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Gator-Max® & Gator-Laid® Slings

Re-writing rated capacity efficiency standards?

See Page 34 for details

Slingmax® Gator-Max® & Gator-Laid® slings

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Over the years, wire rope slings have been the mainstay of rigging and the backbone of the heavy lifting industry. One type of wire rope sling that has found favor over the years is the hand-braided sling, whereby the skills and talent of the individual splicers would play an important part in the strength, performance and quality of the slings. While an accepted strength efficiency was finally established, recent concerns have arisen over the overall consistency and actual breaking strength levels of the 9-part multiple-part braided slings.

Multi-part wire rope slings began with the braiding together of three individual wire ropes, much like the braiding of hair. This method of joining wire rope lengths into a common lifting assembly achieved higher strength, flexibility, into a stability, and nontwisting characteristics. Although the ultimate strength of the final braided sling would suffer in relation to the aggregate breaking strengths of the individual wire rope components, this type of sling did provide greater strength than previously fabricated slings, and enhanced flexibility during handling and rigging.

As time passed, more parts of wire rope bodies were braided together, commonly in 4, 6, 8 and 9-parts. Today, the most predominant type of braided sling incorporates 9-parts of wire rope intricately woven together to achieve high strength factors. As the wire rope components become larger, the labor time and costs for fabrication increases exponentially, and the strength efficiency of these braided slings decreases as the sling size increases.

The overall average breaking strength of braided slings, up through 2" diameter wire rope components, has been established at 70% of the aggregate component wire rope strengths. This is based on industry testing and the Wire Rope Technical Board. This has been accepted and assumed to be consistent until just recently when the U.S. Navy encountered several 9-part braided slings which failed to meet this 70% breaking strength efficiency. Because of these tests, the U.S. Navy initially downgraded the rated capacity of braided slings to 50% of the recognized published capacity values, and later increased this to only 70% of the listed rated capacities. This test data from the U.S. Navy on the 9-part braided slings not only fell short of the expected 70% efficiency, but showed a sizeable variation in the actual breaking strength values.

Today, tests are continuing to be conducted and splicing methods are being evaluated in an effort to verify the 70% efficiency value. But even prior to this revealing test data, Slingmax® had been developing new and improved procedures of fabricating 9-part braided slings. In lieu of using a single length of wire rope to braid a 9-part sling, a new method of braiding three lengths of wire rope into a finished 9-part sling was achieved. From this research and development, a new innovative wire rope sling has been introduced in the forms of Gator-Max® and Gator-Laid® slings from Slingmax®. These 9-part wire rope slings not only offer the inherent flexibility of braided slings with a 9-part body (Photo #1), but also assure a consistently higher breaking strength in all size ranges than the conventionally braided slings. This distinct advantage then translates into high rated capacities for the same size slings.

Photo #1
9 part braided body of Gator-Max® sling

The greater strength in the Gator-Max® and Gator-Laid® slings is partially achieved from altering the braiding method of the sling, but mostly from "parallel laid" eyes (Photo #2) involving 12 parts of wire rope in each eye in lieu of 10 parts as found in normally produced 9-part braided slings. This alone provides 20% more component strength in the eye, plus a higher efficiency of the parallel positioned eyes in lieu of the cross-laid eyes in normal braids. Since the weakest point in braided slings is in the eyes and at the tuck-in positions, increasing the number of wire rope parts in the eyes, along with the eye efficiency, the sling inherently has a significantly higher breaking strength.

Photo #2
12 part "parallel laid" eye of Gator-Max® sling

Another important advantage of these Gator-Max® and Gator-Laid® slings is the ability to be consistently fabricated into exact lengths meeting customer requirements (Photo #3). The small length tolerances that are possible with these slings, and in matched sling sets, have previously been unavailable in the industry. Experience over the years shows that the length tolerance of normal 9-part braided slings can vary considerably, and is difficult to hold less than +/- one half a body diameter. The Gator-Max® and Gator-Laid® slings show a remarkable ability to be consistently fabricated to less than one-half of a wire rope component size. The tech-

Photo #3
Matched sets of Gator-Max® slings

Photo #4
Ultimate tensile testing of Gator-Max® sling - 1/1 D/d ratio)

niques of braiding these new slings have proven to be repeatable in any fabrication shop, and reproducible at all locations. And with using three lengths of wire rope to fabricate these braided slings, splicers find it much easier to handle and control the braiding process.

