Sling vs single strand testing report

VERSION 1.0, 2022

OVER THE EDGE
RESCUE

Sling vs Single strand Testing Report

Version 1.0 , 2022

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For the latest version and for referencing purposes use:

Prattley, Grant. **Why is a sling 2x the strength of a single strand?**

Over the Edge Rescue. Version 1.0, 2022.

https://overtheedgerescue.com/anchors/sling-strength-vs-single-strand

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Introduction

This question was sent to me recently

How is a loop of rope (or sling) theoretically twice as strong as a single strand? At the end of the loop (i.e. where it goes around a carabiner), isn't there is a point where it's a single strand? The rope (or sling) must be under equal tension from either side, thus at the top, bearing the entire load on this single strand?

This test report uses evidence to back up the theory explained in the blog post here:

https://overtheedgerescue.com/anchors/sling-strength-vs-single-strand

What we set out to do

Test that a sling was double the strength of a single strand in webbing.

Variations tested include:

- With 16mm Aspiring Nylon tubular webbing (12.5kN)
  - Single strand, with a tied overhand on a bight knot on each end, 12mm pins.
  - Sling, joined with a tape bend, 12mm pins.
  - Single strand, with a sewn loop on each end, 12mm pins.
  - Sling, sewn, 12mm pins.
- With 13mm Aspiring Dyneema webbing (17kN)
  - Single strand, with a sewn loop on each end, 12mm pins.
  - Sling, sewn, 12mm pins.
  - Sling, sewn, 30mm pins.

Methods and materials

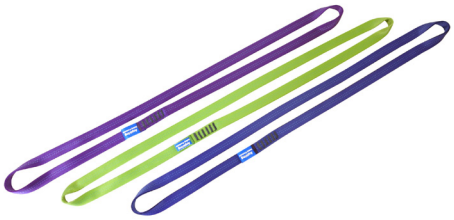
Methods

Slow pull tests

- As each test destroyed the webbing, it was new for every test.
- All knots, bends and hitches had all strands tightened with hand tension.
- Each testing series records the slow pull tests set up (see App. 1 & 2).
- The slow pull testing was in one location:
  - Aspiring Safety, 1/6 Burdale Street, Riccarton, Christchurch, New Zealand.[1]
- Vertical testbed 1.6m Electronic Universal Testing Machine, Model WDW-50
  - Maximum Test Force 50kN, sample rate 60 per second
  - Jinan Chuanbai Instrument Equipment Co Ltd

Materials

Aspiring 16mm Nylon tubular webbing



- Width: 16mm
- Weight: 34 g/m
- Breaking strength: 12.5kN single strand, 22kN sling
- Materials: Nylon
- Standards: EN 565:2017 (webbing) and EN 566 (Sling)
- Brand: Aspiring – https://aspiring.co.nz

General Properties of Nylon 6[2]

- Elongation @ Break (%): 16-19
- Melting Point (°C): 215

Aspiring 13mm Dyneema webbing

- Width: 13mm
- Weight: 42 g/m
- Breaking strength: 17kN single strand, 22kN sling
- Materials: Dyneema
- Standards: Complies with EN 566 (sling)
- Brand: Aspiring – https://aspiring.co.nz

General Properties of Dyneema[3]

- Elongation @ Break (%): 2-5
- Melting Point (°C): 150

1 https://www.aspiring.co.nz
2 https://www.rykneldtean.co.uk/products/polyamide-webbing/
3 https://www.sciencedirect.com/topics/engineering/dyneema

Slow pull test results

Aspiring 16mm Nylon Webbing

Items tested	Avg. kN	%	# tests	Comment	Appx. 1
Between 12mm pins					
Single strand, overhand on a bight knot each end	9.57	66	5	Broke at one of the overhand knots, single strand side	pg. 9
Sling, joined by a tape bend	20.72	83	5	Broke at one side of the tape bend	pg. 12
Single strand, sewn loop each end	11.59	93	5	Broke at one of the stitching blocks, single strand side	pg. 15
Sling, sewn	26.09	104	5	Broke at one side of the stitching block	pg. 18

