NEL REPORT 1199

WIRE CABLES FOR OCEANOGRAPHIC OPERATIONS

Tests of elastic and rotational stretch show 3×19 cable most satisfactory of types now available

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THE PROBLEM

Conduct tests to determine which cables are most suitable for oceanographic applications.

RESULTS

1. Extensive tests were conducted on 14 cables now in general use for marine operations, to determine their resistance to elastic and rotational stretch.

2. The 3 x 19 cable was found to have characteristics that would favor its use for sensitive oceanographic problems when compared with the other cables tested.

RECOMMENDATIONS

1. On the basis of the evaluation reported here, consider the 3 x 19 cable the most suitable of those now available for precision oceanographic applications.

2. In future procurement of oceanographic cables, conduct similar tests on sample lengths before adopting any new types.

3. Continue investigation of new cable designs for oceanographic use.

ADMINISTRATIVE INFORMATION

Work was performed under SR 004 03 01, Task 0539 (NEL L4-1). The report covers work from March 1952 to September 1963 and was approved for publication 13 November 1963.

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INTRODUCTION

Wire rope has important applications in industry for holding, towing, and lifting, and much has been done to improve its quality and dependability. It has equal importance in oceanographic work. Deep mooring by the taut-wire technique, coring and dredging, under-water photography, and sampling of water, bottom materials, and biological life, are only a few of the oceanographic activities which require the use of cables and which present new and rigorous demands upon the strength, flexibility, and general reliability of the wire used in their construction. These demands increase as oceanographic investigations continue to involve greater depths and longer periods of submersion. Whereas in most industrial applications both ends of a cable are firmly secured, oceanographic operations require suspension and subsequent maneuvering of a weight on the end of a line which is capable of stretching and rotating as the load is lowered into the water. The destructive effect of the ocean environment upon cable material adds to the problem of selecting wire rope of optimum characteristics for marine operations.

The investigation reported here was undertaken to determine which cables, of the many types now available, are most suitable for oceanographic applications.

FACTORS IN CABLE EFFECTIVENESS

The basic requirements for any cable are strength and flexibility. The cables used in oceanographic operations require special characteristics in addition to the basic strength necessary to handle heavy loads. Corrosion, magnetic properties, conditions of shock, abrasion, vibration, and extremes of temperature are all potential sources of damage, premature wear, and unsatisfactory performance. These hazards must be considered in any choice of marine cable.

Both the materials used and the method by which a cable is fabricated are factors in its suitability. Table 1 summarizes the pertinent characteristics of several materials which are in wide use in the manufacture of wire rope. It will be noted that these materials vary in effectiveness, depending upon the application for which they are considered.

The method by which the cable is constructed strongly influences its ability to meet the rigorous demands of oceanographic operations. Two common types of construction are the Warrington and the Seale configurations, both consisting of two layers of wire about a central wire: six wires in the inner layer and twelve in the outer. The Warrington varies from the Seale by using large and small wires alternately in the outer layer; the Seale construction uses the same size throughout. The Seale type yields a smoother surface which reduces friction and resulting abrasion; and the presence of smaller wires in its outer layer increases flexibility and therefore reduces bending stresses, especially when the cable is being operated over sheaves of small diameter.

The strength of a wire rope increases with its size and with the excellence of the material (especially the core material) of which it is made. The strength offered by any method of construction will vary with the metallic area involved and the basic strength of the wire used. If a cable is made with an independent metallic core or inner strand it will be somewhat stiffer than a similarly constructed rope with a fiber core but, when heavy loads and high radial pressures are involved, may offer greater strength and resistance to bending fatigue. In many applications the fiber-core wire rope is satisfactory or even preferable, as when it must conform to the diameter of a small sheave or drum.

The flexibility of a wire rope is a function of its "lay," or the manner in which the strands are joined or twisted, and also depends upon whether or not the wire is preformed. The commonly used Lang lay produces a cable with large cover wires and the same number of wires in the outside layers as in the inside layer.

If the helical angle of the wire wrap is kept tight with a small angle from the normal to the cable, flexibility will decrease.

A long lay will tend to increase the flexibility up to a point where, if too great a load is placed on the core of a cable, its strength will be reduced.

The flexibility of a wire rope of fixed diameter also increases with the number of wires or strands used in its construction, with the size of the individual strands decreasing proportionately.

HAZARDS TO CABLE IN OCEANOGRAPHIC OPERATIONS

Cable used in oceanographic operations must meet rigorous demands, imposed both by the ocean environment itself and by the nature of the work in which the cable is used. The principal hazards to the cable are as noted briefly here.

