Biostabilisation of Sediments for the Protection of Marine Infrastructure from Scour

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Abstract : Industry-standard methods of mitigating erosion of seabed sediments rely on ‘hard engineering’ approaches which have numerous environmental shortcomings: (1) direct loss of habitat by smothering of benthic species, (2) disruption of sediment transport processes, damaging geomorphic and ecosystem functionality (3) generation of secondary erosion problems, (4) introduction of material that may propagate non-local species, and (5) provision of pathways for the spread of invasive species. Recent studies have also revealed the importance of biological cohesion, the result of naturally occurring extra-cellular polymeric substances (EPS), in stabilizing natural sediments. Mimicking the strong bonding kinetics through the deliberate addition of EPS to sediments – henceforth termed ‘biostabilisation’ - offers a means in which to mitigate against erosion induced by structures or episodic increases in hydrodynamic forcing (e.g. storms and floods) whilst avoiding, or reducing, hard engineering. Here we present unique experiments that systematically examine how biostabilisation reduces scour around a monopile in a current, a first step to realizing the potential of this new method of scouring reduction for a wide range of engineering purposes in aquatic substrates. Experiments were performed in Plymouth University’s recirculating sediment flume which includes a recessed scour pit. The model monopile was 0.048 m in diameter, D. Assuming a prototype monopile diameter of 2.0 m yields a geometric ratio of 41.67. When applied to a 10 m prototype water depth this yields a model depth, d, of 0.24 m. The sediment pit containing the monopile was filled with different biostabilised substrata prepared using a mixture of fine sand (D50 = 230 μm) and EPS (Xanthan gum). Nine sand-EPS mixtures were examined spanning EPS contents of 0.0% < b0 < 0.50%. Scour development was measured using a laser point gauge along a 530 mm centreline at 10 mm increments at regular periods over 5 h. Maximum scour depth and excavated area were determined at different time steps and plotted against time to yield equilibrium values. After 5 hours the current was stopped and a detailed scan of the final scour morphology was taken. Results show that increasing EPS content causes a progressive reduction in the equilibrium depth and lateral extent of scour, and hence excavated material. Very small amounts equating to natural communities (< 0.1% by mass) reduce scour rate, depth and extent of scour around monopiles. Furthermore, the strong linear relationships between EPS content, equilibrium scour depth, excavation area and timescales of scouring offer a simple index on which to modify existing scour prediction methods. We conclude that the biostabilisation of sediments with EPS may offer a simple, cost-effective and ecologically sensitive means of reducing scour in a range of contexts including OWFs, bridge piers, pipeline installation, and void filling in rock armour. Biostabilisation may also reduce economic costs through (1) Use of existing site sediments, or waste dredged sediments (2) Reduced fabrication of materials, (3) Lower transport costs, (4) Less dependence on specialist vessels and precise sub-sea assembly. Further, its potential environmental credentials may allow sensitive use of the seabed in marine protection zones across the globe.

Keywords : biostabilisation, EPS, marine, scour
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