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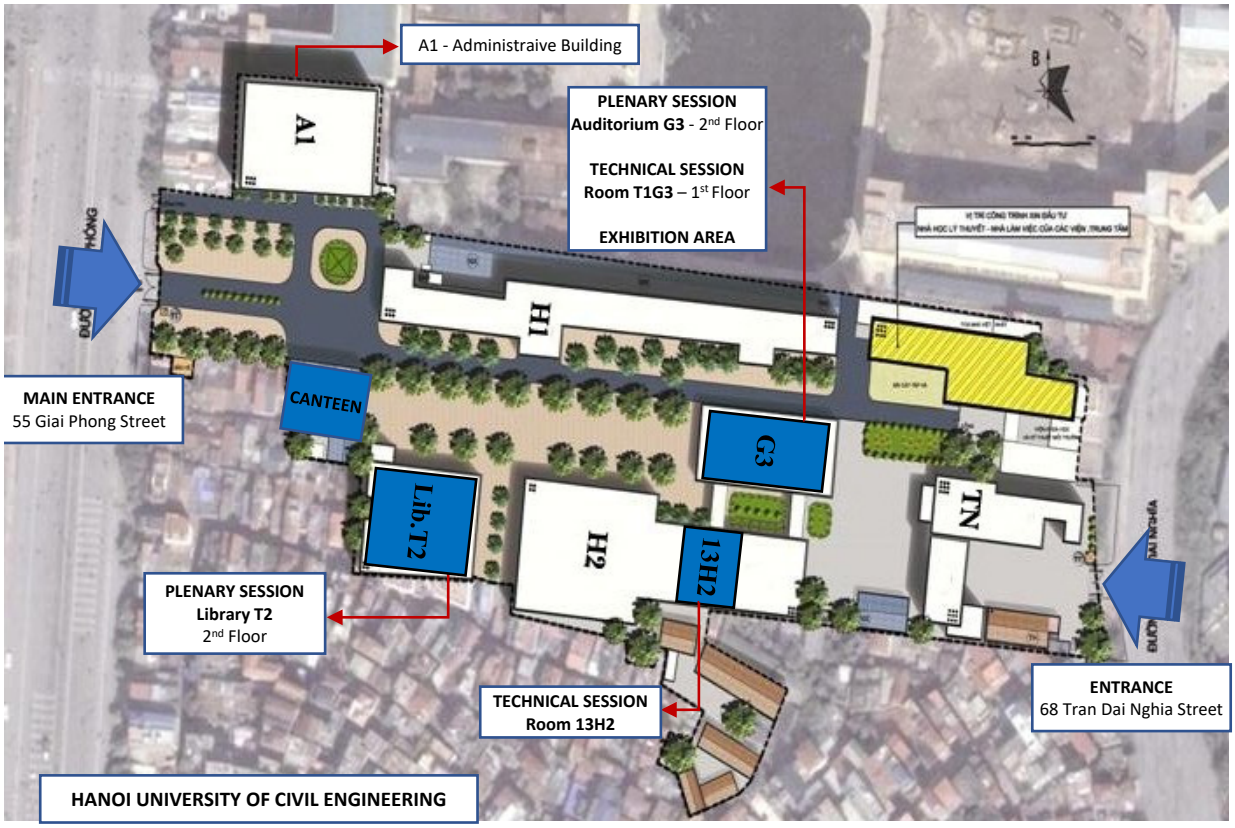

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Keynote Lectures

(Thursday, 9:00 – 12:10 ; Auditorium G3 ; KL1 & KL2)

Global Trends and Challenges to Offshore Wind Energy in Vietnam

G.A. Abdelghany and C. Guedes Soares*

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Abstract. Vietnam has experienced a sharp rise in electricity demand in recent years, driven by rapid industrialisation and economic growth. In response, the country has prioritised energy security and sustainable energy expansion to counter the depletion of fossil fuels and address the looming threat of climate change. The country's renewable energy sector has seen notable progress, particularly in offshore renewable energy, which is becoming a key focus for Vietnam, leveraging its extensive coastline and abundant wind and marine resources. This overview examines Vietnam's offshore renewable energy potential, primarily focusing on wind energy while considering solar, wave, and tidal energy as complementary sources. Special attention is given to offshore wind energy, which holds significant potential for contributing to Vietnam's energy diversification and sustainable development objectives. This overview examines the potential of floating wind energy in Vietnam, highlighting its economic and environmental advantages, its capacity to address the nation's increasing energy demands, and its role in advancing sustainability objectives, enhancing energy security, alleviating land-use pressures, and supporting climate goals. The potential and future outlook of wave and tidal energy in Vietnam and the available technological advancements are also presented.

Keywords: Offshore wind energy; Floating Solar energy; Vietnam

Supply Chain Innovations for Offshore Renewable Energy

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Abstract. In the context of the rapidly developing global offshore wind energy sector to race towards net-zero emissions, an increasing number of offshore wind projects are being constructed with breakthrough advancements in turbine technology, transmission technology, and construction technology. Offshore wind energy has become a potential market segment but also fiercely competitive for investors, manufacturers, and technical service providers worldwide. Only companies that quickly adapt and proactively organize their supply chains will have an advantage. The article presents several development directions for offshore wind technology and the most important issues in the supply chain to successfully develop an offshore wind project. It also discusses the opportunities and challenges for technical service providers in this industry. The vision, potential, and preparations of PTSC in general and PTSC M&C in particular for transitioning from the offshore oil and gas market to dominating the offshore wind energy market.

Keywords: Offshore Wind Energy, Supply Chain Innovations, Technical Service Providers

An Overview of Recent Advances in Offshore Data Acquisition and Processes

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Abstract. Technology has advanced over the years and the pace has escalated recently with the growing use of artificial intelligence and machine learning. This, in turn, has raised the expectations of the stakeholders in many industries. We need to embrace advanced technology in new dimensions, adopt digitilisation transformation and provide innovative solutions while creating systems that are environmentally sustainable in offshore industries.
The world is facing population growth (projected population 9.8 billion by 2050), increased urbanisation, and global warming. Hence the world needs to address UN sustainable development goals and energy trilemma (availability, affordability, and sustainability). We have only one PLANET for people and nature. There is no viable alternative. The future cannot be just about more, it must be about better.
This paper provides an overview of recent advances in offshore data acquisition and processes, and changes in mindset in offshore markets especially the energy and water sectors. Understanding Geo-data is the key to planning, constructing, and operating any structure on earth. A few cases will be used to illustrate the need to serve more sophisticated clients by providing innovation solutions, namely (1) a holistic approach towards integrating Geo-data from various disciplines, (2) a Geo-data platform, VirGeo®, and (3) remote operations and robotics.

Keywords: Digitalization Transformation, Innovative Solutions, Sustainable Development, Energy Trilemma.

Can data science help us make better geotechnical decisions?

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Abstract. Geotechnical knowledge of the seabed is typically limited to specific locations that are either sampled or probed. Engineering judgement is required to deduce (interpolate) the likely variability between known locations, and in some instances to extrapolate to adjacent locations – with this process of interpolation/extrapolation introducing a level of uncertainty that needs to be addressed in foundation design. The TIDE Research Hub at UWA is investigating the use of statistical and machine learning models, as well as database informed interpretations, to predict ground conditions at unseen locations with defined uncertainty – which can be used (for instance) to guide decisions on whether to carry this uncertainty through to design, or to conduct additional (targeted) investigation that may lead to more cost-effective outcomes. This presentation will provide an overview of the work to date, including the development of preliminary predictive tools and identification of next steps towards their use on future offshore projects.

Keywords: Data-Driven Approaches, Machine Learning Models, Statistical Modeling, TIDE Research Hub

Invited Lectures

(Friday, 8:30 – 11:00 ; Library T2 ; IL1 & IL2)

Artificial Intelligence in Offshore Infrastructure

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Abstract: Artificial Intelligence (AI) was developed based on the concept of working procedures of human brain. In AI, dataset is required to develop the model. AI acquire knowledge from data for any physical phenomena. Hence, no assumption is required for the development of AI. In this article, various AI techniques {(Deep Learning(DL), Random Forest(RF), Recurrent Neural Network(RNN), K Nearest Neighbour(KNN), Decision Tree(DT), Classification and Regression Trees(CART), Logistic Regression(LR), Histogram-based Gradient Boosting(HGB) and Naive Bayes(NB)} are adopted to solve the various problems of offshore infrastructures. Various examples will be given to show the working procedures of AI models in different fields of offshore infrastructure. Participants will know the use of MATLAB for development of different AI techniques. The practical application of various AI will be discussed in the field of offshore infrastructure. This article also gives the advantages of various AI techniques.

Keywords: Artificial Intelligence, Wind Energy, Neural Network.

The Green Reuse of Dredged Marine Soils in Civil Engineering Works

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Abstract. Dredging is a necessary process for the maintenance of shipping channel depths and port facilities access. It is also carried out in the development works of marine infrastructure, primarily to create safe navigation route for teh vessels. Sediments removed from the seabed, termed dredged marine soils or DMS, are destined for disposal, either inland or in offshore containment. While various measures are introduced to minimize the negative impact of dredging on sea lives and marine ecosystem in general, less is being directed at managing the DMS for second lives. Categorised as a geo-wastes, DMS are generally considered a soil of poor engineering qualities, i.e. low strength, excessively compressible, long term excess pore water dissipation leading to consolidation subsidence, as well as potentially tainted with contaminants with high human risks. As such, it follows that the materials require special characterisation and pre-treatment prior to being reused, especially for applications in close contact with human beings. Starting with a description of the emergence and history of dredging, the lecture then unfolds the dredging procedure and machinery involved, followed by outcomes of DMS characterisation study with a discourse on the geo-parameters examined. Next concise accounts of the research works being conducted in the past decade with DMS from Malaysian waters are presented. With the specific aim of giving second lives to the otherwise geo-wastes, summarised findings from the related experiments and field measurements are discussed, illustrating the latent potential of DMS in various civil engineering applications, especially as sound geomaterials for backfilling and reclamation projects.

Keywords: Dredged Marine Soils, Backfill, Drainage, Contamination, Reclamation, Landfills.