Corrosion

Constant exposure to sea water has a corrosive effect upon cable, first appearing as microscopic pitting which cannot be detected without powerful magnification. The pits act like little keys; as they develop they restrict the action of the cable elements, creating stress concentration points, rapidly diminishing the flexibility of the cable, and reducing its ability to withstand impact loads and shock. Corroded rope creates a serious hazard not only to the equipment being handled but to the persons using it. Frequent inspection and regular lubrication are imperative, as by the time the corrosive effect becomes visible it is too late to take preventive action.

Generally, corrosion attacks wire rope on the exposed surface of the wire first and, when this is the case, it is readily apparent. However, it is possible for corrosion to develop inside the wire rope before any evidence is visible on the outside. This has been found to be the result of a lubricating practice which has been adequate to keep the outside of the rope coated but has been insufficient to prevent the loss of the original lubricant from inside the cable and has permitted moisture to penetrate it.

Abrasion

Abrasion and other forms of wear generally appear to progress very rapidly on a new rope, since only a small surface of the wires is exposed to abrading objects. However, as worn surfaces develop on the wire crowns, the wear is distributed over a larger area of contact and the apparent rate of abrasion decreases. On regular lay ropes, the wearing action causes a loss of metal from the crowns of the outside wires and small, elliptical flat surfaces develop.

A constant contributor to wear is the peening action produced when the wire rope is subjected to short, sharp blows against stationary or moving objects such as small track rollers on a ship. This type of abuse causes some loss of metal from the wires, but its principal damage is the deformation of their original circular shape.

The speed with which the wire rope is handled is a very important factor in its wearing qualities. Any section of rope operating over a sheave makes two complete bends (one when it conforms to the sheave groove and another when straightened). These changes in curvature require rapid movement of the wires and strands, and materially influence their bending fatigue.

In general, the safety of a working load is determined by the same conditions which contribute to abrasion and corrosion: the weight of the applied load, the speed of operation and of acceleration and deceleration, the length of the wire rope used, and the number, size, and location of sheaves and drums.

Stretch

Stretching is a propensity of wire rope which must be taken into account in selecting and using marine cables. When drops to precise depths are required, a lengthening of the cable could result in erroneous data. Also, long cables could be weakened to a point where critical instrumentation could be lost or subsurface buoys would gradually rise to the surface as the cable unwound.

There are two types of wire rope stretch: (1) elastic stretch, which is a function of the elastic properties of the material of which the rope is made, and which is recoverable in accordance with Hooke's law; and (2) constructional stretch, which is caused by the progressive adjustment of the individual wires moving to seat themselves more firmly into the cable structure. Constructional stretch is not recoverable and will manifest itself, during the first few times the cable is loaded, to a degree depending upon the severity of the loading.

Corrosion and rope stretch, as discussed above, may be considered mechanical problems, which depend largely upon the composition and construction of the wire rope. There are other aspects of the corrosion and wear problems, such as electrolytic corrosion and the effects of sheave and drum action, but these all point mainly to proper selection and maintenance of the cable.

Rotation

A further problem which exists in the use of wire rope in oceanographic operations is that of rotation. When a weight is suspended from a ship, the cable supporting it becomes a free body able to rotate at will. Such rotation causes an unlay of the wires composing the cable and could, if permitted to proceed far enough, reduce its strength capability to the breaking point and cause the loss of both cable and load. The personal hazards involved are obvious. A further undesirable effect of the rotation is that it opens the cable structure and allows entry of sea water, thus hastening corrosion of the core and inner wrap wires.

Rotation of the wire rope is a function of its helical construction, and the direction in which it rotates depends upon the direction in which the strands are laid. Length of cable and weight of loading determine the degree of rotational stretch which will be produced.

TEST PROCEDURES

Conducting a study at sea to gather the information sought in this evaluation would require operation of a test vessel with instrumentation which would be prohibitively expensive. The manufacturers of wire rope and cable were not able to supply directions for such an investigation, and since no A. S. T. M. standards or guide lines were available, the test procedure to be described was developed empirically at NEL.

NEL towers were used to support a length of cable. Generally 120 feet of cable was used so that one end could be secured in the tower. The working length was 100 feet, suspended to within 5 or 6 feet of the ground. A drag or brake system was used to regulate the twist, from unwind to rewind, to the speed at which it was estimated the cable would be turning in the sea, and to simulate the drag it would encounter in sea water. Count was made of rotational turns from unwind to wind. Other tests were made, on longer lengths of cable, by securing sheaves at different levels in the tower and, by means of a winch from a tractor, raising and lowering the weights to distribute a load over the required length of cable (figs. 1-6). To determine the amount of stretch for any given load, the cable length was measured before addition of a weight and again after it was completely "relaxed" under the additional load.

