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Stability analysis and design of offshore submerged breakwater constructed using sand filled geosynthetic tubes

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Abstract

Kadalur Periyakuppam (KPK) is a fishing village located 70 km south of Chennai in Tamil Nadu. The coastline of KPK was subjected to severe erosion due to high energy waves during Thane (2011), Nilam (2012) and Madi (2013) cyclones. The Tamil Nadu Fisheries department facilities located near the coast is subjected to damage as the coastline has receded by 45 m in the last few years following the severe erosion caused by cyclones. Since most of the erosion occurred after the storm waves hit the shoreline, sustainable option for shoreline protection would be to shift wave breaking to deeper depths. Based on numerical model studies and assessment of shoreline behaviour over two years, it is proposed to construct a submerged segmented breakwater. The submerged breakwater is proposed to be constructed at 4 m water depth up to a height of 3.5 m using sand filled geosynthetic tubes. Geosynthetic tubes shall be placed in a stacked manner with 2 tubes of 1.5 m high each at the bottom and a tube of 2.5 m height at the top accounting for height loss due to settlement. Design and stability checks are carried out by using available literature as no standard methods or design codes are available for design or stability checks for the geosynthetic tubes. The breakwater structure is checked for stability against sliding, overturning and bearing capacity. The geosynthetic tube material specifications such as tensile strength, ultra violet ray resistance, apparent opening size and fabric material are calculated using suitable design methods. The scouring, in front and behind the breakwater structure under prevailing wave conditions, is estimated for designing scour protection.

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1. Introduction

National Institute of Ocean technology (NIOT), Chennai has proposed to install a submerged segmented shore parallel breakwater at 4 m water depth at Kadalur Periyakuppam, Tamil Nadu. It is proposed to use sand filled geosynthetic tube for the construction. The design of material properties of geosynthetic tubes, stability of the sand filled geosynthetic tubes under wave loading and scouring action near the tube are discussed in detail in this paper.

1.1. Background

Shoreline erosion is a major threat to coastal infrastructure. Erosion results from natural or man-made causes. Natural geomorphologic evolution in the form of erosion can occur due to prevailing wave climate, water levels, currents etc. Human interventions with the coastlines such as construction of breakwaters, seawalls are also likely to result in large-scale erosion.One of the important natural causes is the waves breaking on the shore. These waves become furious and cause severe damage during cyclones. In the last few years, the east coast of India is frequently affected by cyclones, the major ones being Thane (2011), Nilam (2012), Madi (2013) and Hud Hud (2014). Study area, Kadalur Periyakuppam (KPK) is located south of Kalpakkam (between $12^{\circ}26'57''$N and $12^{\circ}26'14.2''$N). KPK comprises three fishing villages immediately south of Palar River and north of a creek as shown in Fig. 1. A number of fisheries facilities have been developed by Tamil Nadu Fisheries Department on the coast of KPK, which is found to severely erode during cyclones. Accretion occurring in the following calm season is not sufficient to regain the lost beach. The net erosion has caused scouring below the fisheries structures and beach loss as shown in Fig. 2. The extent of the KPK shoreline requiring protection is about 1.5 km long comprising of three villages.

Fig. 1. Location of KPK

1.2. Detached submerged breakwater

The design of a coastal protection measure needs to consider stabilizing the coastline in a long-term and protection of the shoreline from the effects of storms. Also, it should not cause changes to the adjacent coastline or transfer the problem to nearby areas. Long term studies by agencies like the USACE indicate that conventional shore protection measures like groins, breakwaters, seawalls, revetments, bulkheads, beach-fill, etc., have certain disadvantages like blocking of long shore sediment transport resulting in severe erosion to the down-drift side, scouring near toe of revetments etc. In the case of a shore-parallel breakwater, which is placed near the shoreline to protect a beach-fill or placed offshore and designed to intercept a portion of long shore moving sediment, it is likely to perform well for various coastal environments (CERC-90-15(1990)).