Advanced SPH framework for coupled large deformation and soil-structure interaction in offshore engineering

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Abstract: Coupled flow deformation analysis and soil-structure interaction are critical in many geophysics and offshore engineering applications. Accurately modelling large deformations and soil-structure interactions in these settings remains a considerable challenge due to the complexity of soil behaviour under varying and extreme loading conditions. Traditional mesh-based methods, such as the finite element method (FEM), face significant limitations, particularly in scenarios involving large deformations. FEM-based approaches often suffer from severe mesh distortion in large deformation analysis, making it difficult to capture post-failure behaviour and the evolving geometries that occur in complex offshore engineering operations, such as spud can penetration, anchor embedment, and pile installation. To overcome these challenges, the Smoothed Particle Hydrodynamics (SPH) method has been recently introduced and shown to be a promising approach for coupled large deformation and soil-structure interaction in offshore geotechnical applications. In this talk, we will discuss our recent attempts to advance the SPH method to address these complex applications. Key advancements in constitutive modelling and numerical techniques are presented, offering enhanced capabilities for tackling challenging offshore engineering problems.

Keywords: Soil-Structure Interaction, Large Deformation Analysis, Smoothed Particle Hydrodynamics, Offshore Geotechnical Engineering.

Mass stabilization solution for soft marine clay soil and dredging mud improvement apply into Vietnamese coastal projects

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Abstract: In recent years, coastal infrastructure in Vietnam has seen significant investment to support economic development, improve living standards, and combat climate change. However, several issues have arisen in practice, such as dealing with soft marine clay soil, dredged mud disposal, and shortages of construction materials. This presentation aims to introduce shallow mixing technology and the author's innovative research to provide an effective solution to these problems.

Keywords: Mass Stabilization, Soft Marine Clay, Shallow Mixing Technology, Dredged Mud Improvement.

Advances in Offshore Geoscience and Geotechnics

(Thursday, 13:30 – 15:00 ; Room T1G3 ; S1R1)

Digital Twins for Intelligent Operation and Maintenance of Floating Offshore Wind Turbine Infrastructure on MODENERLANDS

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Abstract. This study proposes a pioneering approach to the operation and maintenance (O&M) of floating offshore wind turbine (FOWT) infrastructure on MODENERLANDS through the application of digital twins, boosted by advanced Artificial Intelligence (AI) techniques. The escalating challenges of maintaining FOWT structures, exacerbated by harsh marine environments and dynamic forces, demands a shift towards more intelligent and predictive O&M strategies. AI-enhanced digital twins are used, creating a dynamic and responsive model that copies the real-time state of FOWT infrastructure, thereby facilitating a proactive approach to O&M. By synthesising real-time data acquisition, advanced analytics, and predictive modelling, the AI-enhanced digital twins offer a substantial improvement over traditional corrective maintenance method. The digital twins allow for the identification of potential failure modes, prediction of deterioration progression, and recommendation of timely maintenance actions. The case study focuses on the MODENERLANDS project, employing the DTU 10MW reference turbine as a prototype to demonstrate the effectiveness of digital twins in optimizing the lifecycle management of FOWT infrastructure. Multi-physics simulations, informed by site-specific environmental data and material test results, are utilised to predict structural responses and assess corrosion fatigue (CF) deterioration states. The integration of these simulations with a probabilistic CF model enables a comprehensive evaluation of the structural health of FOWT towers and supports the development of refined adaptive control strategies aimed at minimising O&M costs while maximising operational durability and reliability. The research output not only highlights the potential for significant advancements in FOWT O&M but also sets a new benchmark for intelligent infrastructure management in the civil engineering sector.

Keywords: Floating Offshore Wind Turbine (FOWT); MODENERLANDS; Deterioration; Digital Twins; Artificial Intelligence (AI); Operation and Maintenance (O&M).

The role of multi-objective optimization for digital twins in geotechnics

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Abstract. Digital twins (DT) present a paradigm shift in how engineers construct and interact with a digital model. Due to material variance complexity in making reliable forward predictions, the implementation of DT in geotechnical engineering lags the other fields. To address these challenges, new standards, guidelines, and methodologies need to be developed specific to geotechnical engineering. Recent advancements in the application of multi-optimization (MOO) algorithms have demonstrated the possibility of achieving optimal design solutions having considered various design performance and economic objectives in geotechnical design. This contribution explores the use of MOO in the context of DT in geotechnical engineering. The use of MOO in a DT model can deliver an optimal set of model parameters tailored to the geotechnical design. The integration of a multi-objective design approach in a DT model framework simplifies the decision-making process at the early stages of a project where any design change is still highly effective and cost-efficient to implement.

Keywords: Digital twin, multi-objective optimization, machine learning

A Data-Driven Approach on the Cyclic Effects on Shaft Capacity of Axially Loaded Offshore Piles

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Abstract. This paper describes an automation tool designed for the quantitative assessment of cyclic loading effects on the shaft capacity of axially loaded pile foundations, commonly used in fixed offshore structures such as wind turbines, substations, and O&G platforms. The tool, developed using Python programming language, relies on a well-established database of cyclic testing results encompassing various soils and drainage conditions. The cyclic effects, whether cyclic degradation or cyclic densification, are quantified based on the cyclic loads mobilised as a result of the push-pull mechanisms of axially loaded piles and cyclic interaction diagrams interpolated for given cyclic stress levels. The practical application of the tool is demonstrated using a case study involving a piled 4-legged jacket foundation installed in typical North Sea conditions. The results show the capability of the tool to offer a robust, engineering-based (data-driven) assessment, often yielding predictions less conservative than those assumed through a gross factor. Notably, this rapid-response tool is particularly well suited for early-stage design phases where advanced numerical analyses are not yet justified and a site-specific cyclic soil database is unavailable. In the detailed design phase, if required, the results from this tool can serve as guidance for more complex and time-consuming studies. The tool has been successfully employed in a number of projects at DORIS UK.

Keywords**:** Offshore geotechnics, cyclic loading, axial pile capacity.

Numerical simulation of the installation of monopiles driven under static load

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Abstract. Monopiles are widely used for offshore wind turbines with diameters up to 10 m and weight of more than 2000 Mg. A safety and efficient installation of this kind of super-large steel open-ended pipe pile is crucial, especially for commonly encountered complex geological conditions, during which pile running or refusal may happen. To study the interaction between soil and monopile, a sophisticated three-dimensional Large Deformation Finite Element (3D-LDFE) model is constructed with the technique of Coupled-Eulerian-Lagrangian (CEL) approach with ABAQUS software. This model was first verified against the field observation on a monopile's installation in an offshore wind farm located in the Yellow Sea of China, which shows the relatively good agreement between measured and calculated blow counts. The development of soil resistance on the shaft and tip of the monopile is retrieved and investigated, which shows that the soil resistance during monopile penetration is mainly from the shaft as the penetration depth increasing, and a higher resistance is developed on the inner side of monopile tube.

Keywords: Monopile installation, Coupled Eulerian-Lagrangian (CEL) approach, Soil-monopile interaction, Static load.

Design concepts for the geotechnical verification of offshore foundations based on cyclic laboratory test results

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Abstract. With the rapid development of the offshore wind industry, a number of foundation solutions are widely used for offshore wind turbines and platforms. The main loading regime of these foundations in offshore areas is the cyclic lateral loading from wind and waves. The paper summarizes different approaches to the analysis of cyclically loaded foundations - especially those based on cyclic laboratory test results. This is linked to the recent development of the offshore wind industry, especially related to the foundations of offshore wind turbine generators. Examples for different concepts are given and the fields of application are described.

Keywords: Design Concepts, Pile Design, Cyclic Loading, Laboratory Test

Field observation on soil core developed in steel pipe piles driven with vibratory hammers

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Abstract. Steel pipe piles are widely used by various structures, such as bridges, ports, offshore oil and gas platforms and offshore wind turbines, etc. Vibratory hammers working as an efficient and silent tool are increasingly used for bridge construction in city areas, as well as for noise reduction required habitat for wildlife, like Cetacea, dolphins, and sea turtles. However, in-situ test results show that vertical bearing capacity fails to reach the design value for some steel pipe piles driven with vibratory hammers. Further observation and investigation indicate that the force developed at the pile tip is relatively small and heavily dependent on the degree of soil plug in the pipe. To address this, studies have been conducted through full-scale field tests on steel pipe piles driven with resonance-free vibratory hammers in Shanghai area, China. This paper focuses on the soil core developed in the steel pipe piles driven in the clayey site interbedded with sandy soil layers. Field observation and penetration tests show that the degree of soil plug is extremely low, which should be considered during the design of steel pipe piles driven with vibratory hammers.

Keywords: Soil Core, Steel Pipe Piles, Vibratory Hammers, Field Tests.

Interpretative Framework of a Robotic CPT P-Y Module for Direct In-situ Measurements of Undrained Clay Behaviour

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Abstract. Current industrial design of offshore single- or multi-pile foundations highlights the critical role of accurately assessing soil properties for the development of lateral load-displacement (p-y) springs. Conventional CPTs, as one of the most widely used site investigation tools over last 50 years, have been used to infer strength and stiffness parameters for p-y springs, despite the use via empirically derived correlations. To improve the speed of site investigation and the data quality for supporting the design of laterally loaded piles, the ongoing collaborative research project 'ROBOCONE' has implemented a robotic cylindrical module that fits in a CPT shaft and is capable of horizontal translation – referred to as p-y module – which allows the soil to be probed through the application of kinematic mechanisms and strain histories. This paper sets out an interpretive framework that showcases how the p-y module can measure directly the key mechanical properties of undrained clay, i.e., undrained shear strength and elastic shear modulus. A systematic series of finite element analyses were carried out for deriving the lateral bearing and stiffness factors that vary with the roughness of soil-structure interface and the p-y module geometry. These research outcomes also provide a basis for determining the optimal geometry of the p-y module for use in clay.