Each cable was tested under these conditions to determine the elastic stretch and rotational effect when known loads were applied to a given length of cable. The test results are summarized in tables 2-15 which indicate the amount of elongation produced by suspension with various loads and the amount of "return" to original length, both immediately after release of weights and as measured after the cables were removed from the test location, coiled, and allowed to relax for several hours or days.

SUMMARY

On the basis of the extensive tests reported here, the 3 X 19 cable is considered the most suitable of those now available for oceanographic applications, from the standpoint of its resistance to elastic and rotational stretch. In future procurement of marine cables, any new types under consideration should be similarly tested before adoption. New cable designs should be investigated as they are developed.

TABLE 1. MAJOR CHARACTERISTICS OF PRINCIPAL CABLE MATERIALS

Material	Composition	Applications	Advantages	Disadvantages	Comments
Blue center steel	Finest quality improved plow steel	Fabricated into ropes for uses requiring optimum strength, toughness and uniformity	Can withstand heavy loads, severe abrasion, shock, and vibration		All cables should be properly lubricated before immersion and carefully rinsed with fresh water after using in sea water
Plow steel		Steel ropes	High strength; unusual toughness		Advantages exceeded only by those of blue center grade
Traction steel		Designed especially for elevator cables	High resistance to bending fatigue; shows minimum wear over sheaves and drums		Is of exceptionally high quality
Iron ropes	Low carbon steel				Low in strength compared to other steel grades
Stainless steel	18 chromium, 8 nickel	Principally used for wire ropes in marine and aircraft applications and in industrial uses where excessive environments are to be encountered	Corrosion resistant when material is properly chosen and treated for expected environment	Inferior to carbon steel in stress fatigue	Recommended for situations requiring frequent submersion and removal rather than continuous submersion
Phosphor bronze rope	Tin-copper alloy	Used mainly when loads are light	Effectively resists certain types of corrosion; is nonmagnetic	Has little resistance to abrasion; low fatigue life	

TABLE 2. TEST FOR TOTAL STRETCH OF 0.170" DIA. CABLE (50-FT LENGTH)

Load (lb)	Number of Turns: To Unwind	Number of Turns: To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
500			0	0	
	137.0				
		56			
	54.4			10.00	
			18	10.12	
300		67.75	23		
	51.5				
100			42	6.00	
Load released				4.50	
100			0	0	
	40.0				
		25.5		3.0	
300			4		
	84.25		7		
		48.0			
500	104.75		96		
		51.25			
	37.5				
		16.00			
	8.25				
		3.5		10.00	
500			101	10.12	
Load released				6.00	
					Cable removed from tower, coiled in 2-ft circle, allowed to relax for 175 hr at 70°F. Cable measured; it had returned to original length and was in good condition.

TABLE 3. TEST FOR TOTAL STRETCH OF 0.170" DIA. CABLE (150-FT LENGTH)

Load (lb)	Number of Turns To Unwind	Number of Turns To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
1000			0	4.00	Test cable up in the control tower through three sheaves. Elastic stretch at loading.
	100		96	6.0	
	129.75		120		
		63.75			
	34.5				
		21.0		6.35	
	15.5		168	6.35	
		5.25			
	6.5				
		3.00		8.0	
			288	8.35	
	Load raised 50 feet				
	Load lowered 50 feet		336	8.83	Total elongation 26.5"
500				6.50	7" relaxation
	Load raised 50 feet				
	Load lowered 50 feet		408		
			456	7.50	
	51.75		504	2.12	
		13.5		2.83	
					When the final increment of load was released and the cable relaxed for 48 hours, the cable was back to its original length.

TABLE 4. TEST FOR TOTAL STRETCH OF 3 X 19E (0.217" DIAMETER) GALVANIZED MONARCH CABLE (150-FT LENGTH)

Load (lb)	Number of Turns To Unwind	To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
1500			0		
	40.5		72	0.67	
		23.33			
	14.33				
				1.0	
	27.75				The load was raised for 48 hours then lowered to distribute the loading equally in all sections of the cable.
		14.00			
	7.00				
		4.00	120	1.67	
	12.00				
		2.75		4.00	This resulted in an additional elongation of 7.0". When compared to the stretch in 120 hours with the same load, the effects of sheave resistance are striking.
1000			192		
			240	2.33	
500			264		
			336	1.5	
			408	0.67	
			456		

TABLE 5. TEST FOR TOTAL STRETCH OF WIRE CABLE 7 X 19 (150-FT LENGTH)