Tests conducted by several sling fabricators, independent laboratories and the U.S. Navy prove that the Gator-Max® and Gator-Laid® 9-part braided slings achieve consistently higher splicing efficiency and overall strength than the normally produced 9-part braided slings. Actual tests conducted by the U.S. Navy show that the Gator-Max® and Gator-Laid® slings exceed the Navy requirements of meeting 70% of the aggregate nominal breaking strength of the wire rope components when tested over a pin with a 1/1 D/d ratio based upon the finished sling diameter or 4/1 based upon the component wire rope diameter (Photo #4). Identical testing programs have been conducted at other sites with the same D/d ratio, resulting in the same high strength results. Testing with the D/d ratio of 4/1 based upon component wire rope size, all slings tested broke at the contact point with the pin. Table #1 shows the test results of both Gator-Max® and Gator-Laid® slings using ½", 5/8" and 1" wire rope components with this 4/1 component wire rope to pin ratio.

In an effort to establish a method of closely predicting the actual breaking strengths of Gator-Max® and Gator-Laid® slings, three types of breaking strength tests using the same wire rope in these braided slings were conducted and compared to the actual breaking strengths of the finished Gator-Max® and Gator-Laid® slings. The first series of tests is the straight ultimate tensile tests on the wire ropes, performed mostly by the wire rope manufacturers. The second series of tests consist of the wire ropes being pulled to ultimate strength over a steel pin with a D/d ratio of 4/1 (Photo #5), simulating the breaking of the wire rope in a basket hitch configuration. In all cases, the wire rope failed at the bearing with the pin (Photos #6 & #7). The third series of tests involves laying a second loop of wire rope over an underlying loop and pulling it to ultimate breaking strength as shown in Photo #8). The wire rope loops were held in position with the use of U-bolts and tape (Photo #9), and were retained during testing by wedging the loops between the socket eye and a wood support (Photo #10). This third series actually places the outer rope under tension against an inner identical wire rope and increases the D/d ratio to 6/1 of the component wire rope diameter. Table #2 presents the resulting data from these tests.

The goal of the pin tests is to determine if there is a relationship between these pin breaking strengths to the actual breaking strengths of the Gator-Max® and Gator-Laid® braided slings. This would allow a pin test to be conducted on the wire rope used in the braided slings with parallel eyes whereby the actual breaking strength of the slings can be closely predicted. As seen from the data in Table #2, a relationship does exist on the wire rope to pin tests using consistent D/d ratios. This has been established throughout the years, but these tests expand the comparisons to 6 x 25 FW versus 6 x 36 WS construction and EIP to EEIP wire rope strengths.

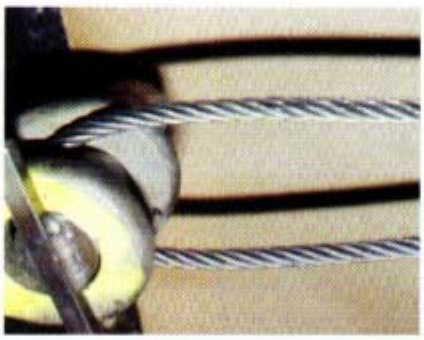

Photo #5
Wire rope pin test - 4/1 D/d ratio

The wire rope loops pulled to destruction over inner loops of wire rope were conducted to determine if a significant difference in breaking efficiency occurs at this slightly higher 6/1 D/d ratio and with the wire rope body compressing against another wire rope instead of against a smooth bodied steel pin. The data suggests that the efficiency of the wire ropes in this configuration is actually slightly less than the same wire rope tested over a steel pin with a smaller D/d ratio of 4/1. This substantiates what has been consistently observed in the testing of Gator-Max® and Gator-Laid® slings; that is ultimate breaking strength of the slings, the outer wire rope parts in the eyes always break first. It is felt that this occurs from the strength reducing phenomenon of wire rope notching and crushing against adjacent wire rope, and the limiting ability of the wire rope to adjust around the bend.