Keywords: CPT p-y module, Lateral bearing factor, Stiffness factor, Undrained Clay

Use of Xgboost in Offshore Geotechnical Engineering Applications

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Abstract. This paper investigates the application of machine learning techniques to a selection of offshore geotechnical engineering problems which in current industry practice is typically addressed using empirically calibrated analytical models. The specific problems covered herein are the estimation of the soil's small strain shear stiffness from CPT data, the assessment of soil resistance to driving and the assessment of required installation pressure for suction bucket foundations. Among the several machine learning algorithms available, those belonging to the gradient boosting family were selected, as they can be effectively trained with the relatively small field datasets typically available in offshore engineering. When validated against field evidence, gradient boosting returned higher or comparable accuracy with respect to the industry standard approaches, in all the applications investigated.

Keywords: Machine Learning, Geotechnics, Foundations.

Advances in Offshore Geoscience and Geotechnics

(Thursday, 13:30 – 15:00 ; Room 13H2 ; S1R2)

Case History: Development of a Methodology to Study Marine Gassy Clay Behavior

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Abstract. Due to a gas emanation event in the Gulf of Mexico in 1998, a platform shook for approximately 4 hours. As a result, a desk study and a site characterization program were conducted in 2002 to evaluate the geological conditions and mechanical properties of the foundation soils. On the results was found that there are certain areas with shallow gas pockets, and in some of them, it was noted that shallow gas accumulations increase their size and number through time. It also identified some areas where the gas seeps into the water column. It was also observed that the clay was saturated with gas, or some parts of the clay strata contained a high volume of gas, recognizing that the clay could also contain gas. A methodology was developed to try to understand how the clay was saturated with gas. This article focuses on the methodology developed to study marine clay with gas and some of its results, in which it is shown that depending on the application of the load and consistency, marine clay may have a slightly higher resistance to higher gas content.

Keywords: Shallow gas, gassy soils, clay behavior, consolidation.

Assessing the Quality of Silty Sand Samples: A Case Study

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Abstract. The geotechnical site investigation strategy for the development of an offshore wind farm - which often comprise more than 100 wind turbine generators (WTGs) - employs a combination of both *in situ* testing and sampling boreholes for classification and advanced laboratory testing. The piezocone cone penetration test (CPTu) is the main investigation tool and is conducted at each WTG foundation location to facilitate location-specific foundation designs. As such, a robust correlation between CPTu parameters and engineering properties needs to be established based on results of laboratory testing performed on high-quality samples. The effects of sampling on the triaxial behaviour of transitional soils have not been reported in the literature to the same extent as for clays. This paper explores the use of the gel-push (GP) sampler to retrieve intact specimens of transitional soils to guide and inform the widely accepted practice of specimen reconstitution in the offshore industry – due to the difficulty in sampling in these types of soils. An onshore test site was selected because it provides more control on the operational procedures during sampling and *in situ* testing. Sample disturbance was assessed by comparing shear wave velocity measurements from seismic CPTu with values measured in laboratory tests. Triaxial tests were performed on intact and reconstituted specimens to evaluate the effects of fabric and structure on the constitutive response. The analyses show that the shear wave velocity of GP samples agree well with seismic CPTu measurements, indicating that the retrieved specimens are of good quality. In contrast, the intact and reconstituted specimens exhibited dilatant and contractive behaviour, respectively, during triaxial testing indicating the importance of testing specimens mimicking the *in-situ* fabric and structure.

Keywords: Geotechnical Site Investigation, Gel-Push, High-Quality Sampling, Sample Disturbance, Offshore Wind.

On The Automated Calibration Of Elastoplasticity Constitutive Model: The Hardening Soil

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Abstract. In this article, the modified Hardening Soil model which is implemented in GEO5 FEM software with the Matsuoka-Nakai failure criterion and a modified stiffness dependency on the mean stress to mitigate the problem of stress rotation with the original Hardening Soil model is discussed. A calibration scheme is presented which identifies values of all parameters of the model. The calibration is based on analysis of laboratory data containing compression and triaxial shear tests and prioritizes the physical meanings of each parameter and utilizes an optimization of the objective error function where advantageous. The calibration is currently implemented in the free-to-use online application ExCalibre. Example of calibration results for sand specimen is presented.

Keywords: Hardening soil model, calibration, ExCalibre

Development of an ABAQUS-Python simulation model of offshore caisson

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Abstract. The caisson foundation has developed into a viable substitute foundation for offshore structures, particularly for offshore wind turbines (OWT). These OWT caisson foundations experience a combination of lateral loads, vertical loads, and overturning moments. An accurate response detection to horizontal loads guarantees the effective operation of these foundations. Due to the significant costs and time constraints associated with experimental techniques, coupled with the restricted utilization of working conditions, finite element approaches have demonstrated efficacy as an analytical means to evaluate foundations' failure and displacement mechanisms. The development and verification of the finite element model to simulate the lateral load-bearing properties of the caisson foundation used in offshore wind turbines are described in this study. This study automates the simulation and data extraction using ABAQUS-Python, making it easier and faster. The experimental data from the literature was used to validate the developed numerical model. The automation procedure and simulation matrix are discussed in detail.

Keywords: Offshore Wind Turbines; Caissons; ABAQUS-Python; Simulations

Effect of Saturation Degree on The Soil Behavior Under Offshore Structures Subjected to Cyclic Loading

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Abstract. In recent years, with the increasing appearance of coastal constructions, numerous studies have concentrated on the behavior of sands under dynamic loading. Soil liquefaction is considered a phenomenon that can cause major impacts and damage with a consensus emerging that soils with less than full saturation can undergo liquefaction. Many studies have shown that reducing saturation can minimize the liquefaction potential of soil and therefore, studying the liquefaction phenomenon of unsaturated soil has attracted great attention. However, there remains a need for systematic investigations to gain a deeper understanding of this phenomenon. In this research, experiments were conducted to examine the mechanical response of sand to cyclic loading and the residual strength following liquefaction under monotonic loading. All samples were prepared using the wet tamping method, followed by measurement of the Skempton parameter B to assess saturation levels. Subsequently, sample consolidation and cyclic loading were systematically carried out. The findings indicate a direct correlation between liquefaction susceptibility and sample saturation degree, with emphasis on the relationship between cyclic stress ratio and Skempton's parameter.

Keywords: Liquefaction, Sandy soil, Unsaturated, Skempton's parameter B, Cyclic loading

Advanced High-Resolution Measurements of Surface Waves and Currents Using Two Land-Based HF Radars for Offshore Operations

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Abstract. This paper presents the installation and resulting dataset in the offshore area of the Binh Thuan province, which has the highest wind energy potential in Vietnamese waters. Two land-based HF radars were installed from November 2022 to November 2023 to measure the surface parameters of waves and currents. The 16 MHz HF radar system provided a measured coverage of up to 30 km x 50 km offshore. A dataset with spatial resolutions of 1.5 km every 30 minutes was achieved. In addition, the comparison of parameters measured by the HF radar system and AWAC was presented. The sea was rough in the winter due to the strong NE monsoon. The average wind speed was almost over 10 m/s of the measurement time. The maximum wave height was over 4 m in January and February 2023. The surface current speed in offshore areas was over 100 cm/s and decreased to the shore. The sea is calm in the summer due to the weak SW monsoon. The average wind speed was about 7 m/s. The average significant wave height was about 1 m. The mean surface current speed was about 30 cm/s, and its maximum value was smaller than 80 cm/s. An extensive coverage measurement like this is needed for offshore exploitation or surveying the potential for renewable energy.

Keywords: HF Radar, wave measurement, current measurement.

Support Structures for Fixed Wind Turbines in Harsh Environments Like Offshore Vietnam

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Abstract. The design and installation of support structures for offshore wind turbines in regions prone to severe weather conditions, such as Vietnam, where typhoons are frequent are critical. The need for robust design strategies that can withstand extreme wind and wave loads is emphasized. A review of different types of fixed support structures, including monopiles, steel space frames, and concrete foundations, while considering the challenges of installation, soil conditions, and cost is carried out. The study highlights the importance of selecting appropriate support structures to extend the water depth limits for fixed wind turbines to 100 meters, thereby enhancing the feasibility of offshore wind projects in Vietnam. The logistical and economic aspects, such as the availability of installation vessels and the potential for local fabrication, are crucial for the successful deployment of offshore wind farms in harsh environments.

Keywords: Offshore wind turbines, Fixed support structures, Typhoons, Mono-towers, Steel structures, Concrete support structures.

Standards, Challenges and Achievements on Design of Offshore Wind Turbine Jacket and Monopile Foundations

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Abstract. Vietnam is considered to be one of potential countries for offshore wind energy development and offshore wind foundation design is one of important tasks contributing to success of a wind farm project. However, offshore wind industry is new in Vietnam and the country has not yet released standards and guidelines supporting this work. To partly address this shortage, this paper makes a review on international standards and industrial practices as well as design related issues of jacket and monopile offshore wind turbine foundations, which have been the most two popular solutions applied in the real wind farms all over the world. The latest achievements and challenges about structural and geotechnical design of these foundation types are also discussed in this paper.

Keywords: Offshore wind standards and guidelines, offshore wind turbine jacket foundation, offshore wind turbine monopile foundation.

Foundation Engineering and Subsea Technologies

(Thursday, 15:30 – 17:00 ; Room T1G3 ; S2R1)

Vertical and lateral capacity of a monopile in layered soils using 3D finite element analyses

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Abstract. During the initial design phase of a monopile foundation for offshore wind turbines it is necessary to estimate its vertical capacity and more importantly the lateral one, together with its initial stiffness from the relevant response curves. In this paper, the vertical and lateral capacities of a large diameter monopile passing through a loose sand layer and penetrating a dense one are evaluated. 3D Finite Element (FE) pushover analyses were conducted using two different constitutive models, namely the advanced SANISAND and the standard linear-elastic perfectly-plastic model with a Mohr-Coulomb failure criterion. Soil properties like the shear modulus and friction angle were matched in both sets of analyses, while additional parameters required for SANISAND were adopted from previous literature. It is shown that the vertical and horizontal response obtained with the constitutive models above were in a fair agreement, thanks to the proper calibration of the constitutive parameters. Nonetheless, some discrepancies arose in the vertical response of the soil-monopile system, which may be attributed to the different formulation of the plastic volumetric strains in the constitutive models.

Keywords: Monopile, capacity, loose sand, 3D Finite Element Analyses.