Load (lb)	Number of Turns: To Unwind	Number of Turns: To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
1500			0		Data required were limited to stretch characteristics after preload; therefore, the preliminary stretch measurement was not taken.
	319.8				
		202.0			
	164.5				
		130.8			
	95.0				
		64.0			
	37.3				
		14.8			
	4.5				
		2.1		4.79	
	Load raised 75 feet		48	4.83	
	Load lowered 75 feet				
	90.5				
		40.3			
	11.0				
		2.3	72	7.00	
	1.0		168	7.04	
1000		23.3			
	3.3				
		1.3		6.12	
	Load raised 75 feet		192		
	Load lowered 75 feet		240		
	21.6				
		3.3			
	1.1			6.50	
			312		

TABLE 5. (Continued)

Load (lb)	Number of Turns To Unwind	Number of Turns To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
500		42.3			
	6.3				
		1.5			
	1.3			5.03	
	Load raised 75 feet		360	4.95	
	Load lowered 75 feet		408		
		3.81			
	0.8				
		0.3		4.65	
			480	4.67	
0			504	1.04	Upon release of the last 500 lb, the wire cable twisted and curled considerably. There was a permanent stretch of 3.13 inches.

TABLE 6. TEST FOR STRETCH CHARACTERISTICS OF PRELOADED WIRE CABLE 3 X 19D, SPECIMEN 474, 3/32" DIAMETER, REEL 34893 (100-FT LENGTH)

Load (lb)	Number of Turns To Unwind	Number of Turns To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
292	2.33		0	-0.03	Data required were limited to stretch characteristics after preload; therefore, the preliminary stretch measurement was not taken.
	Load raised 50 feet		48	0.28	
	Load lowered 50 feet		72	0.72	
		67.5			
	20.0				
		7.5			
	4.5		144	0.72	
196				-0.28	As the load was lightened, the reduction in elongation extended negatively from the initial measurement.
	10.5			-0.31	
	Load raised 50 feet		192	-0.37	
	Load lowered 50 feet		288	-0.47	
			312	0.41	
	1.0				
		10.0			
100				1.94	
	Load raised 50 feet		336	-1.97	
	Load lowered 50 feet		360	-2.12	
		15.0			
	6.0		384	-2.12	
0				0.00	No permanent stretch.

TABLE 7. TEST FOR STRETCH CHARACTERISTICS OF PRELOADED WIRE CABLE 7 X 7D, SPECIMEN 475, 3/32" DIAMETER, REEL 34894 (100-FT LENGTH)

Load (lb)	Number of Turns: To Unwind	Number of Turns: To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
292			0		Data required were limited to stretch characteristics after preload; therefore, the preliminary stretch measurement was not taken.
	10.0				
		1.0			
	Load raised 50 feet		48	0.25	
	Load lowered 50 feet		72	0.63	
		37.0			
	5.0			0.63	
			168	0.75	
196				-0.16	As the load was lightened, the reduction in elongation indicated a zero elongation at 100 lb.
	Load raised 50 feet		192	-0.35	
	Load lowered 50 feet		216	-0.57	
		18.75			
	2.5		240	-0.50	
100				-1.69	
	Load raised 50 feet		264		
	Load lowered 50 feet		336		
			360	-1.66	
0				0.12	Permanent stretch.

TABLE 8. TEST FOR STRETCH CHARACTERISTICS OF PRELOADED STANDARD B.T. CABLE SPECIMEN 476, WIRE CABLE, 3/32" DIAMETER (100-FT LENGTH)

Load (lb)	Number of Turns: To Unwind	Number of Turns: To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
292			0		Data required were limited to stretch characteristics after preload; therefore, the preliminary stretch measurement was not taken.
	152.5				
		40.0			
	21.0				
		11.75			
	7.75				
		3.75			
	0.75			2.47	
	Load raised 50 feet		48		
	Load lowered 50 feet		120		
	45.0				
		4.0		4.00	
		14.25			
	1.5			3.75	
196		42.25			
	4.0			2.25	
	Load raised 50 feet		144	2.00	
	Load lowered 50 feet				
	3.25				
		2.0		1.97	
			168	1.97	
100		39.0			As the load was lightened, the reduction in elongation indicated a zero elongation at 100 pounds.
	6.5				
		2.0		0.35	
	Load raised 50 feet		240	0.35	
	Load lowered 50 feet				
		9.0	264		
	3.0			0	
0			288	1.63	Permanent stretch.