In conclusion, the Gator-Max® and Gator-Laid® braided slings consistently achieve significantly higher breaking strengths than normal 9-part braided slings, especially with the lower D/d ratios of bending in the eyes. This is accomplished by 12 parts of wire rope in the eyes as compared to 10 for other 9-part braided slings; by parallel laying of the wire rope in the eyes; and by a more balanced and uniform braiding of the three wire ropes in the body in lieu of one. The actual effect of crossing the wire rope in the eyes as compared to parallel laying is evident from the comparative data of the Gator-Max® and Tri-Flex® slings in Table #1. These higher breaking strengths allow the Gator-Max® and Gator-Laid® slings to be rated with higher working load limits than normal 9-part braids. All testing shows that the Slingmax® braided slings well exceed the requirements as calculated with an efficiency factor of 70% and design factor of 5/1, as listed in the Wire Rope Sling Users Manual. In fact, these tests substantiate the efficiency of the Gator-Max® and Gator-Laid® slings at a minimum of 75% based on actual wire rope breaking strengths, and even higher based upon nominal wire rope strengths. Consequently, the rated capacities of Gator-Max® and Gator-Laid® slings have been proven to be greater than regular 9-part braided slings.

Next, there is a relationship of the actual breaking strengths Gator-Max® and Gator-Laid® braided slings to pin tests based on the testing data. However,

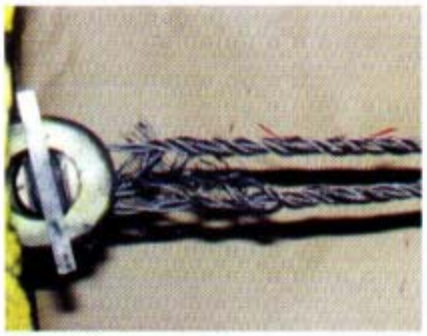

Photo #6
Wire rope rupture in pin test - 4/ D/d ratio

Photo #7
Failure location of wire rope in pin test at pin contact

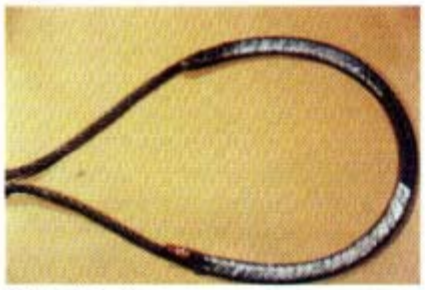

Photo #8
Dual wire rope loop arrangement for pin test

Photo #9
Dual loops with tape & u-bolts for pin testing

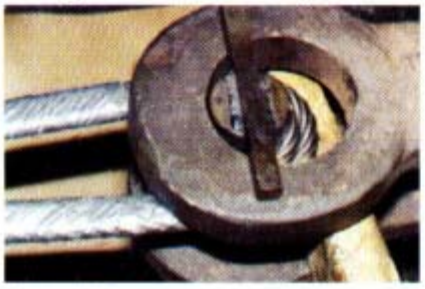

Photo #10
Positioning of dual loops of wire rope for pin test

Table #1
Slingmax® - Gator-Max® & Gator-Laid® Sling Tests
(Tests Conducted with D/d Sling to Pin Ratio of 1/1. unless noted)

SLING TYPE/SIZE	AGGREGATE WIRE ROPE B.S. NOMINAL	AGGREGATE WIRE ROPE B.S. ACTUAL	ACTUAL SLING B.S.	EFF. BASED ON AGG. WIRE ROPE B.S. NOMINAL	EFF. BASED ON AGG. WIRE ROPE B.S. ACTUAL
Gator-Max® - 2" with thimbles	239,000#	252,000#	238,000#	99.4%	94.4%
Gator-Max® - 2"	239,400#	254,700#	222,500#	92.9%	87.4%
Gator-Max® - 2"	239,400#	254,700#	221,800#	92.7%	87.1%
Gator-Flex® - 2" Crossed Eyes	239,400#	270,500#	206,000#	86.0%	76.1%
Gator-Max® - 2½"	370,800#		285,000#	77.0%	
Gator-Max® - 2½"	370,800#		290,200#	78.3%	
Gator-Flex® - 2½" 8" pin - D/d = 3.2	370,800#		360,000#	97.1%	
Gator-Max® - 4"	930,600#		695,600# (Avg. of 5 tests - 521,800# not included)	74. 7%	