Cyclic Lateral Response of a Pile Group Embedded in Offshore Cohesionless Substrata with Inclined Layer Interface

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Abstract. In the marine environment, pile foundations supporting the near offshore structures are often subjected to continuous lateral cyclic loads originating from the ocean waves along with the loads from superstructure. Offshore piles are often bored or driven deep in to the seabed passing through uniform or undulating layers of soft loose sand or compressible clays. Accordingly, their lateral responses are governed by complex soil-pile interaction. In conventional approach, soil strata are considered to have multiple parallel soil layers of uniform thickness. However, in this study, the soil layer interface is considered to be inclined which intersects the pile axes at different depths depending on their position within the group. 3D finite element method is used to model this complex soil-pile interaction and lateral behaviour of a 3×3 pile group, bored in a substrata comprising two cohesionless layers distinguished by an inclined interface. To simulate the wave-loading, a low-frequency two-way cyclic load is applied on the pile-heads. The lateral displacement is observed to be higher for a steeper inclination of the interface. When subjected to cyclic loading, the cohesionless soil tend to densify around the pile and the required number of cycles for the densification is found to be influenced by the interface inclination as well. The *p-y* curves highlight that the cyclic response of the pile group depends on the position of the piles within the inclined layering of the off-shore foundation soil bed as well as the direction of loading on the pile group.

Keywords: Pile group, Lateral response, Cyclic loading, Offshore cohesionless substrata, Inclined layer interface

Foundation Integrity: Effect of Improved Soil Lateral Capacity to Structural Dynamic Response of Offshore Platforms

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Abstract. Design and reassessment of pile supported offshore platforms requires realistic determination of the soil-structure interaction. For dynamic and push-over analysis, the lateral capacity of the soil is typically the most critical interaction. With new development in laterally loaded pile design methods, reassessment of platform Inplace, dynamic and pushover analyses were performed using conventional Matlock P-Y method in comparison to the NGI-PETRONAS (2014) and Jeanjean et. al. (2017) P-Y methods for offshore Malaysian soils. A selection criterion was established to ascertain which platforms were to be studied using the various P-Y methods. These methods resulted in different structural behaviour to the modelled platform structure performance which has online monitoring data used to measure actual natural periods. This paper summarises the different results of the dynamic response of the platform due to the various P-Y methods in relation to the different types of selection criteria of soil types, water depth and platform configuration. The newer NGI-P and Jeanjean methods contribute to improved global performance in pushover analyses. These P-Y methods used for reassessment of existing structures provide justification for more effective underwater inspection program.

Keywords: Lateral Soil Capacity, Platform Reassessment, Dynamic Response.

Prediction of Long-term Cyclic Response of OWT Foundations with a Modified p-y Modeling Approach

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Abstract. To assess the long-term performance of Offshore Wind Turbines (OWTs), this study proposes a modified p-y analysis approach to predict the response of monopile foundations under cyclic loading conditions. Cyclic loading can induce soil degradation and pore pressure buildup in marine soils, leading to reduced soil stiffness and strength. The proposed approach incorporates these effects by adjusting the traditional p-y curves using p-multipliers and y-multipliers. These multipliers are determined based on the soil reaction calculated from the p-y analysis and empirical models for cyclic degradation and strain accumulation.

Keywords: p-y analysis, long-term cyclic loading, stiffness degradation, strain accumulation.

Lateral Resistance of Monopiles in Clayey Soils: Effects of Strength Anisotropy, Strain Rate and Strain Softening

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Abstract. In clayey soils, the response of a monopile subjected to lateral loads can be influenced by strain rate dependency, strain softening, and strength anisotropy. Strain softening, where shear strength decreases with increasing shear strain, can lead to larger deformation, reduced stiffness, and decreased ultimate capacity of the monopile. Conversely, high strain rates typically result in increased stiffness and strength, whereas low strain rates reduce these properties. Additionally, effects of strength anisotropy can modify the load distribution and overall response of the monopile. This paper uses large deformation finite-element (LDFE) analyses combined with the user-defined material model NGI-ADPSoft to investigate the impacts of strain softening, strain rate, and anisotropic strength on monopile behavior. Preliminary LDFE results indicate that these factors could have a substantial impact on monopile resistance. Moreover, the results suggest that the effect of loading rate on pile capacity can be approximately predicted by a linear relationship between the pile's lateral resistance and the logarithm of the normalized penetration velocity.

Keywords: Large Deformation Analysis, Monopiles, Lateral Resistance, Clays, Strength Anisotropy, Strain Rate, Strain Softening.

Foundation damping model for monopile foundations supporting offshore wind turbines

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Abstract. Foundation damping holds significant potential for reducing the loads for large-diameter monopile-supported offshore wind turbines (OWTs). However, understanding the contribution of foundation damping is hindered by a lack of accurate methods for assessing it. Recently, a novel approach has been introduced, proposing a convenient mapping relationship between the soil-pile interaction damping at the *p-y* spring level and the soil damping at the element level. However, this model, based on a flow-around mechanism of the soil surrounding the pile, is specifically tailored for long slender piles typically used for offshore oil and gas platforms and small megawatt OWTs, thereby limiting its applicability for large-diameter monopiles, where the soil around the monopile primarily reacts in a wedge failure along the upper part of the pile. To address this limitation, this study investigates the relationship between foundation damping and damping at the soil element level within the region governed by the wedge failure mechanism using 3D Finite Element Analysis (FEA). Through comprehensive parametric analyses, the mapping coefficients are calibrated, and a foundation damping model tailored for large-diameter monopiles is obtained.

Keywords: Damping; Monopile; Wedge failure; OWTs.

Numerical Modelling of Multidirectional Loading on Piles in Soft Clay

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Abstract. In the search of approaches to reduce costs in the deployment of offshore wind farms utilizing floating systems, multiline anchors present a viable alternative by reducing the number of anchors and installations required. As part of the research objectives of ShareWind project, this study introduces a workflow for conducting numerical simulations that apply multidirectional loads, simulating the convergence of three mooring lines onto a single pile anchor installed in soft clay. Utilizing OpenSees, the numerical model is first calibrated against centrifuge test data for piles under monotonic and cyclic loads. Subsequently, a series of numerical analyses were performed applying variable amplitude load sequences and considering seabed inclination conditions. The research concludes with a suite of numerical simulations that impose loads characteristic of a floating wind turbine, thereby simulating the convergence of three mooring lines onto the pile anchor. The findings present a modeling framework for this specific load condition, which could be instrumental for other researchers and practitioners in the field.

Keywords: Anchors, Piles, Clay, Shared Anchors, Multiline Anchors

Macro-Models for Anchor and Chain-Soil Interaction in Floating Offshore Wind Analyses

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Abstract. The development of floating wind turbines requires precise analysis of the mooring system's response. Previous methods were unable to fully capture the coupled interaction between anchor, chain, and seabed in the integrated analysis of floating wind turbines. This paper presents a numerical formulation to evaluate the dynamic interaction among the seabed, anchors, mooring lines, floating support structure, and a full-scale floating wind turbine. The anchor-chain-seabed interaction is modeled using macro-models, which represent the non-linear relationship between incremental displacements and soil reaction forces along the mooring line in contact with the seabed. This approach also describes the interaction between the seabed and two specific types of anchors-suction caisson and fluke anchors-based on the macro-model framework. By incorporating these macro-models into simulations of the dynamic response of floating wind turbines, uncertainties in anchor design can be minimized. Furthermore, this approach allows for optimization of the mooring system design by accounting for seabed influence, ultimately reducing overall costs. This model also enables efficient evaluation of seabed trench formation resulting from repeated mooring line movements. An example is provided to demonstrate the application of this integrated analysis method for floating wind turbines, highlighting the necessary parameters for implementation.

Keywords: Anchor, Chain, Seabed, Clay, Mooring System.

Foundation Engineering and Subsea Technologies

(Thursday, 15:30 – 17:00 ; Room 13H2 ; S2R2)

End Bearing Capacity of Pile on Crushable Soils Considering Packing Density Effect

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Abstract. Crushable soils, such as calcareous and volcanic soils, present challenges to offshore infrastructure due to their weak grain structures that are prone to breakage under load. Although various studies have explored pile behavior in these soils, the specific impact of packing density on end-bearing capacity remains underexplored. This study employs an advanced constitutive model integrated into finite element analysis using Plaxis 2D to examine the role of packing density in pile performance. Numerical simulations across different densities and confining pressures reveal that higher packing density increases end-bearing capacity, though this effect diminishes with increasing confining pressure.

Keywords: Crushable soils, Pile end-bearing capacity, Packing density, Offshore infrastructure stability.

A mechanistic understanding of interface shear behavior of cohesionless materials using torsional ring shear test

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Abstract. The torsional ring shear test is widely employed to assess soil-pile interface friction angle, which is influenced by factors such as soil gradation, particle morphology, surface roughness, and stress state. A comprehensive understanding of the physical mechanisms governing interface shear behavior of granular soils, such as sand, is essential for offshore soil-structure applications. This study investigates the effects of normal stress, surface roughness, and particle shape on the residual interface friction angle using natural sand particles and synthesized glass beads as an idealized granular material. A wide range of surface roughness values (spanning two orders of magnitude) and normal stresses (10–50 kPa) were selected to identify transitional effects and underlying mechanisms. Results revealed a critical normalized surface roughness where the residual friction angle approaches the internal friction angle. Glass beads, characterized by higher sphericity and smoother surfaces, exhibited lower interface friction angles than sub-angular sand particles. As surface roughness increased, a transition from sliding to rolling motion in the granular particles likely occurred. An empirical relationship was proposed to predict residual interface friction angles, accounting for particle size, normal stress, and interface roughness.

Keywords: Ring shear test; Surface roughness; Cohesionless soils; Interface friction angle; Residual shear strength.