TABLE 9. TEST FOR TOTAL STRETCH OF H.I. WIRE CABLE (100-FT LENGTH)

Load (lb)	Number of Turns To Unwind	To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
(Hanger)					
39					
230			0	0.78	
		1.3			
	1.0				
		1.0			
	0.9				
		1.0			
	0.8				
		1.0		0.65	
	No rotation		72		
423				1.53	
	4.25				
		3.75			
	3.50				
		3.50			
	3.33				
		3.25			
	3.25				
		3.00			
	3.00				
		2.86			
	2.76				
		2.62			
	2.50			1.55	
	No rotation		144	1.75	

TABLE 9. (Continued)

Load (lb)	Number of Turns To Unwind	Number of Turns To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
616				2.22	
	5.13				
		4.75			
	4.50				
		4.38			
	4.13				
		4.13			
	3.88				
		3.88			
	3.63				
		3.50		2.35	
	No rotation		216	2.47	
809				2.90	
	5.25				
		5.25			
	5.13				
		4.88			
	4.75				
		4.63			
	4.50				
		4.38			
	4.25			3.12	
	No rotation		312	3.22	
1004				3.78	
	7.00				
		5.30			
	5.25				
		5.00			
	4.88				
		4.75			
	4.50				
		4.50		3.94	
	No rotation		384	4.10	
	No rotation		480	4.42	

TABLE 9. (Continued)

Load (lb)	Number of Turns To Unwind	To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
809			576	3.68	
		6.00			
	5.50				
		5.25			
	5.13				
		5.00			
	4.88			3.62	
	No rotation		648		
615		4.25		3.15	
	4.00				
		3.75			
	3.63				
		3.50			
	3.38				
		2.25		3.06	
	No rotation		744	3.03	
423				1.53	
		5.30			
	5.00				
		5.00			
	4.75				
		4.63			
	4.50			2.47	
	No rotation		816	2.35	

TABLE 9. (Continued)

Load (lb)	Number of Turns To Unwind	To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
230				1.35	
		5.63			
	5.00				
		4.75			
	4.50				
		4.38			
	4.25			1.75	
	No rotation		912	1.53	
(Hanger) 39	No rotation			1.06	
(Hanger)			1296	0.94	Permanent stretch. The cable shows excellent characteristics in resisting rotation under various loads. The elastic stretch reached 8.44 inches with a 1000-lb load.

TABLE 10. TEST FOR TOTAL STRETCH OF 0.123" DIA. STRANDED CABLE (100-FT LENGTH)

Load (lb)	Number of Turns To Unwind	To Wind	Stretch (in./50 ft)	Notes
Test 1.				
39.0				
134.5	8.75		0.35	
		6.50		
	5.00			
	After rotating to still condition		0.47	
Test 2.				
39.0				
760.0	82.00		2.37	
		60.75		
	53.25			
		40.00	3.32	
	Left hanging overnight		3.40	
	39.75			
		33.25		
	27.50			
		22.25		
	17.50			
		14.50		
	11.00			
		7.00		
	4.50			
		2.50	3.88	
Test 3.				
134.5			2.97	
1195.5	149.0			
		70.75		
	62.25			
		54.00		
	47.00			
		40.25		
	34.25			
		28.25		
	22.75			These tests were made for com-
		17.75		parison with those shown in
	After rotating to still condition		7.10	table 11 for 0.250" dia. cable.

TABLE 11. TEST FOR TOTAL STRETCH OF 0.250" DIA. STRANDED CABLE (100-FT LENGTH)

Load (lb)	Number of Turns To Unwind	To Wind	Stretch (in./50 ft)	Notes
Test 1.				
39.0				
	2.00		0.35	
		1.75	0.25	
134.5	1.62		0.35	
		1.50		
	1.50			
	After rotating to still condition		0.25	
Test 2.				
39.0				
760.0	21.50		0.68	
		20.25		
	20.75			
		19.00		
	18.25			
		17.75		
	17.25			
		16.75		
	16.25			
		15.50		
	15.00			
		14.50		
	14.00			
		13.75		
	13.25			
		13.00		
	12.50			
		12.25		
	After rotating to still condition		1.39	
Test 3.				
39.0	No rotation			
1198.5	30.50		1.44	
		27.00		
	25.00			
		25.00		
	24.00			
		23.25		
	22.25			
		21.50		These tests were made for com-
	20.75			parison with those shown in
	After rotating to still condition		2.16	table 10 for 0.123" dia. cable.

TABLE 12. TEST FOR TOTAL STRETCH OF BLACK POLYETHYLENE-COVERED STEEL CABLE (100-FT LENGTH)

Load (lb)	Number of Turns To Unwind	To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
39.0			0	0	Special consecutive hourly measurements were made on one day to determine the effect of temperature on the length measurement. No effect was noted.
521.0				1.22	
			72	1.25	
	29.75				
		26.00			
	23.50				
		21.25		1.62	
714.5				2.00	
	12.50		144		
		11.00			
	10.00				
		9.00			
	After rotating to still condition			2.28	
905.0				2.65	
			168	2.78	
	13.75				
		11.50			
	10.50				
		9.50			
	After rotating to still condition			2.92	The total stretch was 6 in/100' of cable; of this, 1-13/16" was due to unwinding of the cable under load. This rotational stretch was approximately 30% of the total stretch.
	No rotation		240	3.00	

TABLE 13. TEST FOR TOTAL STRETCH OF PACIFIC TEST ROPE 7971A, 3 X 36, SUPERSTEEL GALVANIZED, REGULAR LAY 3/8" DIAMETER (100-FT LENGTH)

Load (lb)	Number of Turns To Unwind	Number of Turns To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
39			0		
4000	16	0		2.5	
			24	3.06	The lack of rotation is a unique
			144	3.06	characteristic.

