HAWAII DEEP WATER CABLE PROGRAM

PHASE II-D

TASK 7

DEVELOPMENT OF FRICTION TEST SPECIMEN FOR THE HDWC SYSTEM

Department of Business and Economic Development

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DEVELOPMENT OF FRICTION TEST SPECIMEN FOR THE HDWC SYSTEM

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for

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State of Hawaii

Department of Business and Economic Development

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1.0 INTRODUCTION

The work described herein has been completed in support of the State of Hawaii Deep Water Cable (HDWC) program, Phase II-D, and provides matching support for the ongoing SEA GRANT research project, "Design Investigation of Hawaii Deep-Water Cable Systems", R/OE-7.

This effort and the SEA GRANT research project have the common objective to improve modeling accuracy of Self-Contained, Oil-Filled (SCOF) power cables. Improved modeling accuracy is expected to result in improved design methodology. This effort focuses on the effects of cable laying on component stresses at the overboarding sheave (or chute) where maximum tensile and bending actions occur.

2.0 BACKGROUND

There are presently no analytical or numerical techniques available to accurately model the structural properties of a SCOF type of power cable planned for the HDWC system. Although computer programs to model such cables now exist, none of these are capable of representing frictional actions between the components of the cable. The importance of understanding these frictional actions is especially significant when a tensioned cable is bent during the initial laying operation. Component stresses induced by cable bending are greatly influenced by the magnitude of frictional interfaces. The fact that the HDWC system is to be installed at ocean depths greater than any previous installation suggests the increased importance of improved modeling techniques.

3.0 EXPERIMENTAL BENDING OF AN IDEAL CABLE

To study the effects of helical wire frictional slippage on a cable core, an ideal cable has been fabricated from acrylic plastic. Due to the low modulus of elasticity of the acrylic, large bending deformations can be imposed with a nearly elastic response. Thus, the acrylic cable can be successively bent with repeatable measurements of strain and deformation. This material is also well suited to strain gage applications and for optical measurements. Moreover, it is inexpensive and easily machined.

The ideal cable has been designed to permit the measurement of axial displacement of a wire placed in a helical groove on the surface of the core. The lay angle of the helical groove has been selected within the range of practical cable constructions, and at least six lay lengths are provided over the cable test length. The latter condition is significant in order to eliminate end effects on measurements taken at the middle of the specimen. The helical groove is used to constrain the placement of the wire, in this case a smaller diameter acrylic rod. To simulate the effect of radial pressure between the helical rod and core produced by the applied cable tension, the rod is placed onto the groove at a thermoforming temperature, then clamped to the rod at both ends, and finally allowed to cool to room temperature. This places the rod in a uniform state of pretension along the helical path and establishes the desired radial contact pressure. Although the value of this pressure can be calculated by knowing the temperature change during the forming process, it will also be determined experimentally at the conclusion of the tests by reading the snap-back of the wire strain gages when the wire is cut free from the core. An instrumented acrylic helical wire on the core is shown in Figures 1 and 2.

A sheave type of loading fixture has been fabricated to apply a bending load (see Figure 3). Motion of the helical wire on the core is measured optically (see Figure 4) and wire strains are monitored using three-axis strain gages mounted onto the helical wire at significant stress points. Two types of data essential to the understanding of wire motion subjected to a frictional interface will thus be obtained; viz., axial displacement and strain.

Optical tapes placed on both the wire and core at close spacing provide reference lines to measure wire displacement accurately by use of a microscope. Axial wire strain, which is associated with the change of wire motion per unit length, is measured directly with three-axis strain gage rosettes. This data will be compared to confirm measurement accuracy.

4.0 RESULTS

As of the date of this report, all test apparatus, loading fixtures and one ideal test cable specimen have been completed. The test cable has been successfully instrumented and optical measurements have been made. Although this data has not yet been subjected to close examination, a preliminary interpretation of the data shows that these tests will provide the information essential to develop an improved mathematical frictional model of the bent cable. Optical measurements of wire slippage for this first test specimen agree well with simple theory. Strain gage data will be obtained following the optical tests. A total of three different ideal cable models are to be evaluated.

