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Editorial

Advances in Marine Engineering: Geological Environment and Hazards II

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1. Introduction

In October 2021, the editorial office invited Prof. Xiaolei Liu, from the Ocean University of China, Prof. Thorsten Stoesser, from University College London, and Dr. Xingsen Guo, from University College London, to serve as guest editors for the special issue titled "*Advances in Marine Engineering: Geological Environment and Hazards*" [1]. Their task was to collect high-quality papers in the field of marine geological environments and hazards, including marine geological environments, marine geological hazards, marine engineering geology, marine hydrodynamics, marine fluid mechanics, and marine geotechnical engineering. As of October 2022, this Special Issue comprised one review paper, one editorial paper, and thirteen research papers, all of which have been compiled into a single journal issue [2]. The success of this Special Issue led to an invitation from the editorial office to extend it until April 2024, with a subsequent Special Issue titled "*Advances in Marine Engineering: Geological Environment and Hazards II*".

As of April 2024, the new Special Issue includes one review paper [3] and fifteen research papers [4–18] that cover different aspects related to the subject. These papers showcase the latest advancements in research, introducing state-of-the-art concepts, sophisticated methodologies, and valuable data. Their collective contributions are poised to significantly advance the development of marine geological environments and hazards. A comprehensive synthesis of the key findings and noteworthy contributions from each paper within this Special Issue is presented in the following section.

2. Papers Details

Chen et al. [3] conducted a comprehensive review of seabed response induced by nonlinear internal waves, providing an overview of the theories, models, and limited observations that have contributed to our current understanding. They highlight that the pressure disturbance generated by nonlinear internal waves results from the combined effects of interface displacement and near-bottom acceleration. Recent observations in the South China Sea have revealed pressure magnitudes of up to 4 kPa, representing the largest known disturbance caused by nonlinear internal waves. During the shoaling and breaking of these waves, intense pore-pressure variations occur in approximately the top 1 m of the weakly conductive seabed, resulting in transient liquefaction and the appearance of pebbles on the local seabed. The review emphasizes the importance of in situ observations to validate theoretical knowledge and enhance our ability to model the multiscale interaction process between the seabed and internal waves in the future.

Alhaddad et al. [4] assessed the efficacy of an empirical evaluation method aimed at determining the trajectory of failure development during breaching. This involved investigating whether the breach would progressively enlarge (destabilizing breaching) or diminish (stabilizing breaching). The researchers conducted extensive large-scale experiments, observing both stabilizing and destabilizing failure modes. They point out significant inaccuracies in existing methods used for evaluating failure modes, revealing an average absolute percentage error of up to 92% in practical applications. Consequently, Alhaddad et al. recommend the adoption of more sophisticated three-dimensional numerical simulation methods to precisely predict stable and unstable modes during underwater slope failure. The outcomes of this study are important to improving the accuracy of safety assessments for underwater infrastructure and flood protection structures.

Jiang et al. [5] conducted a comprehensive investigation into the monotonic and cyclic performance of composite bucket foundations using centrifuge modeling. They subjected the foundations to monotonic loads to simulate extreme wave conditions and cyclic loads to mimic long-term serviceability conditions. Through well-designed experiments, the researchers examined the effects of different loading types, soil strength, and load eccentricities. Their findings elucidated the failure patterns of ocean structures by analyzing parameters such as rotation, displacement, and pore pressure. They revealed that the variation in failure mechanisms is largely determined by soil resistance. Additionally, the researchers discovered an intriguing phenomenon: non-symmetric loading does not impact bucket foundations as severely as symmetric loading. The outcomes of this study are important for controlling the deformation of underwater infrastructure by harnessing deep-soil resistance.

Kan et al. [6] assessed the impact of the physical–mechanical properties of seafloor sediments on sound speed and formulated prediction equations for sediment sound speed based on either single or dual physical–mechanical parameters on the East China Sea shelf. The researchers highlighted that the determination coefficients of the dual-parameter prediction equations for sediment sound speed all exceeded 0.90, surpassing those of the single-parameter equations. This indicates superior predictive performance. The prediction equations developed in this study serve as valuable additions to marine geoacoustic models, significantly enhancing our understanding of the acoustic properties of seafloor sediments on the East China Sea shelf. They hold substantial significance for obtaining accurate acoustic property information in this region.