Dynamic Analysis of Offshore Free-Span Pipelines Laying on C-phi Seabed Soil

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Abstract. An offshore pipeline often has many free-span formations; it mainly occurs due to entrenched marine pipes being laid on an uneven seafloor of the seabed, wave flow scouring or residual stress of the pipeline. The determination of the fundamental natural frequency of the free-span offshore pipelines is an important part of the dynamic analysis them. The fundamental natural frequency impacts the design of an offshore pipeline; thus, determining the fundamental natural frequency is crucial. A free-span pipeline natural frequency depends on pipeline geometry, seabed soil characteristics, the property of transporting material, etc. This paper deals with the effect of C-phi seabed soil (mixed soil) characteristics on the fundamental natural frequency. In this study, silty clay with sand seabed has been considered, which is referred from Sheyang Offshore Project in Yancheng City Jiangsu Province China. A generalised analytical method, already developed by the author, has been used for the analytical study. The numerical study is conducted by using commercial FEM software ABAQUS for validation purposes on a homogeneous seabed soil. Finally, natural frequency analysis has been performed, and a comparison of results has been provided in this paper. It has been found out that generalised analytical method gives the natural frequency of the free span pipeline without compromising any accuracy. This analysis also shows that free span pipelines rested on the silty clay with sand seabed soil gives higher natural frequency than stiff clay soil but lower than very stiff clay soil.

Keywords: Fundamental natural frequency; Free-span; *C*-phi seabed soil; Numerical and analytical method.

Static Loading Tests on Auger Cast Piles in Texas Gulf Coast Region

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Abstract. A static loading test program was conducted on auger cast piles in the Texas Gulf Coast Region to evaluate their bearing capacity in expansive soils. The tested piles, with a diameter of 24 inches, were installed to depths of 60 and 85 feet below the existing ground surface. The design loads for the piles were 93.5 tons and 207 tons for the 60-foot and 85-foot depths, respectively. Fifteen days after pile construction, static loading tests were performed, with maximum test loads ranging from 2 to 4 times the design loads. Analysis of the test results, correlated with the undrained shear strength of the expansive soils, suggests an α coefficient of approximately 0.38 for the auger cast pile shaft resistances in expansive soil., which is about 1.5 to 1.8 times less than the α coefficient for conventionally drilled shafts.

Keywords: Auger Cast Pile, Static Loading Test, Expansive Soils, Shaft Resistance, α Coefficient

Simulation of Static Liquefaction Taking into Account the Uncertainty of Soil Parameters

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Abstract. Static liquefaction is a phenomenon where internal pore water pressure tends to increase while effective stress decreases to zero, leading to soil structure breakdown when static loads are applied. This phenomenon can happen to soil on the seabed when an earthquake occurs. Many studies have been conducted to better understand the behavior of the ground in these situations; however, there are still points that have not been clarified. This study uses the NorSand model to analyze static liquefaction in the Hostun sand RF. The experimental data are used to determine the model input parameters, which are then applied to build a triaxial model to simulate the experimental tests. Furthermore, the study examined the impact of relative density uncertainty on soil liquefaction, which is an I ssue that has not been clarified in the literature. The model predictions suggest a possible critical value for relative density beyond which soil structural degradation does not occur. Finally, the NorSand model provides a theoretical foundation for the design of structures while considering the uncertainty of soil parameters.

Keywords: Static liquefaction; NorSand model; Uncertainties; Saturated loose sand; Triaxial undrained test

On optimization of gravity retaining wall considering the dimension of the stone base

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Abstract. Gravity retaining wall is an essential structure widely used in civil engineering, roadway, highway construction, breakwater, and coastal protection. However, the dimensions of this structure are still determined based on experience and safety, leading to a surplus of building materials. This paper presents the optimization of gravity retaining walls using Swarm Intelligence algorithms. This research studies the case of a stone masonry gravity retaining wall. A complex step cross-section wall laid on a stone base is proposed. The objective function is based on the cost proportion of the stone masonry part and the stone base, while the constraints are chosen based on the geometry constraints of the structure, the bearing capacity of the materials, and the overall stability of the retaining wall as well as the foundation. Especially the role of the stone base is first time considered.

Keywords: Gravity retaining wall, Optimization, Swarn Intelligence, Stone base, Stone masonry retaining wall.

Reasonable calculation method of the pile stiffness for the piled raft foundation design

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Abstract. Recently, the piled raft foundation has been widely applied in Vietnam. Determination of suitable pile stiffness is one of the most important problem in the piled raft foundation design. This paper presents the analysis and comparison of methods for calculating the pile stiffness. The analytical calculation methods and experimental methods are used to study the pile stiffness. Results of analytical method are compared each other and with the results of the pile load test which is considered as an accuracy method. Research results on the pile stiffness show that Tsutovic method gives results that are closest to the results of pile load tests in the field (from 9.5% to 23.7%), this difference margin is smaller than the other methods. Therefore, this is the recommended method when calculating the pile stiffness. The recommended average difference coefficient between the above two methods has been proposed. Then, it is possible to predict the pile stiffness according to the pile load tests in the field based on the results of Tsutovic method. In addition, in the simulations of piled raft foundation using the finite element method, no matter how large or small the cross-section of a pile is, the pile is usually simulated by one spring in the calculation model. This simulation is not reasonable because it ignores the cross-sectional size of the pile. This does not reflect the nature of the actual working process of piled raft foundations. With large projects, the difference can be significant. To provide a reasonable method when simulating piles using the finite element method, this study conducted simulations of large diameter piles using different options for evaluation and analysis. From the studied results, the conclusions and the proposals are presented for the pile stiffness determinations.

Keywords: pile stiffness, pile load test, piled raft foundation, analytical method, finite element method.

Pile Foundation Engineering in Vietnam: An Overview of Recent Advancements

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Abstract. This paper presents an overview of the recent developments in pile foundation engineering within the Vietnamese context. The review focus is on the three key directions: (i) The development for analyzing bi-directional static load tests, using data specific to the unique geotechnical conditions prevalent in Vietnam. It aims to refine and advance existing techniques, tailoring them to the distinct characteristics of the region. (ii) An exploration of the load-bearing characteristics between super-long large bored piles and barrette piles. It seeks to understand the performance and behavior of these two foundation types by focusing on their distinctive features and influencing factors. (iii) An investigation into the transformative potential of machine learning in shaping the landscape of pile foundation engineering, as well as the framework for constructing valuable research in machine learning techniques, as furnished by real-world field data derived from the diverse terrains of Vietnam. In essence, this paper seeks to provide researchers and practitioners with a roadmap for appreciating the potential of machine learning in enhancing the efficacy and precision of pile foundation studies.

Keywords: Machine Learning Applications, Bi-directional Static Load Tests, Vietnamese context

Foundation Engineering and Subsea Technologies

(Friday, 13:30 – 15:00 ; Room T1G3 ; S3R1)

Random Fatigue Analysis to Assess Sustainability for Mooring Systems of Semisubmersible Offshore Structure in Vietnamese Sea Condition

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Abstract. During exploitation, offshore floating structures are subjected to random loads with repeating cycles that may occur the fatigue in the mooring lines. That can be one of the important causes of incidents for offshore floating structures while exploiting oil and gas as well as exploiting renewable energy. Random fatigue analysis for mooring systems of floating offshore units in general and mining semisubmersible platforms in particular is a complex problem and has an important significance in ensuring the sustainability of these structures. The fatigue damages assessment for mooring lines of offshore floating structures is a nonlinear random problem, which cannot use the deterministic analysis method with conventional S-N fatigue curves as for fixed offshore structures. Therefore, the paper focuses on the methodology of the fatigue damages assessment problem for mooring system using nonlinear random dynamic tension simulations of mooring lines in time domain under the effect of annual statistical sea states. From there, the T-N fatigue curves for mooring lines are studied and the "Rainflow" method is applied to count the cycles of tension expressions in the mooring lines. Finally, the Palmgren-Miner rule is applied to calculate the accumulated fatigue damages and the fatigue life for mooring systems. In the numerical simulation section, the paper conducts the fatigue analysis to assess the sustainability for the mooring system of FPU DH01 semisubmersible platform at Dai Hung field, in the South of Vietnam Sea.

Keywords: Random Fatigue Analysis, Mooring Systems, Offshore Floating Structures, Sustainability, Semisubmersible Platform.

Influence of Rectangular Opening Layout in GFRP-Reinforced Concrete One-Way Slabs Strengthened with CFRP Sheets

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Abstract. The use of fiber-reinforced polymer (FRP) materials to enhance the durability of reinforced concrete (RC) structures in demanding conditions has been well-established. However, the incorporation of openings in FRP-reinforced slabs, while offering architectural advantages, poses challenges to maintaining structural integrity. This paper takes a numerical approach using finite element method (FEM) to investigate the performance of concrete one-way slabs with openings reinforced by glass fiber-reinforced polymer (GFRP) bars and strengthened with carbon fiber-reinforced polymer (CFRP) sheets. The study examines two principal influencing factors, including the opening size and position, which considerably affect the load-bearing capacity of slabs and the effectiveness of CFRP strengthening. The findings of this research have practical implications for the design and construction of RC structures with openings, particularly in terms of optimizing the opening layout to ensure structural integrity.

Keywords: One-way slab, GFRP reinforcement, CFRP sheets, Opening size, Opening position.

Segmentation of Concrete Surface Cracks Using DeeplabV3 and DeeplabV3+

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Abstract. Monitoring damage in concrete structures is essential for maintaining their integrity. Utilizing computer vision is crucial for achieving precise and quantitative monitoring. Recent advancements have integrated computer vision with deep learning, particularly convolutional neural network (CNN) models. CNNs are known for their accuracy and adaptability in various contexts. They have been designed for pixel-by-pixel image classification, specifically for pixel-level detection, which is particularly effective for identifying and categorizing damage with high detail. In practical scenarios, environments are often complex with many non-concrete elements. Therefore, this study aims to use pixel-level CNNs to detect damage on concrete surfaces. The research uses DeepLabV3 and DeepLabV3+ architectures for concrete crack segmentation. These models are evaluated and compared based on specific metrics and prediction outcomes. The results indicate that DeepLabV3 slightly outperforms DeepLabV3+ with Intersection over Union (IoU) values of 0.936 and 0.924 on the testing set, respectively. However, DeepLabV3 requires significantly more training time than DeepLabV3+. These findings demonstrate the practicality and effectiveness of these models for segmenting concrete cracks.