TABLE 14. TEST FOR TOTAL STRETCH OF 1 X 19 BETHANIZED FORMSET AIRCRAFT STRAND, 7/32" DIAMETER, WIRE ROPE, USED FOR THE MOHOLE PROJECT (100-FT LENGTH)

Load (lb)	Number of Turns To Unwind	Number of Turns To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
39 (Hanger)			0		Due to the urgency of this
4000				3.00	problem no intermediate
		42		5.00	loading was required. This
			24	5.75	cable was tested for a specific
	1.5	4	120	5.81	application.

TABLE 15. TEST FOR TOTAL STRETCH OF 3 X 31 WARRINGTON SCALE WIRE ROPE, 21/64" DIAMETER (100-FT LENGTH)

Load (lb)	Number of Turns To Unwind	Number of Turns To Wind	Time From Start (hr)	Stretch (in./50 ft)	Notes
4000			0	2.19	
	89 (slight braking action)				
		3		5.81	
			24	6.25	
	2.12				
		1		6.25	
			48		
	1.25				
		1		6.28	
	0.33		72		
		0.25		6.28	
			96	6.28	
			168		
	0.84				
		0.33		6.28	
	No rotation		336	6.28	This is considered a preliminary test. Due to excessive rotational stretch further testing was deemed unnecessary.

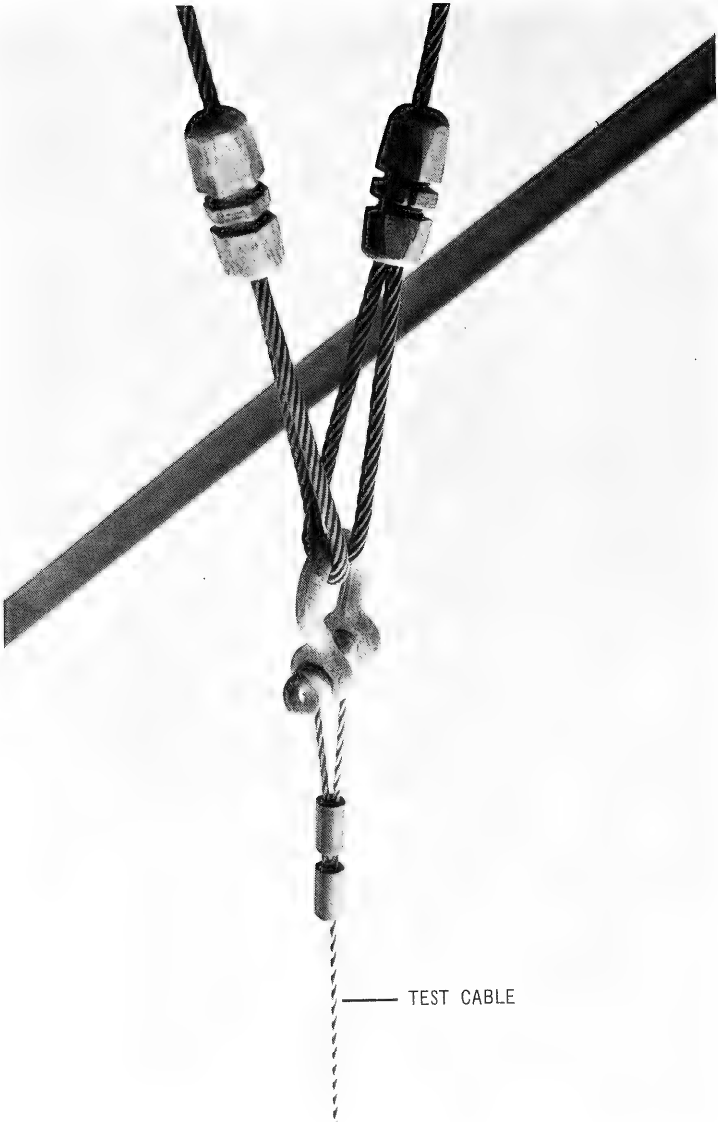

Figure 1. Fittings for securing cable.

Figure 2. Tractor and winch used for raising and lowering test cable.

Figure 3. Hanger and weights used for loading cable.