Li et al. [7] employed a combination of in situ techniques, sediment sampling, and laboratory measurements to gather data on sediment acoustic properties (such as sound speed and attenuation) and physical properties (including particle composition, density, porosity, and mean grain size) in the northwestern South China Sea. Their investigation revealed notable differences between laboratory and in situ measurements of acoustic properties, particularly for shallow-water coarse-grained sediments and deep-sea sediments, with laboratory measurements generally yielding higher values. Building on this observation, the researchers established relationships between measured attenuation and physical properties, as well as between sound speed and mean grain size, which differed from previous empirical equations. Furthermore, their study unveiled significant variations in sediment acoustic and physical properties in the downslope direction, with more gradual variations observed in the along-slope direction.

Li et al. [8] delved into the effects of high temperatures on the microstructure and mechanical characteristics of high-strength fiber composite materials (HSFCM), crucial for understanding material behavior in harsh environments. Through thorough experimentation and analysis, the study revealed the significant impacts of high temperatures on the mechanical properties of HSFCM. Specifically, the material exhibited decreased strength and hardness at elevated temperatures, attributed to alterations in its microstructure. Notably, high temperatures induced softening of the matrix material and failure at fiber interfaces, leading to a decline in overall performance. Moreover, the study investigated the mechanism by which high temperatures affect the microstructure of HSFCM, uncovering distortions in internal lattice structures and grain growth as contributors to structural instability, thereby influencing mechanical properties. This understanding provides valuable guidance for future research into material behavior under extreme conditions.

Meng et al. [9] utilized the horizontal-to-vertical spectral ratio (HVSR) method to evaluate silt liquefaction hazards within the Yellow River Delta and explored its applicability in seismic engineering. Their study revealed a fundamental frequency ranging from 0.8 to 9.8 Hz, with corresponding amplification values ranging from 1.8 to 3.5. Soil characteristics exerted a significant influence on liquefaction susceptibility, with higher vulnerability index values indicating increased potential. Particularly noteworthy were the elevated values observed in the southwestern beaches of the Yellow River Delta, suggesting heightened liquefaction susceptibility in that area. Consequently, it is important to consider the liquefaction potential of sediment deposits in engineering endeavors and assessments of foundation stability. The HVSR method provides a rapid means of assessing liquefaction potential and holds promise for applications in seismic engineering and geology.

Niu et al. [10] introduced novel prediction methods for evaluating the hydrodynamic performance of box-typed free surface breakwater under actual marine wave conditions. They developed an improved viscous numerical wave tank incorporating a mass source wave maker, which demonstrated high accuracy in simulating wave behaviors using computational fluid dynamics (CFD) technology. Their study extensively delineated the wave force characteristics of the box-typed free surface breakwater and identified key influencing factors. These findings are invaluable for enhancing the design and behavior analysis of marine breakwaters.

Sun et al. [11] formulated a predictive model for assessing borehole instability in horizontal wells situated within hydrate-bearing clayey-silt formations. Their research emphasized the optimal azimuthal arrangement of the borehole (60–120°) to mitigate drilling risks. In their paper, they suggested that hydrate dissociation could increase collapse pressure and compromise borehole stability. These insights hold significant implications for drilling operations in hydrate-bearing clayey-silt sediments within the northern South China Sea region.

Sun et al. [12] developed a deep learning model to accurately assess the dynamic changes in the physical properties of seafloor sediments, such as density, water content, and porosity. They utilized both the empirical formula and the deep learning model to map the spatial distribution and temporal variations of these properties in the hydrate test area of the South China Sea over a period of 12 days. Their analysis demonstrated that the deep learning model provided a better fit and more precise predictions compared to the empirical formula. Based on in situ observations within the hydrate zone, they identified a four-layer structure in the sediment's physical properties and explored the potential impact of hydrate decomposition. This study contributes to the monitoring and early warning of changes in seafloor sediment properties, supporting the safety of marine engineering projects.

Wang et al. [13], through systematic experimentation, investigated the bonding strength, shear performance, and tensile strength of HIRA-type materials in various bonding scenarios. Subsequently, they meticulously tracked and observed the development of the material's bonding capability over extended periods. Their observations revealed the resilience of HIRA-type materials in anchoring solids over different time scales, as evidenced by the fluctuation patterns in bonding strength over time. Moreover, through in-depth analysis of the experimental data, they identified patterns indicating rapid changes or persistent increases in material performance at specific time points. These findings are crucial for enhancing our understanding of the material's long-term reliability. The comprehensive experimental data generated by this study serve as essential resources for future maritime engineering structure design endeavors aimed at enhancing stability and safety.