It is anticipated that the final results of these experiments will be available during the Fall of 1989. These results will be published in the open literature with acknowledgement to Parsons Hawaii, Hawaiian Electric Company and the State of Hawaii for the funds used to support this study. Copies of all publications related to this effort and the SEA GRANT project will be sent to each of these organizations when they become available.

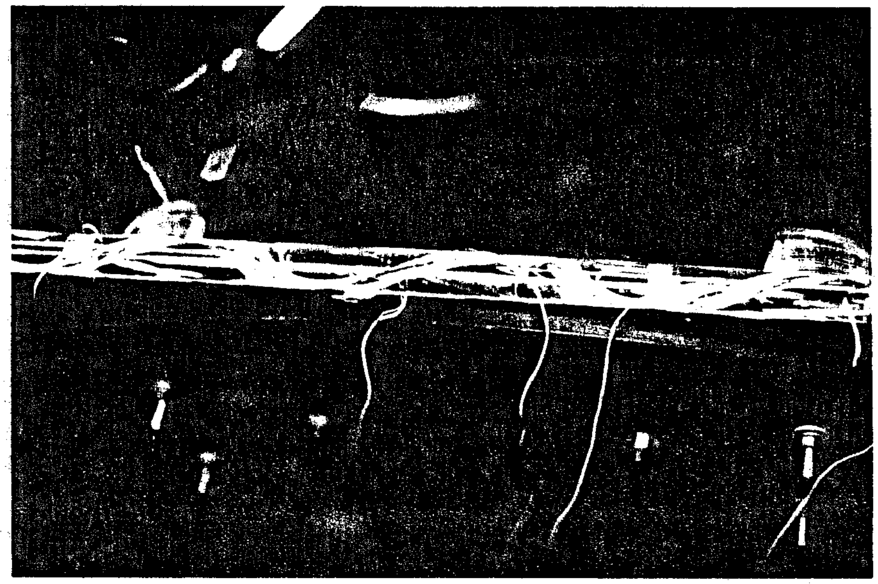

FIGURE 1. INSTRUMENTED TEST SPECIMEN

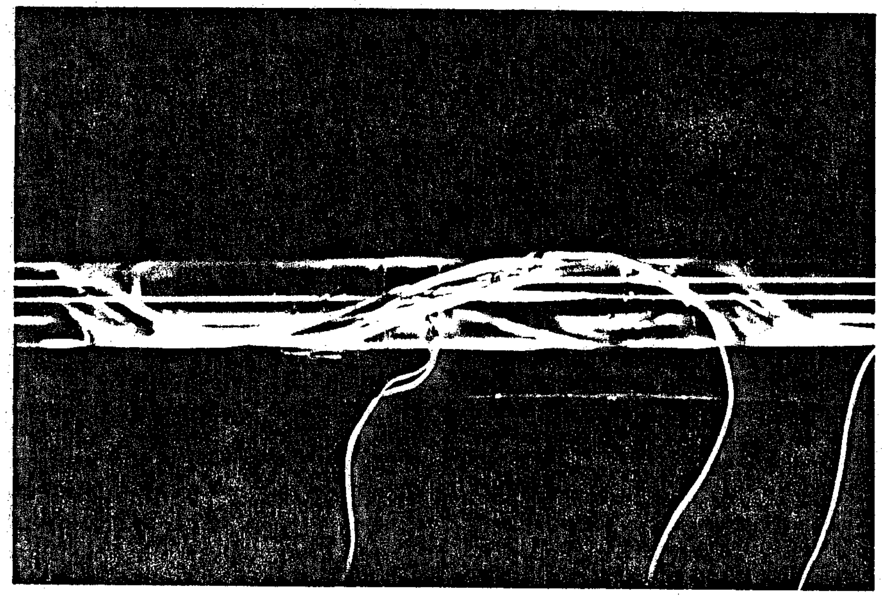

FIGURE 2. CLOSE-UP OF HELICAL WIRE IN CORE GROOVE

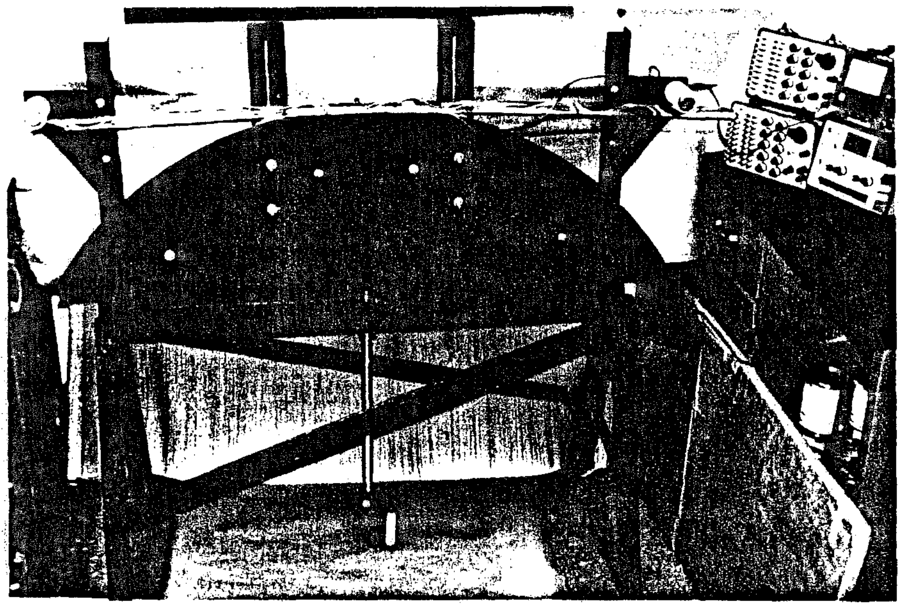

FIGURE 3. LOADING FIXTURE

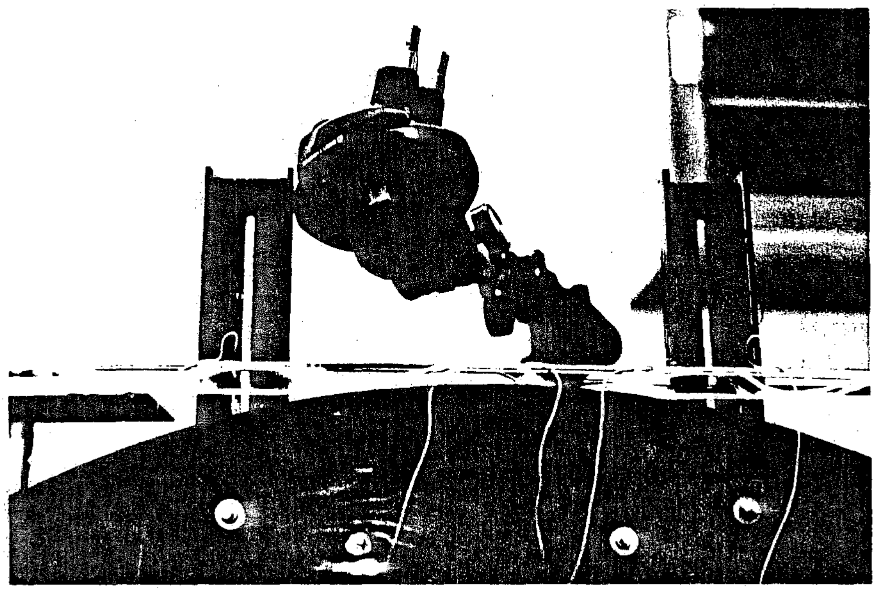

FIGURE 4. OPTICAL MEASUREMENT OF WIRE SLIPPAGE