Table #2
Wire Rope / Pin - Breaking Strength Tests
(D/d Wire Rope to PIN Ratio of 4/1)

WIRE ROPE DESCRIPTION	2 X ACTUAL TEN. B.S.	BASKET HITCH B.S.	BASKET HITCH EFFICIENCY	WIRE ROPE ON WIRE ROPE B.S.	WIRE ROPE ON WIRE ROPE EFFICIENCY
½" 6 X 36 WS RRL EIP IWRC	55,600#	45,130#	81.2%		
½" 6 X 36 WS RRL EIP IWRC	60,000#	47,900#	79.8%		
½" 6 X 36 WS RRL EIP IWRC	57,400#	44,250#	77.1%		
½" 6 X 36 WS RRL EIP IWRC (Avg. of 4 tests)	58,000#	46,300#	79.8%	44,900#	77.4%
½" 6 X 36 WS RRL EEIP IWRC (Avg. of 3 tests)	60,400#	48,000#	79.5%	46,800#	77.5%
½" 6 X 25 FW RRL EIP IWRC	56,000#	42,200#	75.4%		
½" 6 X 25 FW RRL EIP IWRC (Avg. of 4 tests)	59,200#	46,600#	78.7%	45,800#	77.4%
½" 6 X 25 FW RRL EEIP IWRC	59,200#	47,000#	79.4%	45,900#	77.5%
⅝" 6 X 36 WS RRL EIP IWRC	66,800#	43,200#	77.3%	65,800#	76.2%
⅝" 6 X 36 WS RRL EIP IWRC	67,300#	43,200#	77.9%		
1" 6 X 36 WS RRL EIP IWRC	158,900#	105,700#	75.2%		

Table #3
Sling Tests Vs Pin Tests

Sling Type & B.S.	Avg. PIN Test & B.S. %	(6)x(PIN Test B.S.)	Sling B.S.	Sling B.S./ (6)x(PIN Test)
½" 6 X 25 FW RRL EIP IWRC	45,700# 78.0%	274,200#	221,800#	80.9%
½" 6 X 25 FW RRL EEIP IWRC	47,000# 79.5%	282,000#	222,500#	78.9%
½" 6 X 36 WS RRL EIP IWRC	46,100# 78.8%	276,600#	206,000#	74.4%
⅝" 6 X 36 WS RRL EIP IWRC	67,100# 76.6%	402,600#	287,600#	71.4%
1" 6 X 36 WS RRL EIP IWRC	158,900# 74.7%	953,400#	666,700#	69.9%

this efficiency relationship seems to decrease with increasing sling size as shown in Table #3. The testing of wire ropes nested on top of wire rope around pins show they break consistently about 1.7% to 2.4% less than wire ropes on steel pins. This corroborates the findings in actual testing of these slings with the outer layer of wire rope always breaking first in the eye at the bearing against the pin. However, to simplify testing, a pin test with only a single basket hitch arrangement can be used with a 4/1 D/d ratio. The pin test data will simply be adjusted slightly downward to reflect the weakest point of the sling. Table #4 shows empirical formulas developed from the sling tests and pin tests which will accurately project the actual breaking strengths of Gator-Max® and Gator-Laid® slings.

The test data indicates there are no significant differences in pin tests nor sling test efficiencies with EIP and EEIP strength wire ropes, so the higher EEIP strength wire rope slings reflect a greater breaking strength than slings fabricated with EIP wire rope. So with the existing data, no differences between EIP and EEIP wire rope strength efficiencies could be accounted for in calculating the projected sling breaking strengths. The actual breaking strengths of the Gator-Max® and Gator-Laid® slings can closely be predicted by applying an efficiency factor to the actual breaking strength of the wire rope being used in fabrication. Presently, the efficiency factor used is 80%. The current testing largely substantiates this efficiency , and suggests that it is conservative in many cases.

