relies on approaches adapted from buildings, bridges, ports and oil and gas infrastructure. Monopile supported offshore wind turbines are, however, highly dynamic systems whose earthquake response is strongly influenced by soil–structure interaction, including soil non-linearity, pore-pressure generation, liquefaction and permanent foundation rotation. The inherent complexity of these interplaying phenomena creates uncertainty regarding whether existing approaches adequately capture the behaviour relevant to modern offshore wind structures.

Discussion and takeaways

Participants discussed how this uncertainty can influence both safety and project economics. Excessively conservative assumptions may result in heavier foundations, higher costs and installation constraints, while insufficiently conservative assumptions may leave important aspects of seismic performance inadequately assessed. In particular, the role played by the evolution of soil behaviour, including liquefaction phenomena, during strong shaking was emphasised, along with the need to consider seismic response in addition to wind and wave loading.

The main takeaway was that DONISIS should build on, rather than replace, established local practice and recent findings from recent research initiatives such as MIDAS, ACE and ACE 2 – to mention a few. Its role is to provide stronger evidence and validation specifically for large diameter monopiles, reduce

unnecessary conservatism where possible and support seismic design methods that are technically reliable, economically proportionate and suitable for certification.

SESSION 2 – DONISIS PROJECT OVERVIEW

Purpose

Session 2 presented the DONISIS research programme and explained how the project links fundamental soil behaviour to practical engineering design. The programme follows the **CO.PH.FE.E.** methodology, combining **C**onstitutive modelling, **P**hysical modelling, **F**inite **E**lement modelling and **E**ngineering model development. Together, these activities aim to understand the governing mechanisms of seismic soil–monopile interaction, generate benchmark experimental evidence and translate this understanding into practical design tools.

Discussion and takeaways

The discussion highlighted the complementary role of the four work packages. Constitutive modelling addresses irregular cyclic loading, stiffness degradation, damping, pore-pressure generation and liquefaction at the soil element scale; centrifuge testing provides controlled benchmark data soil–foundation–structure response; finite-element modelling enables detailed interpretation of these mechanisms; and engineering models seek to translate this knowledge into tools suitable for routine offshore wind design. Early physical-model evidence also highlighted the importance of capturing the dynamic behaviour of the complete system, including higher vibration modes.

Participants emphasised that the value of the research will ultimately depend on how convincingly these modelling levels are connected. Detailed numerical and physical models are essential for understanding and validation, but they are too computationally intensive for routine application across entire wind farms. DONISIS should therefore establish a clear pathway in which experimental observations and high-fidelity simulations are used to calibrate and verify simpler engineering models, with transparent assumptions, limitations and range of applicability.

SESSION 3 – CERTIFICATION ROUNDTABLE: TRANSLATING RESEARCH INTO STANDARDS AND GUIDANCE

Purpose

The purpose of Session 3 was to examine how DONISIS findings could be translated into engineering practice, certification and future industry guidance. Certification bodies, developers, designers and researchers reflected on how new seismic methodologies can maintain sufficient flexibility for innovation while providing the consistency, transparency and evidence required for confidence in design outcomes.

Discussion and takeaways

A central conclusion was that the offshore wind industry does not necessarily need a single approved seismic analysis method. Different modelling approaches can be acceptable provided their assumptions, calibration, validation, limitations and applicability are clearly demonstrated. Participants therefore supported a **performance-based framework** built around minimum technical requirements, traceability, model qualification, verification and transparent management of uncertainty rather than prescription of particular software or constitutive models. Particular attention was devoted to the identification of soil damping during seismic motion, which remains an important uncertainty, as well as

to avoiding the accumulation or “stacking” of unjustified conservatism across soil, seismic and structural analyses.

The discussion also supported a staged approach to modelling: use physical testing and advanced numerical analysis to understand key mechanisms, calibrate practical engineering models against this evidence, apply simplified models during iterative design, and use higher-fidelity analyses for verification where appropriate. Certification bodies stressed the importance of traceability from site data through model parameters to design decisions and encouraged continued engagement throughout DONISIS. Participants also noted that application in markets such as Japan will require region-specific considerations to account for local soils, seismic conditions, standards and regulatory practice rather than direct transfer of approaches from established markets.

SESSION 4 – CURRENT GAPS AND INDUSTRY NEEDS: BRIDGING INDUSTRY AND ACADEMIA

Purpose

The final session considered what is still needed to convert advances in seismic soil–structure interaction research into methods that can be used efficiently in commercial offshore wind projects. The discussion focused on the remaining gaps between academic research, site characterisation, numerical modelling, engineering workflows, certification requirements and project delivery.

Discussion and takeaways

Participants agreed that the main challenge is no longer simply developing increasingly sophisticated analysis tools but determining which physical mechanisms must be captured and translating this knowledge into robust and usable engineering methods. Centrifuge testing was recognised as particularly valuable for understanding complex mechanisms and validating numerical and simplified models, but not as something that should be required for each commercial project. Where available, field observations and monitoring of operational structures should complement physical and numerical models, helping determine whether research findings reflect actual site and seismic conditions. Higher-mode response and tilt caused by combined wind and seismic loading in liquefied soils also require further investigation, as first-mode analysis alone may not adequately capture the seismic behaviour of highly dynamic offshore wind turbines.

The session further emphasised that increasing model complexity does not automatically reduce uncertainty. Ground variability, limited site information and uncertainty in local soil behaviour may dominate the reliability of predictions. Participants therefore supported matching model sophistication to the quality of available evidence and using the simplest validated method capable of representing the behaviours important to the design decision. Continued collaboration between researchers, developers, designers and certification bodies was considered essential to convert emerging knowledge into transparent, validated and practical methodologies.

Overall workshop takeaways

The workshop demonstrated broad agreement that improved seismic design of monopile-supported offshore wind turbines should focus on **reducing uncertainty rather than simply increasing model complexity**. Offshore wind requires methods that recognise its distinct structural dynamics and soil–structure interaction, while remaining practical for large-scale commercial design. Validation, damping,

liquefaction, higher-mode response, site characterisation and localisation to regional conditions remain important areas for development.

The strongest overall message was that DONISIS should help establish a **transparent, performance-based pathway from research evidence to engineering application**. Physical testing, advanced numerical modelling and simplified engineering methods should be connected through clear calibration and validation procedures, while certification bodies should remain engaged as the methodology develops. This provides a route towards reducing unnecessary conservatism, improving confidence in seismic design and supporting safe and cost-effective offshore wind deployment in earthquake-prone regions.

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Published in the UK: 2026.