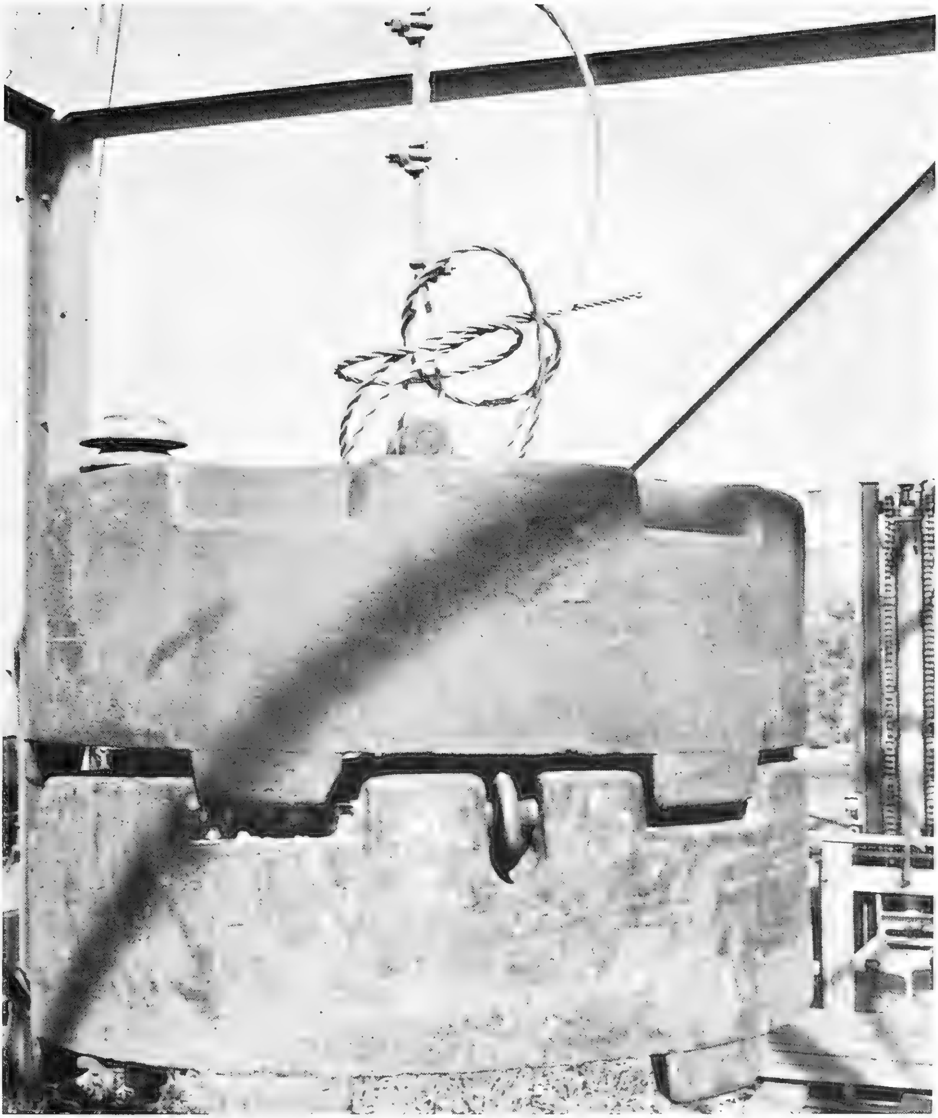

Figure 4. 4000-lb load on 3 X 31 wire rope of 21/64" diameter.

