Scour and Erosion: A Global Perspective

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This editorial presents a global perspective on scour and erosion, based on the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) Technical Committee 213 Special Issue on Scour and Erosion of the International Journal of Geoengineering Case Histories (IJGCH). This Special Issue covers a broad range of scour and erosion, from road embankment scour and erosion to river bridge scour with their countermeasures, coastal erosion, scour and internal erosion, and marine scour at/around offshore structures, from America, Europe, Asia, and Oceania. An overview and a concise summary of a total of six papers presented in this Special Issue can be described as follows.

Sundaram et al. presented disaster events that took place under record-breaking rainfalls in Queensland, Australia from 2021 to 2022. The severe rainfall of >1,800 millimeters and flooding caused extensive damages to road networks traversing about 540 kilometers of mountainous road terrain, 3,700 kilometers of rolling road terrain, and 29,100 kilometers of level road terrain, resulting in the loss of road embankment slopes, deep scouring of road bridge foundations, road bank scour and erosion, failures of cut slopes, debris slides, sinkholes, the reactivation of old landslides, and numerous other damages. The interim and permanent remediation measures adopted for a representative damaged highway with bridge abutment failures are described in detail. These involved gabion walls with rockfill with percussion earth anchors and drains. Amid various restrictions—involving limited space, required clearance, limited equipment and material availability, and the constructability and performance of a minimum design life of 50 years—the safety measures and remediation works have ensured the highway's status as open and safe, and are projected to prevent such failures in changing climate conditions in the future.

Shan et al. presented a detailed assessment of scour for the Lafayette Avenue Bridge replacement project in the Saginaw River, Michigan, U.S.A., through a so-called NextScour approach combining geotechnical site investigation, laboratory erosion testing, flume tests, and advanced numerical analysis. The geotechnical site investigation demonstrated that the subsurface soils consisted of loose sand and silty sand layers that were underlain by the medium to hard lean clay at depths of 4.6–6.1 m (15–20 ft) below the river channel. Conventional design methods predicted scour depths that would penetrate the clay layer by several feet. The laboratory erosion tests on the in-situ soil samples and the computational fluid dynamics modelling of the three-dimensional flow around the Lafayette Avenue Bridge's wide bascule piers that was calibrated and verified using the flume test data of the bridge piers and abutments, together with a probabilistic scour analysis considering various statistical uncertainties in the annual flood events for a 75-year bridge design life, led to the 51% reduction of the total scour compared with the conventional estimates. These results improved the scour depth predictions and made the foundation design more cost-effective.

Avila presented the results of scour analysis and scour countermeasure installation for the Lucas Valley Road Bridge in Marin County, California, U.S.A. Bridges in the United States are inspected every two years. The field investigation showed that water was flowing rapidly upstream of the bridge due to a head cut through the bridge that had undermined the bridge foundations as well as exposed the bridge piers. The variations of the channel cross sections were reviewed for the period from 1960 to November 2017. The results indicated that the pile exposure increased dramatically before the January 2017 storm event. This pile exposure required scour countermeasures to stabilize the bridge and protect it from collapse. Three remediation measures were applied, involving structural countermeasures, where the pier footings were extended; hydraulic countermeasures, where rock riprap and criss-cross weirs were used to prevent pier scour and headcutting through the bridge; and monitoring countermeasures, where stage gages, sonar, and tilt meters were used to continuously monitor conditions at

Reference: Sassa, S. (2022). Scour and Erosion: A Global Perspective. International Journal of Geoengineering Case Histories, Volume 7, Issue 4, pp. ii-iii, doi: 10.4417/IJGCH-07-04-00-B

the bridge. Following these three emergency conteameasures in place, the bridge has remained stable and open to the traveling public.

Tsubokawa et al. presented the processes and mechanisms for the coastal disasters that took place in December 2014 and in November 2021 in Hokkaido, Japan. Both disasters represented coastal road slope collapses behind a retaining wall due to scour and erosion under high wave conditions. In the face of global climate change, the frequency of high waves has been increasing along coasts worldwide. The field surveys and the numerical estimation of the wind waves, combined with a series of hydraulic wave flume experiments under the estimated offshore waves, demonstrated that the wave-induced runup and return flow caused surface erosion and scour of foreshore sands in front of the retaining wall, and the continued severe wave action gave rise to the occurrence of progressive internal erosion accompanied by the formation and collapse of cavities beneath and behind the retaining wall. These disasters shared the same basic mechanisms, including how the wave-induced coupled surface erosion, scour, and internal erosion surrounding the structure led to collapse. The presence of overtopping flow enlarged the extent of collapses in the 2014 disaster compared to the 2021 disaster. These results showed that preventing erosion beneath the retaining wall may serve as an effective countermeasure for such coastal embankment slope collapse disasters.

Chambel et al. presented a probabilistic assessment and comparison of scour protections at Horns Rev 3 and Egmond aan Zee offshore wind farms located in the Danish sector of the North Sea and off the Dutch North Sea Coast, respectively. The development of offshore wind is increasing rapidly worldwide. To account for the uncertainty in scour protection design, Monte-Carlo-based reliability analyses of the dynamic stability of the armor layer stones for the offshore wind monopiles were performed based on the damage number. This damage number takes into account the number of waves in a reference storm, the water depth, the depth-averaged current velocity, the bottom orbital velocity, the relative density of the stones, the particle's settling velocity, and the nominal median stone diameter with the significant wave height and the peak period. The results show that the probabilities of failure of a scour protection with rubble-mound materials depend considerably on the site-specific conditions for each offshore windfarm. Further research is needed to improve current knowledge on the failure mechanisms as well as the likelihood and reliability of scour protections applied to offshore wind foundations.

Harris et al. presented scour predictions in cohesive marine soils based on a hybrid approach using soil erosion testing and empirical scour equations for a planned offshore wind farm with monopile foundations in the Baltic Sea. The surficial seabed sediment was fine-grained soils with clay contents up to 30% that had extremely low to low undrained shear strengths (0–15 kPa). The extreme wave height, associated peak periods, and the current speeds were derived from the statistical field data combined with the numerical analysis, which led to the determination of the acting bed shear stresses from the combined wave and current. Estimates of a range of scour depths from 0.2 m to 3.0 m were obtained for a subset of 50 foundations, and were largely dependent on the profiles of the undrained shear strength and the applied correction factors based on the results from the soil erosion testing on the samples retrieved from boreholes at all locations for the offshore wind turbines. There was a dependency between the organic content and the erodibility of the seabed soil samples. The knowledge gained from the hybrid approach allowed an improved evidence-based set of scour estimates to be made, which benefited the project.

The contents presented in this Special Issue represent recent advances in understanding and reducing the risks of scour and erosion. Hopefully, these and other related advances will facilitate a better understanding of processes and design for the protection and mitigation of scour and erosion through an integration of hydraulics and geotechnics.