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The Residual Strength of Damaged Polyester Rope

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Abstract

Full-scale polyester ropes were tested to determine the impact of damage on the strength of polyester rope used as mooring lines for deepwater structures. The ultimate goal of this project - to provide information on the residual strength of damaged polyester rope for the industry and MMS to use in developing guidelines for mitigating damaged polyester rope mooring lines - has been accomplished.

Test Program

Ropes from four manufacturers Bexco, CSL, Whitehill, and Marlow were tested to represent different rope constructions. The ropes represent rope product lines that are commercially available, and were furnished with commercially available splices. All ropes are parallel subrope constructions. The rope constructions are illustrated in Figure 1.

Three series of tests on damaged polyester rope samples were conducted in the sequence as shown below. Important test parameters are summarized in Table 1. The length to diameter ratio L/D is an important parameter. L refers to the free length of the sample between the eye splices (see Figure 2), and D is the diameter of the rope. All rope strengths are in tonnes (t).

Length Effect Tests (35t). The purpose of these tests was to qualitatively examine the potential influence (if any) of length effects on test results for damaged polyester ropes. Model scale ropes (35 tonne specified break strength) with L/D ranging from 40 to 1000 were used for these tests. These tests were completed at the Lloyd Beal test facility in Cardiff, Wales, UK. Hydraulic rams were used for cyclic loading and break tests. The test setup is shown in Figure 3, and Figure 4 shows the damage to a rope being simulated by cutting a specified portion of the rope.

Full-Scale Damaged Rope Tests (700t). The purpose of these tests is to quantify the influence of damage on full-scale ropes. Full-scale ropes (700 tonne specified break strength) were used for these tests. The sample lengths were typical of the lengths used to qualify prototype ropes, and had L/D ratios of 40. These tests were completed in facilities located at Stress Engineering Services in Houston, TX and at CSL in San Leopoldo, Brazil. Hydraulic rams were used for cyclic loading and break tests. The test setup at Stress Engineering is shown in Figure 5, and Figure 6 shows an example of cut damage on a 700t rope.

Verification Tests (700t). The purpose of these tests was to verify a selected Full-Scale Damaged Rope Test result (i.e. damage level) for each rope type with one test of longer sample. Full scale ropes (700 tonne specified break strength) with L/D ratios of 290 were used for these tests. The Verifications Tests were completed at Tension Member Technology. The test setup is shown in Figure 7. The stretch of the long rope samples was taken up using an eccentric loading arm, and a hydraulic ram was used to cycle the rope as well as apply the load for the break test.

Test Procedure. The test procedures included the following steps:

- Initial cycling to bed-in the rope
- Relaxing the rope and inflicting a prescribed damage
- Cycling the rope to simulate storm loading on a damaged rope. The magnitude of the cyclic loading was a mean load of 30 percent of the specified break strength and +/- 15 percent of the specified break strength to simulate storm loading after the rope had been damaged. For the 700 tonne ropes, the cyclic loads thus ranged from 105 tonnes to 315 tonnes. The frequency of the cyclic loading was sufficiently low to prevent heat build up in the rope or the splices.
- Post-cyclic examination of the rope to examine any progression of the damage. Damaged subropes failed during cycling during some of the tests.
- Break test - the rope was loaded such that the load increased at a constant rate until it broke.

Specifications for each of the three test series are shown in Table 2.

Damage. The amount of rope damage used for this study was centered around 10 percent loss of cross sectional area. This damage level was selected following the API RP 2SM