Keywords: Semantic segmentation, concrete crack, DeepLabV3, DeepLabV3+, deep learning.

Fast Evaluation of Crack Propagation Using Artificial Neural Network

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Abstract. This paper presents a machine learning (ML) method to study crack propagation issues in fracture mechanics and correlates the results with experimental and numerical data. The main goal is to accurately predict crack propagation in engineering fracture structures without the need for re-modeling or re-computation. The approach employs an artificial neural network (ANN) to predict the crack propagation in a fuselage panel under constant amplitude mode, an ADB610 steel specimen with a stress ratio of 0.3, and an L-shaped concrete specimen under load ratio. Based on the optimal parameters learned by the model from the dataset, a trained ANN is used to predict crack propagation quickly without any other analytical tools. The effectiveness and accuracy of the method are verified by comparing the results obtained from the ANN model with the results from the numerical method or experimental data. The predicted results show well-agreed with experimental data and numerical data.

Keywords: Crack Propagation, Artificial Neural Network, Machine Learning, Fracture Mechanics.

Layout Design of Prefabricated Vertical Drains using Differential Evolution and Artificial Neural Networks

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Abstract. Prefabricated vertical drains (PVD) are widely used in Vietnam for the improvement of soft soils. This article presents a methodology to predict the most efficient arrangement of PVD through a two-stage process. Initially, the differential evolution technique is employed to determine the best layout of PVD. Subsequently, this optimal information is used to train and evaluate an artificial neural network (ANN) model. The relationship between the outcomes indicates the feasibility of utilizing ANN to design an effective PVD system, considering variables such as the elapsed time, the degree of consolidation, and the embankment height.

Keywords: Prefabricated vertical drain, optimal design, artificial neural network, differential evolution.

Numerical Analysis of Vacuum Consolidation: a Case Study in Viet Nam

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Abstract. Recently, the vacuum preloading method has been used as a popular improvement method in Vietnam. In this paper, the improvement work by the vacuum consolidation at the new urban of Thu Thiem is presented and analyzed. The project is located in the Ho Chi Minh City of Viet Nam, which has a thick layer of soft clay. The behaviors of vacuum-induced consolidation process have been analyzed by the finite element method via the Geo-Studio Suite software. The simulated results were close to the monitored settlement, lateral displacement, and excess pore water pressure. The further analysis of settlement showed the degree of consolidation by vacuum pumping as compared with fill preloading method. Moreover, the effects of the sand seem layer on the vacuum consolidation process were studied. From the studied results, the conclusions and the proposals are presented for the soft ground improvements by the vacuum preloading method at the new urban of Thu Thiem, Ho Chi Minh City, Viet Nam.

Keywords: Vacuum consolidation, conventional preloading, soft soil, finite element method.

Optimal Intensity Measures of Ground Motions for Probabilistic Seismic Demand Models of Shallow-Founded Buildings in Liquefiable Granular Soils Considering Duration Effects

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Abstract. In traditional earthquake-resistant design, peak ground acceleration (*PGA*) has been recognized as an important measure for evaluating earthquake- induced damages and assessing seismic risk of structures and ground deposits against natural hazards. However, it has become evident that PGA's correlation with engineering demand parameters (EDPs) is relatively weak. As a result, this study first performs nonlinear dynamic analysis of shallow-founded buildings in liquefiable granular soils based on the effective stress analysis-based code, namely LIQCA3D. Sixty records of seismic motions are collected from the PEER NGA-West 2 database and chosen with various characteristics, such as moment magnitude (M_w), rupture distance (R_{rup}), Arias Intensity (I_A), cumulative absolute velocity (*CAV*), and significant duration ($D_{s5\text{-}75}$). Secondly, this study explores the relationship between many well-established single and compound IMs and EDPs of shallow-founded buildings, i.e., buildings settlements and tilts. Finally, the study proposes the most appropriate IMs for effectively predicting EDPs and developing probabilistic seismic demand models (PSDMs) for shallow-founded buildings in liquefiable granular soils. The analytical findings reveal that cumu- lative absolute velocity (*CAV*) and sustained maximum velocity (*SMV*) are found to be the optimal single IMs, showing a high interrelation with settlement and tilt of buildings, respectively. However, recently developed compound IMs, such as $CAV^{2/3}\times D_{s5\text{-}95}{}^{1/3}$ and $SMV\times D_{s5\text{-}95}{}^{1/3}$, surpass the single IMs (i.e., *CAV* and *SMV*) in exhibiting the strongest correlation with earthquake-induced building settle- ment and tilts, accordingly.

Keywords: Shallow-founded buildings, Effective stress analysis, Optimal intensity measures, Strong ground motions.

Seismic Response of Shallow-founded Buildings in Liquefiable Granular Soils subjected to Long Duration Ground Motions

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Abstract: In earthquake-resistant design, spectral matching techniques have traditionally been used to consider the amplitude and frequency characteristics of ground motions. However, it is crucial to highlight that the effects of duration have not received enough attention in designing buildings on liquefiable soils. Recent research has shown that the duration of ground motions markedly impacts structural responses, playing a crucial role in assessing potential damage to buildings. Therefore, this study explores the effects of ground motion duration on the seismic response of shallow-founded buildings on liquefiable granular soils. Nonlinear dynamic analyses based on the effective stress approach are conducted to capture dynamic the responses of buildings. Furthermore, an advanced constitutive model is employed to effectively capture the stress-strain relationship of both liquefiable and non-liquefiable granular soils under cyclic loading. Numerical results clearly demonstrate that shallow-founded buildings experience greater settlement and tilting when subjected to longer-duration ground motions. Overall, the authors' findings indicate that the duration of strong ground motions is of utmost importance and exerts a substantial influence on the seismic response of structures located in liquefiable soils.

Keywords: Shallow-founded buildings, Long-duration ground motions; Effective stress analysis.

Offshore Wind Energy: Vietnam's Challenges and Global Trends

(Friday, 13:30 – 15:00 ; Room 13H2 ; S3R2)

Dredging for Offshore Energy: Construction of Large Artificial Islands for Energy Resources Exploitation in the Arabian Gulf

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Abstract. The construction of artificial islands in the Arabian Gulf region has gained significant prominence due to the booming real estate sector and its substantial benefits across various industries, including oil and gas. A prime example the use of artificial island in oil exploration project in UAE, recognized as the first in the region to utilize artificial island technology as an alternative to traditional steel jack platforms. This ambitious project involves the construction of four artificial islands strategically located within the oil field in UAE, one of the world's largest oil fields. The water depths in these locations range from 7 meters to 15 meters. The selection of these specific sites was based on careful consideration of several critical factors, including reservoir plans, existing production facilities, seabed bathymetry, and metocean and geotechnical conditions. This paper provides a detailed analysis of the engineering principles behind the design and construction of these islands, the construction techniques employed, and the materials used to ensure their durability and functionality in the challenging marine environment of the Arabian Gulf. The construction of these islands has involved the mobilization of more than 100 marine vessels and includes approximately 25 million cubic meters of land reclamation, which requires improvement using vibro-compaction techniques. Additionally, the project entails the construction of revetments and breakwaters using around 14 million tonnes of rock and 285,000 cubic meters of concrete armor units, as well as the creation of mini harbors involving the construction of about 1,720 meters of quay walls (approximately 88,000 cubic meters of concrete).

Keywords: Artificial Island, Dredging, Reclamation, Improvement, Revetment, Breakwater, Quay Wall.

Rehabilitation of Mangrove Ecosystem for Hai Phong Coastal Protection

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Abstract. Mangrove forests play a significant role in stabilizing coastal regions, preventing flooding, and providing great potential for sedimentation. Our recent field trip revealed that the mangrove forest was being destroyed at an unprecedented alarm rate and that portions of Hai Phong Beach were eroding quickly. In locations at Do Son Beach, mangroves have even disappeared. It appears that the vegetative belt is insufficient to "trap" sediment on the shore. The abundant healthy vegetation that protects the shore from erosion should, in theory, be residence to a diverse range of living plants and animals. The wider the mangrove forest can be, the stronger the ability to accumulate shore. However, a minimum mangrove belt width is necessarily investigated for flood protection and coastal accretion. Rehabilitating the vegetation in front of the sea dike and identifying the minimum mangrove width by modelling simulation are the main objectives to give Hai Phong Province sufficient resilience against flooding. The research carried out a couple of models SWAN-SWASH, taking SS- and IG-waves into account to simulate wave attenuation by vegetation for three different coastline regions. The critical range of the mangrove width is found from 400 m to 700 m.

Keywords: rehabilitation, mangrove width, numerical model, IG-waves

Towards Robust Climate Projections: A Multi-Model Ensemble of GCMs using Hybrid Multi-Criteria Approach for Offshore Wind Assessment

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Abstract. Offshore wind energy has the potential to significantly alter the energy mix of a nation. However, like other renewable energy sources, the power generated from offshore wind farms is susceptible to the impacts of climate change. Therefore, conducting critical assessments before installing offshore wind farms is crucial. Climate model data are proven valuable for evaluating offshore wind potential at specific sites or regions and assessing their susceptibility to climate change. The accuracy of these evaluations, however, depends on the biases presented in the climate models. This study aims to develop an effective ensemble approach to more accurately assess India's offshore wind potential. Two types of multi-model ensembles were created using ten CMIP6 global circulation models (GCMs). One ensemble, termed the differential weighted ensemble, assigns different weights to the GCMs. These weights are computed using various multi-criteria decision-making techniques. The other ensemble assumes equal weights for all GCMs. These ensembles were compared against data from the ECMWF reanalysis v5 (ERA5). The results indicate that the differential weighted ensemble outperforms the uniform weighted ensemble with higher overlapping percentage, lower bias, and better K-S test results, making it a more reliable approach for offshore wind resource assessments and climate change studies.

Keywords: CMIP6, Weighted Multimodal ensemble, offshore wind speed, MCDM, GCMs.