Wang et al. [14] introduced a methodology aimed at evaluating the susceptibility of wave-induced seabed liquefaction, utilizing deterministic analysis and empirical Bayesian Kriging (EBK). This approach integrates the safety factor, determined by combining cyclic stress ratio and cyclic resistance ratio, as key evaluation parameters. It employs EBK interpolation within ArcGIS to delineate the susceptibility of wave-induced seabed liquefaction in a localized study area. In their study, Wang et al. implemented this method in the Chengdao area, calculating safety factors. They subsequently generated wave-induced seabed liquefaction susceptibility maps under 5-year, 10-year, and 25-year wave conditions. These maps facilitated discussions on the engineering geological conditions of the Chengdao area. This methodology offers a quantitative means of assessing liquefaction susceptibility in the study area, providing valuable insights for the selection and maintenance of marine engineering facilities. As such, it holds considerable engineering significance.

Xie et al. [15] proposed a convenient simulation method for the runout simulation of submarine landslides based on the Eulerian analysis technology of Abaqus/Explicit, providing a large deformation calculation method in an explicit finite element scheme. A flume experiment and a simple submarine landslide case were used to validate the proposed model. The simulation results reported in this paper demonstrate good consistency with those of the flume experiment and other widely validated numerical methods. Focusing on the potential mass movements of submarine landslides in the Shenhu Sea area on the northern slope of the South China Sea, the runout process was analyzed under different combinations of soil parameter cases by using the convenient method proposed. The shear strain softening and rate-dependency effects are highly involved in the runout process. The simulated landslide's failure mode is consistent with the geophysical interpretation of existing landslide characteristics.

Xu et al. [16] conducted numerical simulations to confirm the high-speed movement of submarine turbidity currents. They validated the underwater movement dynamics of turbidity currents through laboratory flume experiments and analyzed the propagation speed and amplitude of excitation waves induced by their movement. The aim was to identify the controlling factors and formulate expressions for the propagation speed of these excitation waves. Through extensive numerical simulations across various field scales, the researchers monitored the propagation speed of excitation waves and the resulting changes in surface elevation. Their findings revealed that the propagation speed of excitation waves greatly exceeds the speed of the turbidity current itself, with its magnitude solely dictated by water depth. This research offers a fresh perspective on the rapid movement of turbidity currents in submarine canyons, enhancing our comprehension of sediment resuspension and transport in underwater environments.

Yu et al. [17] investigated the vortex-induced vibration (VIV) characteristics of a riser model tensioned by a buoyancy can, which experiences low-frequency vortex-induced motion. They conducted a series of model tests involving the combined riser model and buoyancy can under uniform flow, regular wave, and wave–current conditions. The researchers employed various methods, such as mode superposition, Euler angle conversion, band-pass filtering, and signal processing techniques, such as fast Fourier and wavelet transforms, to analyze the testing data. By exploring the dynamic interactions between the real structure's environmental loads, dynamic boundary conditions, and riser VIV under different environmental scenarios, the study revealed crucial insights. The authors underscored the importance of considering the dynamic boundary of the platform or vessel motion in VIV fatigue assessments during riser design. This highlights the necessity for a comprehensive understanding of environmental influences on riser performance and structural integrity.

Yu et al. [18] presented a novel testing methodology for investigating soil–structure interaction in marine engineering, aiming to offer insights into the safety assessment of marine structures within the Yellow River Delta. The researchers conducted cyclic shear tests on the steel–silt interface under constant normal load conditions, systematically examining the influence of normal stress, shear amplitude, roughness, and water content on key parameters, such as the interface shear strength, shear stiffness, and damping ratio. Their findings underscored the substantial impact of normal stress and shear amplitude on the shear strength, stiffness, and damping ratio at the interface. Moreover, roughness and water content emerged as pivotal factors shaping the variation of these parameters with the number of cycles. Importantly, the outcomes of this study are poised to provide valuable technical guidance for understanding other forms of soil–structure interactions in marine engineering applications.