The Gator-Max® and Gator-Laid® Braided slings can also be fabricated to extremely close length tolerances, as proven by the repeatability at an individual Slingmax® facility, and the reproducibility at all Slingmax® locations. These close tolerances allow adherence to customer requirements, resulting in high quality performance and equalized loading with matched sets of slings. This has been confirmed by the Slingmax® facilities and independent evaluation.

Table #4
Closest Fit Data Formula

2" GATOR-MAX® & GATOR-LAID®	CALC. B. S. = (4/1 PIN TEST)X(6)X(.75)
2½"	CALC. B. S. = (4/1 PIN TEST)X(6)X(.72)
4"	CALC. B. S. = (4/1 PIN TEST)X(6)X(.70)

The Slingmax® Gator-Max® and Gator-Laid® slings are truly innovations which have improved the overall quality and value of braided slings. More developments are underway at Slingmax® involving continuing testing of current products and development of new slings and fabrication methods to advance the rigging industry.

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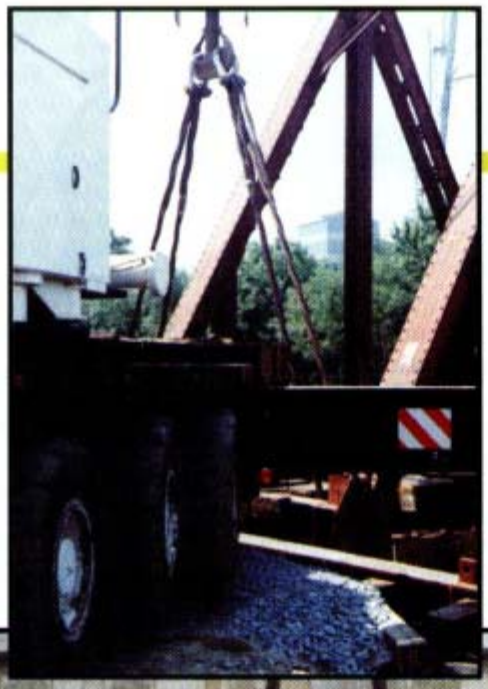
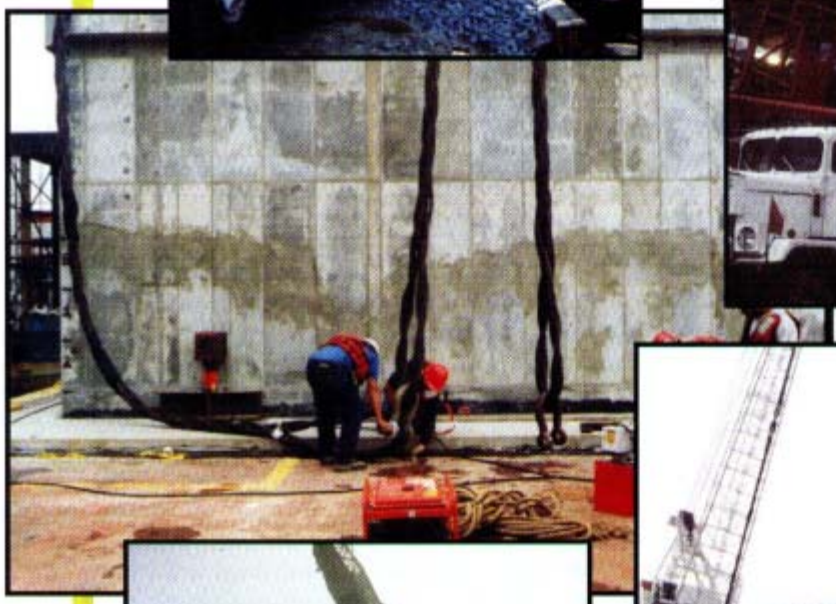
Slingmax® Multi Part Slings in Action!





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