Assessing the Potentials of Offshore Wind Energy in Hai Phong

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Abstract. While offshore wind farms are a global reality, Vietnam remains untapped in this renewable energy sector. Hai Phong, a city experiencing rapid economic growth, faces increasing electricity demands. This study assessed the wind energy potential of Hai Phong's offshore area by measuring at 10 meters. The data at 10 meters then was extrapolated to get data at 100 meters using meteorological data and semi-empirical formulas. Results indicate significantly higher average wind energy density offshore compared to coastal areas (1.36 times at 10 meters). At 100 meters, average wind energy density fluctuates substantially (2,927 to 22,108 W/m²) with a notable difference between monsoon seasons (2.04 times higher in the Southwest monsoon than the Northeast one). This preliminary investigation seeks to evaluate the potential of Hai Phong's sea wind as a resource, laying the groundwork for comprehensive research initiatives in the future.

Keywords: Wind, Energy, Offshore

Unveiling Future Offshore Wind Potential: A Multi-Criteria Framework for Sustainable Development

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Abstract. Climate change poses a risk to the human societies and environment, encouraging a shift towards clean energy sources. Among these sources, offshore wind energy emerges as a favorable solution, due to its steady and strong wind resources, coupled with mature technology. Establishing offshore wind farms requires substantial financial investment. However, uncertainties induced by climate change may not only impact the cost-effectiveness of offshore wind farms but also influence the suitability of regions for their development. Therefore, the present study presents a novel framework for identifying optimal regions for offshore wind farms by considering future projections under the various Shared Socioeconomic Pathway (SSP) scenarios. A weighted multi-model ensemble (MME) of ten CMIP6 climate models was considered. Offshore wind energy resource are classified based on resource richness, stability, risk, and economic viability. Criteria Importance Through Intercriteria Correlation (CRITIC) method is used to assign weights to each factor, offering insights into their influence on wind resources. The findings reveal that projections for the SSP2-4.5 and SSP5-8.5 scenarios show that the western and northeastern offshore regions within the study areas have emerged as the top-ranking regions due to their abundant wind energy resources and favorable stability, risk and economic factors. By employing a novel methodology, this study produces suitability maps that identify promising wind regions for future development, providing important information for long-term planning in India's offshore wind sector.

Keywords: Offshore wind energy; Climate change; Multi-model ensemble; MCDM techniques; CMIP6 climate models

Investigating Renewable Wind Energy Using Electromagnetic Energy Harvesting from Aeroelastic Instability

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Abstract. This paper presents an evaluation approach for wind energy harvesters based on annual wind velocity measurements. The proposed method facilitates the selection of an optimal device tailored to specific wind conditions. The research was conducted on two harvester designs: one utilizing a double magnet configuration and the other using Halbach arrays. Five types of wind velocity distributions were examined to assess maximum power production. The Rayleigh distribution was employed in the analysis for wind velocities ranging from 3 m/s to 7 m/s. Measurements of energy production, energy production density, and annual energy production highlighted the suitability of the harvesters under consideration. The modified Halbach array, where the tip mass was reduced by altering the support of the magnet and coil, proved to be the most effective compared to the original design and the double magnet configuration. The novelty of the proposed approach lies in its ability to evaluate the productivity of various wind harvesters, enabling the selection of the most effective energy producer.

Keywords: Energy harvester, power production, electromagnetic, wind-induced vibrations.

A Realistic Approach to the Sustainable Use of the Offshore Environment in the Vietnamese Sea

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Abstract. Vietnam has abundant offshore resources that must be developed in an integrated way to ensure that the total solution represents a sustainable and commercially attractive offshore infrastructure. The paper discusses the following themes:
• Of main concern is resource-managed fisheries; catching fish at a rate where the fish population is kept for future generations.
• Recently, Vietnam has developed offshore oil and gas fields. This activity has brought in funds that have been used to invest in the future. The most efficient way to use gas is to generate electricity for industrial activities. The country should continue to develop the hydrocarbon potential as the alternative use of coal is much more polluting. Presently the facilities built to handle the gas are lacking gas from the shelf, therefore, it should be considered to continue to import LNG to avoid panic development of other sources of electricity.
• The wind energy potential is large offshore Vietnam. Fixed nearshore wind farms are well suited for Vietnamese waters. It must, however, be recognized that when there is no wind, no electricity is generated. A backup electricity source must be available. To build a sustainable offshore infrastructure, wind turbines must be integrated with fisheries, shipping, and tourism to
• Floating wind turbine technology is under development. However, the technology is at present unproven technology and costs are rising. The wind industry could tap Vietnam for economic resources without contributing substantially to energy needs. A word of warning must be in place.

Keywords: Offshore, Fisheries, Oil and Gas, Windfarms, LNG, Economy.

Conversion of abandoned offshore oil and gas platform jackets into offshore wind turbines: policy initiatives for Vietnam

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Abstract. Decommissioning options for offshore oil and gas structures range from complete removal to partial removal or full retainment for rigs-to-reefs or alternative uses such as tourism, recreation, carbon capture and storage, national defence, or generation of wave or wind energy. In Vietnam, key mature structures will be decommissioned in the coming years, due to the reserve exhaustion. Such retired structures could be repurposed for offshore wind development, while saving significant decommissioning costs for the operator. As mentiond in the National Power Development Plan VIII, offshore wind power is one of the pivotal energy sources for Vietnam to achieve the goal of net zero carbon emissions by 2050, as committed at the 2021 United Nations Climate Change Conference (COP26). However, the country lacks renewable energy laws and regulations at present. Thus, this research aims to explore the policy initiatives that can facilitate the conversion of abandoned offshore oil and gas platform jackets into offshore wind turbines in Vietnam. Particularly, a review of the legal frameworks for oil and gas decommissioning in the UK and for offshore wind development in France will be undertaken, given the comprehensiveness of such frameworks and the experiences of the respective countries in the related fields. Then, policy recommendations will be provided to improve the existing legal framework for oil and gas decommissioning in Vietnam, for instance, to develop a technical regulation or guidance for converting abandoned offshore oil and gas platform jackets into offshore wind turbines, with consideration of the design criteria for offshore wind turbines.

Keywords: Decommissioning; Offshore Oil and Gas Platforms; Offshore Wind Turbines

Environmental Challenges and Solutions in Offshore Engineering

(Friday, 15:30 – 16:30 ; Room T1G3 ; S4R1)

Scour development around an offshore substation in the Taiwan Strait: Effects in substructure and foundation design

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Abstract. In addition to enduring severe environmental conditions and strong seismic activity, the design of an offshore substation located in the Taiwan Strait must address the technical challenge of scour formation induced by waves and currents. Scour phenomena can occur shortly after the installation of the offshore substation and can persist throughout the operational lifespan of a project if an appropriate scour protection system is not in place. This study focuses on the adverse impacts of scour phenomena and presents an approach to account for scour effects in the design of the substructure and foundation for an offshore substation. It was found that scour can significantly affect pile capacities, the dynamic responses and fatigue lifetime of the substructure, either necessitating larger pile dimensions and heavier steel substructures or a substantial periodic inspection and maintenance schedule. However, scour protection systems are not always cost-effective, depending on site-specific conditions. Therefore, it is essential to consider scour protection strategies at the beginning of the project to fully understand all constraints and optimize the total project cost.

Keywords: Offshore Substation, Scour, Pile capacity, Substructure, Dynamic behavior, Fatigue, Taiwan Strait

Fully Nonlinear Wave and Current Effects on the Dynamic Behavior of Spar-Type Floating Offshore Wind Turbines

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Abstract. This paper explores the nonlinear dynamic responses of a floating offshore wind turbine (FOWT) subjected to the coupled effects of large-amplitude waves and an underlying uniform current. Using a Euler-Lagrangian analytical model, a 5MW OC3 spar-type floating wind turbine is coupled with a nonlinear hydrodynamic mooring model to evaluate structural responses and calculate cable fairlead forces. We demonstrate that the combination of current and large-amplitude waves significantly impacts the FOWT's responses and mooring forces. The coupling load generates larger vertical and horizontal displacements of the FOWT, as well as increased cable forces, compared to scenarios involving only waves or linear waves and current. Additionally, the direction of the current must be considered to ensure accurate results. The analysis encompasses various current direction, allowing for a comprehensive investigation of the relationship between wave conditions and current strength, which can be used to explore the internal mechanisms of the FOWT's responses from various wave conditions.

Keywords: Large-amplitude waves, wave-current interaction, floating offshore wind turbines, nonlinear waves.

Multi-area coverage path planning optimization for vertical oil tank inspection by wall-climbing robot

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Abstract. Vertical cylindrical storage tanks containing oil and gasoline require periodic inspections to prevent structural collapse due to corrosion and stress concentration caused by surface cracks. Wall-climbing robots have been increasingly utilized to overcome the limitations of manual inspection methods, which are often inefficient and struggle to accurately cover large areas. In practice, the tank surface is divided into multiple areas for inspection due to obstacles such as pipes and staircases, or due to the preference of inspectors to focus on specific regions rather than inspecting a continuous large surface. This division poses a significant challenge for optimizing the coverage path, as it requires the robot to efficiently traverse multiple discrete areas. In this study, we propose a global path-planning method to address this issue. The path-planning problem is formulated as an extended version of the well-known Traveling Salesman Problem (TSP) to optimize the route connecting multiple areas. An optimal line-sweep generation algorithm is then employed to generate the coverage path within each area. Finally, an Elitist Strategy Genetic Algorithm (ESGA) is proposed to solve the problem effectively. Computational experiments not only demonstrate the applicability but also the effectiveness of the proposed algorithm.

Keywords: Wall-climbing robot; Vertical oil tanks inspection; Multi-area coverage path planning; Genetic algorithm.

The Variation of the Lateral Density Gradient during Flood Tides in a Shallow Estuary

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Abstract: This paper examines the distribution of lateral density gradients within a shallow estuary during a typical flood-neap tide. The investigation utilizes data obtained from three comprehensive Compact Conductivity-Temperature-Depth (CTD) sensor campaigns, which deployed the CTD sensor and other instruments at a strategically chosen bridge crossing in the estuarine region. The outcomes of this study reveal substantial variability in the lateral density gradient values throughout the observation period, albeit demonstrating a consistent overall trend. Remarkably, despite significant density fluctuations, the lateral density gradient remains relatively stable. The data analysis reveals a strong connection between the salinity and lateral distribution of the density gradient, with the density gradient identified as the main contributing factor. Additionally, the study reveals that the relaxation of the lateral density gradient is a common mechanism affecting the distribution of lateral salinity. This research enhances our understanding of estuarine dynamics and offers important insights into the factors that shape lateral density gradients and salinity patterns.