Aspiring 13mm Dyneema Webbing

Items tested	Avg. kN	%	# tests	Comment	Appx. 2
Between 12mm pins					
Single strand, sewn loop each end	16.93	100	5	Permanent deformation (4) or broke (1) in webbing on the single strand	pg. 21
Sling, sewn	26.80	79	5	Mostly broke except for a few strands at 12mm pin	pg. 24
Between 30mm pins					
Sling, sewn	29.76	88	5	Permanent deformation in webbing (1), mostly broke except a few strands (1), broke stitching block (2), broke in webbing (1)	pg. 27

Analysis of the testing

Items tested	Tested between	Single strand (kN)	Sling (kN)	Multiplication Factors (2 DP)	(1 DP)
16mm webbing tied	Both 12mm pins	9.57	20.72	2.17	2.2
16mm webbing sewn	Both 12mm pins	11.59	26.09*	2.25	2.3
13mm webbing sewn	Both 12mm pins	16.93	26.80	1.58	1.6**
13mm webbing sewn	12mm pins single strand 30mm pins sling	16.93	29.76	1.76	1.8***
			Average	1.94	1.9

Sling (kN) DIVIDED BY Single Strand (kN) = Multiplication Factor (to 1 or 2 decimal places – DP)

Theoretically, a sling should be 2x the strength of a single strand. As you can see, the results are close to being a 2x (average 1.9x) multiplication factor from a single strand compared to a sling.

As the breaking strength of the webbing has not changed, the only way for this 2x multiplication factor to occur is for the tension on all parts of the sling have to be half the load.

Testing Notes

* Results with the Aspiring 16mm Nylon sling were higher than the stated 22kN (EN566) on the label, as the label reflects the EN sling standard, not the test results.

**Results with the Dyneema 13mm the sling were less than 2x (1.6x). The effect of the tight radius of the 12mm pin in combination with the material (Dyneema) properties (such as lower melting point and lower stretch – compared to Nylon) could be the reason for this not reaching 2x.

***In order remove the influence of the 12mm pins and to get the Dyneema 13mm sling to break in the webbing we tested with 30mm pins (for comparative purposes). The effect was to move the failure to either the webbing or the stitching block in between the two 30mm pins and increase the breaking strength of the sling by 2kN and closer to 2x (1.8x) breaking strength of a single strand.

Conclusions

1. That testing shows a sling is around 2 times the breaking strength of a single strand.
2. As the breaking strength of the webbing has not changed, the only way for this 2x multiplication factor to occur is the tension on the sling must be half the load – the load divided by 2.

Note: see the Blog Post reference below for more information on the theory behind sling strength.

Why is a sling 2x the strength of a single strand? Over the Edge Rescue. Version 1.0, 2022.

https://overtheedgerescue.com/anchors/sling-strength-vs-single-strand/

Disclaimer

1. Information contained in this test report is not an instructional guide—intended to supplement training from experienced and competent instructors.
2. Use at your own risk. The publisher and author assume no responsibility or liability for any accident, injury, loss or damage sustained while following any of the recommendations or techniques described.
3. The publisher and author assume no responsibility or liability for any errors or omissions in the content of this report. The information contained in this report is provided on an "as is" basis with no guarantees of completeness, accuracy, usefulness or timeliness.
4. Testing was under controlled conditions with a limited set of equipment. Testing with different equipment or operating in different conditions may result in different outcomes.
5. The views, information, or opinions expressed in the test report are solely those of the author and do not necessarily represent those of other organisations or individuals listed.

Glossary of terms

Bend: Where two pieces of rope or webbing are tied together usually at their ends, with both playing an integral part. The load is pulling in line through the bend. An example is a double fisherman's bend.

Break/Broke: to (cause something to) separate suddenly or violently into two or more pieces.

Force (kN): In physics, force is the push or pull on an object with mass that causes it to change velocity (to accelerate). Force represents as a vector, which means it has both magnitude and direction. The SI unit of force is the newton (N).

Knots: 'If it's not a bend or a hitch then it's a knot'. In the widest sense a generic name for all types of rope and cord entanglements but specifically where a connection is tied that is self-sustaining in rope or webbing.

Load: Load is weight or source of pressure borne by someone or something.

Maximum Force (kN): Maximum amount of tensile stress that the material can withstand before failure (rupture), such as breaking or permanent deformation. Tensile strength specifies the point when a material goes from elastic to plastic deformation.