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Short Biography of the Authors

Xingsen Guo is a research fellow in the Department of Civil, Environmental, and Geomatic Engineering at University College London (UCL) and a member of the Fluid Mechanics Research Group at UCL since 2020. He obtained his PhD at the Dalian University of Technology (DUT) in 2021. His research mainly concerns marine engineering geology (e.g., surficial sediment and hydrodynamic environments) and geotechnical engineering (e.g., pipeline and pile), marine geological hazards (e.g., seabed stability and submarine landslides), and computational fluid dynamics in turbidity currents and deep-sea mining plumes. He has published over 60 peer-reviewed journal papers (e.g., *Acta Geotechnica*, *Coastal Engineering*, *Computers and Geotechnics*, *Engineering Geology*, *Landslides*, *Ocean Engineering*, and *Physics of Fluids*) and has been recognized with an ESI hot paper, five ESI highly cited papers, and a cover paper. He also serves as a valuable editorial board member for several journals (e.g., *Marine Georesources & Geotechnology*, *FDMP-Fluid Dynamics & Materials Processing*, and *Frontiers in Earth Science*). He has organized four Special Issues in the *Journal of Marine Science and Engineering* and *Frontiers in Marine Science* and served as the Secretary-General of the Marine Geo-disaster and Geo-environment Committee in the ICGdR and the Deputy Secretary-General of the Coastal and Offshore Engineering Disaster and Environmental Protection Committee in the Seismological Society of China. For his research, he was honored with the Geoenvironmental Disasters Best Paper Award in 2024, the BGA (British Geotechnical Association) Poster Award in 2024, the ICGdR Outstanding Young Scientist Award in 2023, the Liaoning Province Excellent Doctoral Dissertation Award in 2023, the 2nd National Postdoctoral Innovation and Entrepreneurship Competition Silver Award in 2023, the JMSE Travel Award in 2023, the ICGdR Excellent Doctoral Dissertation Award in 2022, the Excellent Doctoral Dissertation Award of the Chinese Society for Rock Mechanics & Engineering (CSRME) in 2021, the DUT Excellent Doctoral Dissertation Award in 2022, the BGA Fund Award in 2022, and the Liu Huixian Earthquake Engineering Scholarship Award awarded by the Huixian Earthquake Engineering Foundation (China) and the US–China Earthquake Engineering Foundation (USA) in 2020.

Xiaolei Liu works as a professor and doctoral supervisor at the Ocean University of China (OUC). He is the director of the Institute of Marine Engineering Geology and the Environment at OUC and the deputy director of the Shandong Provincial Key Laboratory of Marine Environment and Geological Engineering. Additionally, he is the chairman of the Committee on Marine Geo-disaster and Geo-environment (TC-4) in the International Consortium on Geo-disaster Reduction (ICGdR). His research interests are focused on marine engineering, the geological environment, and related disasters, including the phase transition mechanism of submarine sediment, the evolution mechanism of fluidized sediment movement, and probe techniques for observing seabed interface layers. He has obtained the first prize of the Science Research Famous Achievement Award in Higher Institution, the first prize of the Qingdao City Science and Technology Progress Award, and the special prize of the Technological Invention Award from the China Association of Oceanic Engineering. He has undertaken more than 10 national scientific research projects and published over 120 peer-reviewed journal papers in mainstream journals within the international marine engineering geology field such as *Engineering Geology*, *Journal of Geophysical Research: Oceans*, *Landslides*, *Marine Geology*, *Ocean Engineering*, etc. At the same time, he has published three monographs and authorized more than 60 invention patents from China, the United States, Japan and Europe.

Thorsten Stoesser is the leader of the Fluid Mechanics Research Group in the Department of Civil, Environmental, and Geomatic Engineering at University College London. His research interest is in developing advanced computational fluid dynamics (CFD) tools and their application to solve environmental fluid mechanics problems. Thorsten has published over 100 peer-reviewed journal papers on developing, testing, and applying advanced CFD methods to predict the hydrodynamics and transport processes in rivers, estuaries and coastal waters, the fluid–structure interaction of marine turbines, and the nearfield dynamics of jets and plumes. For his research, Prof. Stoesser received twice the American Society of Civil Engineers (ASCE) Karl Emil Hilgard Hydraulic Prize (2012 and 2016); in 2015, he won the International Association of Hydro-Environmental Research (IAHR) Harold Shoemaker Award; and in 2016, he won the Institution of Civil Engineers' George Stephenson Medal. He has received over GBP 5 M in funding from industry, government institutions, and research councils, including the DFG (Germany), NSF (USA), and EPSRC (UK).