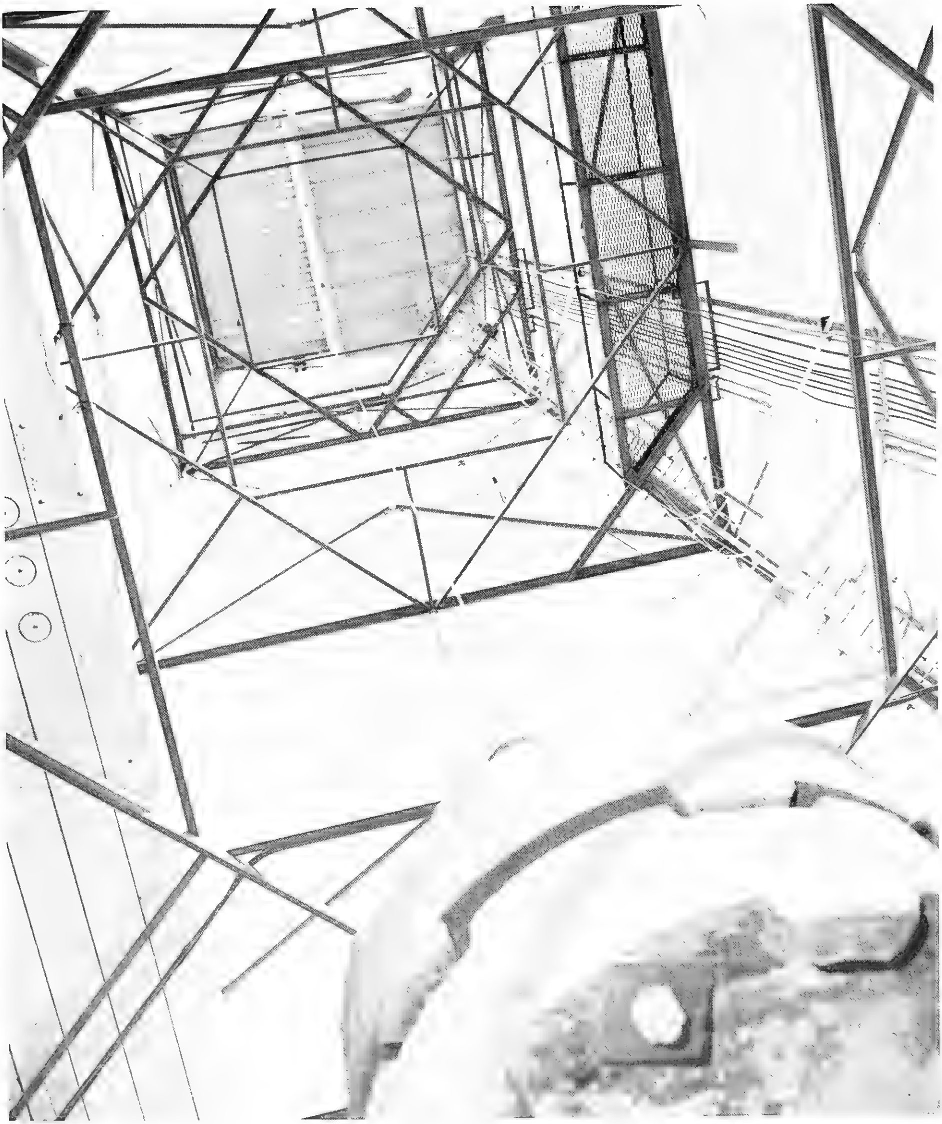

Figure 5. 4000-lb load secured to cable test specimen.

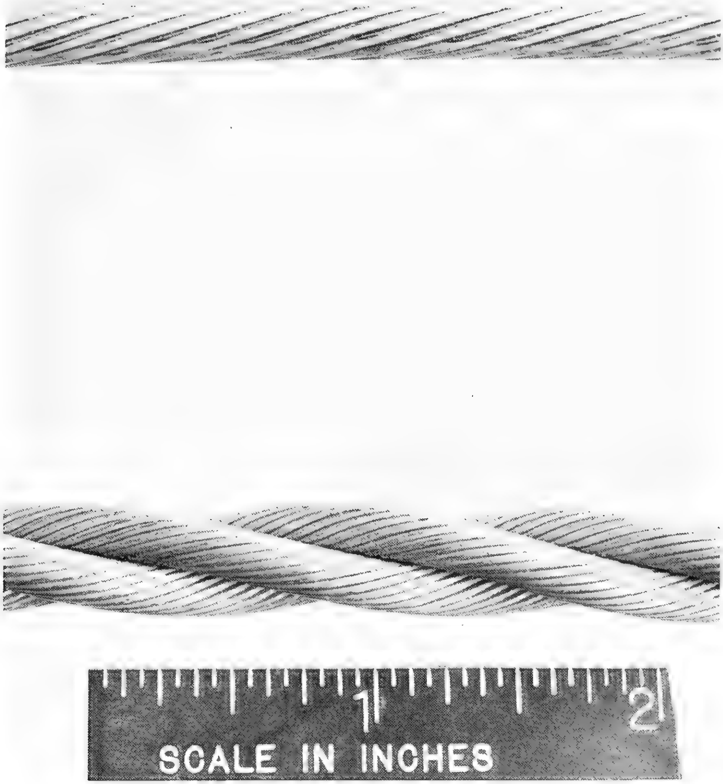

Figure 6. Cable used in Mohole project (top) and specimen of 3 X 31 wire rope 21/64" in diameter.

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Extensive tests were conducted on fourteen cables now in general use for marine operations, to determine their resistance to elastic and rotational stretch. The 3 X 19 cable was found to have characteristics that would favor its use for sensitive oceanographic problems when compared to the other cables tested.

1. Cables - Tests
2. Oceanography - Instrumentation
3. Underwater cables - Tests

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