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Behavior of Buried Cables in Seafloor Soil Under Lateral Loading

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ABSTRACT

Primary hazards that the underwater cable burial vehicle (CBV) must contend with are buried or unburied obstacles in the path of the plow blade. Existing buried or unburied laid cables are one such example. This paper analyzes the response of an existing buried cable crossing the path of a CBV with a plow assembly that is designed to ride over obstacles in order to assess the potential for damage.

KEY WORDS: Buried cable, subgrade modulus, ultimate soil strength, axial force, rotation angle, bending moment, shear force.

INTRODUCTION

One of the preferred methods for burying cables in seafloor is by towing an underwater cable burial vehicle (CBV) along the seafloor surface. The CBV typically includes a vertical blade that plows through the seafloor soil. It therefore must contend with various obstacles in the path of its plow blade. Existing buried cables are one such example.

When the CBV encounters a buried cable, its blade is designed so that the vehicle rides over such an obstacle. However, during the ride-over process, the buried cable is subjected to a lateral load, which if excessive may damage the cable and therefore impair its function. The objective of this paper is to analyze the behavior of buried cables under lateral loading in order to assess its damage potential. The results included in this paper is based on a study as part of the extensive research program by the US Naval Facilities Engineering Service Center, Cable Burial Technology Program.

FORMULATION OF CABLE DISPLACEMENT

The solution for the analysis of cables buried in seafloor subjected to a lateral, concentrated load has been developed based on the modified "flexible beam on elastic foundation" approach (Hetenyi, 1946). The flexible beam on elastic foundation approach is an idealized soil-structure problem in which a loaded area is applied to a homogeneous soil mass. The soil is treated as an elastic half-space. The deflection of the soil at a point (w) is assumed to depend only on the pressure acting at that point (p) through a proportional spring constant (k_o), i.e., $p = k_o w$.

The flexible beam on elastic foundation approach has been modified so that the soil is treated as a nonlinear inelastic medium. The relationship between the soil resistance (p) and the corresponding cable displacement (w) is assumed to follow the hyperbolic mathematical function. Hyperbola has been chosen because it can characterize two most fundamental and important nonlinear soil behaviors, namely the initial modulus and the ultimate soil resistance. The initial modulus (subgrade modulus) is represented by the slope of the hyperbola at zero displacement and the ultimate soil resistance is characterized by the asymptote of the hyperbola (Fig - 1). The mathematical expression of the hyperbola is described as

$$p = \frac{w}{\frac{1}{k_o} + \frac{w}{p_{ult}}} \tag{1}$$

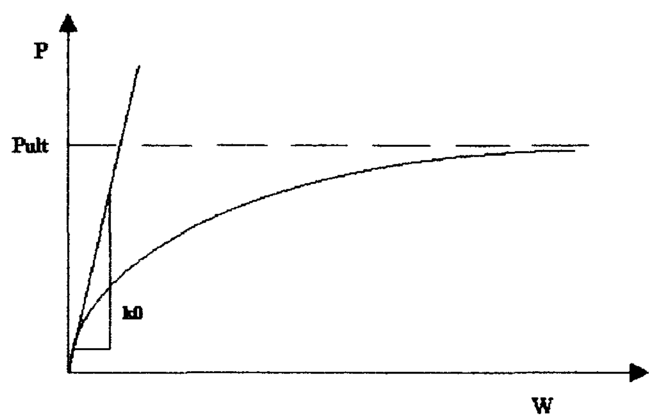

FIG. -1 Hyperbolic soil model