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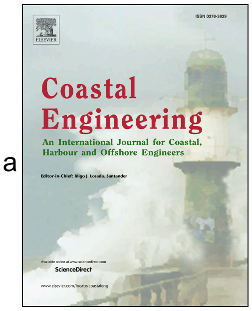

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Sediment transport and trench development beneath a cylinder oscillating normal to a sandy seabed

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Abstract

The purpose of this study is to explore the conditions in which trenches form beneath oscillating cylinders – such as pipelines, cables or idealised chains – close to the seabed. Experiments are conducted by oscillating a circular cylinder in a direction normal to an initially flat sandy bed. Across a relatively wide parameter space, the transport patterns and trench geometries reveal three transport regimes that are linked to vortex dynamics and depend primarily on the ratio of oscillation amplitude to cylinder diameter (KC number). For $KC \lesssim 4$ sediment motion results in bedload transport that is symmetric about the cylinder centreline. This leads to the formation of two parallel trenches with a prominent ridge forming directly beneath the cylinder. For $4 \lesssim KC \lesssim 9$ sediment motion occurs via localised transport events, which are associated with the motion of vortices shed from the cylinder. These transport events are irregular but occur on both sides of the cylinder and lead to the formation of a symmetric trench geometry. For $9 \lesssim KC \lesssim 12$ the sediment motion is characterised by localised transport events and asymmetric bedload transport driven by overall vortex dynamics. In terms of trench size, the maximum (equilibrium) depth is found to increase with KC and a mobility number (ψ) defined in terms of the maximum cylinder velocity. The initial rate of trench development also increases with KC number and ψ, with an additional dependency on the cylinder β number. The cylinder motions required to initiate trenching are predicted well using continuity arguments and an oscillatory boundary layer assumption, provided the KC number and minimum gap between the cylinder and the bed are relatively small. The findings in this study provide insight into the mechanisms and prediction of trench formation. In particular, this study reveals that significant trenches can form in sandy seabeds solely due to fluid flow induced by pipeline/cable/chain motion without direct seabed contact, which has implications for structural fatigue.

Keywords: Pipelines; risers; sediment transport; trenching; chains; cables

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