Keywords: Density Gradient, Flood Tides, NeapTides, Shallow Estuary, Salinity distribution.

Vermifiltration Coupled with Biofiltration Technology: A Comparative Review for Sustainable Approach to Domestic Wastewater

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Abstract. Vermifiltration with biofiltration technology offers a sustainable solution for addressing domestic wastewater treatment needs. This integrated system combines vermiculture and biofiltration principles to construct an efficient, environmentally friendly option, well suited for smaller-scale applications like households and communities. The potential of this technology in domestic wastewater treatment is substantial, offering cost-effective treatment through natural processes, making it suitable for smaller communities. Treated effluent can be repurposed, conserving freshwater resources. This research addresses two critical environmental challenges: water scarcity in India and the innovative approach of vermifiltration coupled with biofiltration technology in domestic wastewater treatment. In conclusion, vermifiltration with biofiltration technology presents an environmentally sound approach to address water scarcity and wastewater treatment challenges, underscoring the need for tailored water quality standards, reliable water reuse systems, and effective regulatory enforcement to meet growing demands sustainably.

Keywords: Biofilters, Earthworms, Eisenia fetida, Vermifiltration, Wastewater treatment and reuse.

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Enabling Intelligent Multi-Modular Structures for Offshore Solar Energy Harvesting

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Abstract. Solar energy is forecasted to be a major contribution to meeting global energy demand by 2050. Offshore solar platforms offer a promising solution by utilizing abundant areas available at sea, but the high cost and harsh conditions can be a challenge. This paper discusses a novel idea of creating intelligent multi-modular offshore platforms designed to harvest solar energy. The key innovation lies in investigating active control of structural dynamics by using the connection points as actuators, allowing the platform to adapt dynamically to changing sea states. The paper covers three main areas of development: (1) the conceptual modelling of intelligent structures, (2) preliminary simulation and experimental results validating the feasibility of these adaptive connectors, and (3) the exploration of control algorithms for optimal performance. The findings demonstrate the potential of smart structures to revolutionize the construction and operation of cost-efficient offshore solar energy platforms, contributing to the transition to renewable energy on a global scale.

Keywords: Multi-modular, floating solar, modelling, experiments, control.

Infrastructure and Interaction with the Marine Environment

(Friday, 15:30 – 16:40 ; Room 13H2 ; S4R2)

Modeling Punching Shear Behavior of Locally Corroded Reinforced Concrete Slab-Column Connections

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Abstract. This paper undertakes a unique exploration, delving into the effects of reinforcement corrosion on the punching shear (PS) behavior of reinforced concrete (RC) slab-column connections. The study employs a nonlinear finite element (NLFE) model, a widely accepted method for analyzing complex structural behavior, to examine the influence of three key factors, including corrosion degree, concrete compressive strength, and column size, on the performance of corroded slab-column connections. The results obtained show that all three factors have an important influence on the load-bearing capacity of the structure. The findings, which have practical implications for the design and repair of RC structures, reveal that heightened corrosion significantly diminishes the load-carrying capacity of RC slab-column connections.

Keywords: Reinforced Concrete, Slab-Column Connections, Reinforcement Corrosion, Punching Shear.

Effects of bottom roughness on wave overtopping over dike on steep fringing reefs

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Abstract. The steep fringing reefs are mainly formed from plate tectonics and coral growth, with coral rock on the surface layer. These topographic features greatly influence the wave propagation and wave overtopping on steep fringing reefs. However, these effects are practically ignored since only few studies focus on them. In this paper, the impact of of bottom roughness on waves overtopping over dikes on steep fringing reefs are investigated by a physical model. A series of experiments, including 72 tests of complex hydrological dynamics processes, is elaborated with three different slopes, a combination of three water depths and two bottom roughnesses. The results show that the bottom roughness significantly influences the wave propagation process and wave overtopping over the dikes on steep fringing reefs. The lower water depth on the flat reef leads to the greater of bottom effects. As a result, the discharge of wave overtopping is 35% larger when taking into account the effect of bottom roughness.

Keywords: Wave overtopping, steep fringing reef, bottom roughness, wave flume.

REEF3D::CFD model approaching for wave propagation on fringing reefs

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Abstract. Fringing reefs with a steep fore-reef slopes are commonly complex and distinct in shape, bottom roughness and hydrodynamic conditions. Due to different input conditions, simulating the wave propagation process on fringing reefs with large fore-reef slopes is challenging to calculate according to current standards, complicating the design of structures on these reefs. Therefore, this paper proposes a numerical model that simplifies addressing this issue. This paper addresses the issue by employing the numerical model REEF3D::CFD to simulate the wave propagation process on fringing reefs with large fore-reef slopes. REEF3D::CFD is an open-source CFD model capable of simulating the interaction between fluid and terrain, incorporating complex structures based on the RANS equations coupled with a complex free surface modeling using the level set method. The simulation results have been validated with experimental data in the same conditions. A detailed validation of water levels, velocities, and wave parameters at measurement points also shows good agreement with physical model data. The validation results determine that REEF3D::CFD can demonstrate wave propagation on fringing reefs in an accurate and efficient way.

Keywords: REEF3D::CFD model, steep fringing reef, wave propagation.

Wave overtopping reduction by Rakuna-IV blocks placed in front of seawall on fringing reefs

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Abstract. This paper presents an experimental study of wave overtopping reduction by Rakuna-IV blocks placed in front of a vertical wall structure on a fringing reef. The experiment has been carried out in a 2D wave flume, where Rakuna-IV blocks are placed in front of a wave return crest seawall on a 1/100 slope fringing reef and 1/5 seaward slope. In this study, a series of irregular wave conditions in three water depth have been tested. In the results, the Rakuna-IV decrease wave reflections by half and effectively reduce wave overflow from 45% to 67% if there is no presense of the blocks. Next, the experimental data have been used to assess wave overtopping reduction by Rakuna-IV blocks. Last but not least, the influence of the relative crest freeboard, wave steepness, and shallowness of the reef on wave overtopping are presented.

Keywords*:* Wave overtopping, overtopping discharges, fringing reef, Rakuna-IV, physical model.

Numerical Model Approaching for Effects of Turtibility Dispersion Due to Depositing Sediment Activities

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Abstract. Sediment dredging activities in ports have been regularly recognised as a solution to maintain channels for transportation. However, deposited sediments and turbidity due to dredging will harm the coastal environment and ecosystems. In this study, the Mike 3 hydrodynamic models (DHI - Danish Hydraulic Institute) are applied to simulate the turbidity processes from sediment deposition activities in an offshore area near the Nghi Son port, Thanh Hoa province, Vietnam. This study firstly presents a good agreement of water level between the measured and simulated data collected in an offshore station. Further findings in turbidity dispersion plot the sediment concentration field around the disposal site. The deposition area in the North-East monsoon is distributed southward, with a value ranging from 0.01 to 0.4 kg/m³ in a radius of 2.5 km, while the northern region of Nghi Son port is affected by sediment turbidity dispersion with a value below 0.04 kg/m³ in the South-West monsoon. Last but not least, the results give a brief conclusion for the effects of depositing activities and open a new window for future research to evaluate the accuracy of sediment dispersion with measured data.

Keywords: MIKE 3, Sediment Deposition, Sediment Turbidity, Sediment Concentration, Ports.

Delft3D-based hydrodynamic modeling to study the impact of sediment transport on the exposure of the subsea gas pipeline: a case study of the Bach Ho-Long Hai and Nam Con Son 2 Pipelines, southern offshore Vietnam

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Abstract. This study investigates the causes to exposure of the 16A Bach Ho-Long Hai (BH-LH) gas pipeline in a coastal area, Ba Ria-Vung Tau province, Vietnam. A Delft3D numerical model was developed to simulate hydrodynamics, wave propagation, and sediment transport under four simulations scenarios. Historical data on bathymetry, waves, currents, and sediment properties were employed, and the model was calibrated and validated using field measurements. Simulations were conducted for Southwest and Northeast monsoon seasons, before and after construction of the Nam Con Son 2 (NCS2) pipeline to see whether or not construction of this new pipeline has contributed to the exposure of the existing BH-LH pipline. The simulation results revealed that the seabed erosion and pipeline exposure risks of the latter have existed even before construction of the former, particularly during the Northeast monsoon (NEM) season. However, the additional construction of NCS2 pipeline have significantly increased flow velocities and erosion potential near the BH-LH pipeline during the NEM conditions. Maximum erosion depths increased from about 1.0 m to more than 1.5 m after construction of the NCS2 pipeline. The results of the Delft3D-based hydrodynamic modeling in this research could highlight the influence of the sediment transport process on the pipeline exposure and the need to consider properly various adverse factors as well as to have a continuous monitoring and adaptive management in subsea pipeline construction.

Keywords: Hydrodynamic modeling, Delft-3D, subsea gas pipeline construction, sediment transport

Soil Classification and Estimation of Potential Soil Erosion in Mainland Viet Nam Using Improved Rusle Model

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Abstract. Research on soil erosion in agriculture is urgent because it affects soil quality, and agricultural production, and causes environmental pollution. Research and application of science and technology to soil erosion can also contribute to the development of sustainable soil cultivation techniques. Our research aims to address the remaining issues of the RUSLE model [1] in calculating soil erosion levels, errors with actual measurement data, especially the results of erosion and sedimentation calculations, and the complex formulas that make the processing speed slow. We did this by experimenting with different combinations of factors to match the climate, specific properties, and soil composition of the two main landforms in Vietnam, which are mountainous and lowlands. Then, we compared the results with reality to select the optimal combination of factors. The best model is K+C, which produces output results ranging from 13.7 to 674 tons/ha/year and the calculation speed is increased to 1.32 seconds. This is also the desired outcome from an academic standpoint of this research.

Keywords: Climates, Soil Erosion, RUSLE Model, Combinations of Factors, Sedi-Mentation, GIS.