Sling: In climbing and rigging, is a an item of equipment consisting of a tied or sewn loop of webbing.

Strand: fibers or filaments twisted, plaited, or laid parallel to form a unit for further twisting or plaiting into yarn, thread, rope, or cordage.

Tension: In physics, tension is described as the pulling force transmitted axially by the means of a string, a cable, chain, rope or similar object.

Appendix 1: 16mm Nylon Webbing Tests

16mm webbing, single strand, tied overhands

Materials

Webbing	– Aspiring Nylon Webbing 16mm (12.5kN)

Test setup

Knots	– Overhand on a bight each end

Test parameters

Speed	– Slow pull 100mm/minute
Tested between	– 12mm pins

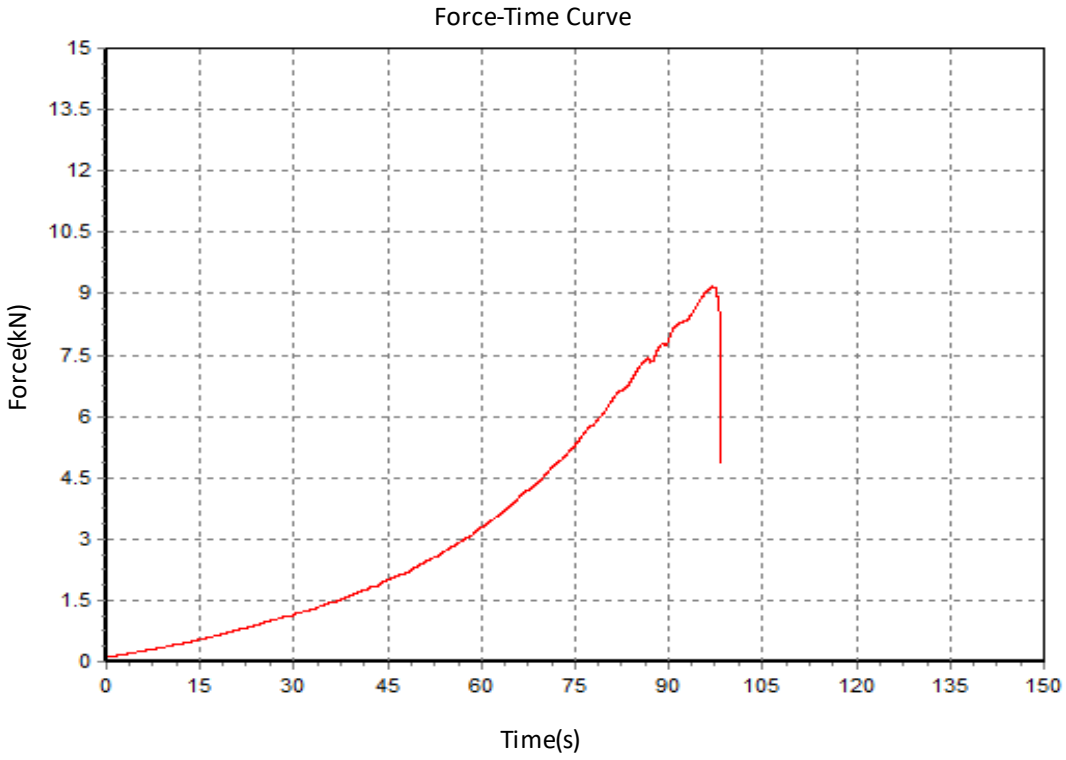
Results

Date	#	Max force (kN)	%	Comments
15/06/22	1	9.76	78%	Broke at one side of the overhand on a bight, single strand side
15/06/22	2	9.89	79%	Broke at one side of the overhand on a bight, single strand side
15/06/22	3	9.23	74%	Broke at one side of the overhand on a bight, single strand side
23/06/22	8*	9.17	73%	Broke at one side of the overhand on a bight, single strand side
23/06/22	9	9.80	78%	Broke at one side of the overhand on a bight, single strand side
Average		**9.57**	**77%**	

* Sample 23/06/22 #8 shown on the following pages.

ASPIRING

Test Date:	Monday, 27 June 2022
Max Force (kN):	9.17
Product Name:	Single strand, two tied loops
Test #:	8
Material:	16mm Aspiring Nylon webbing



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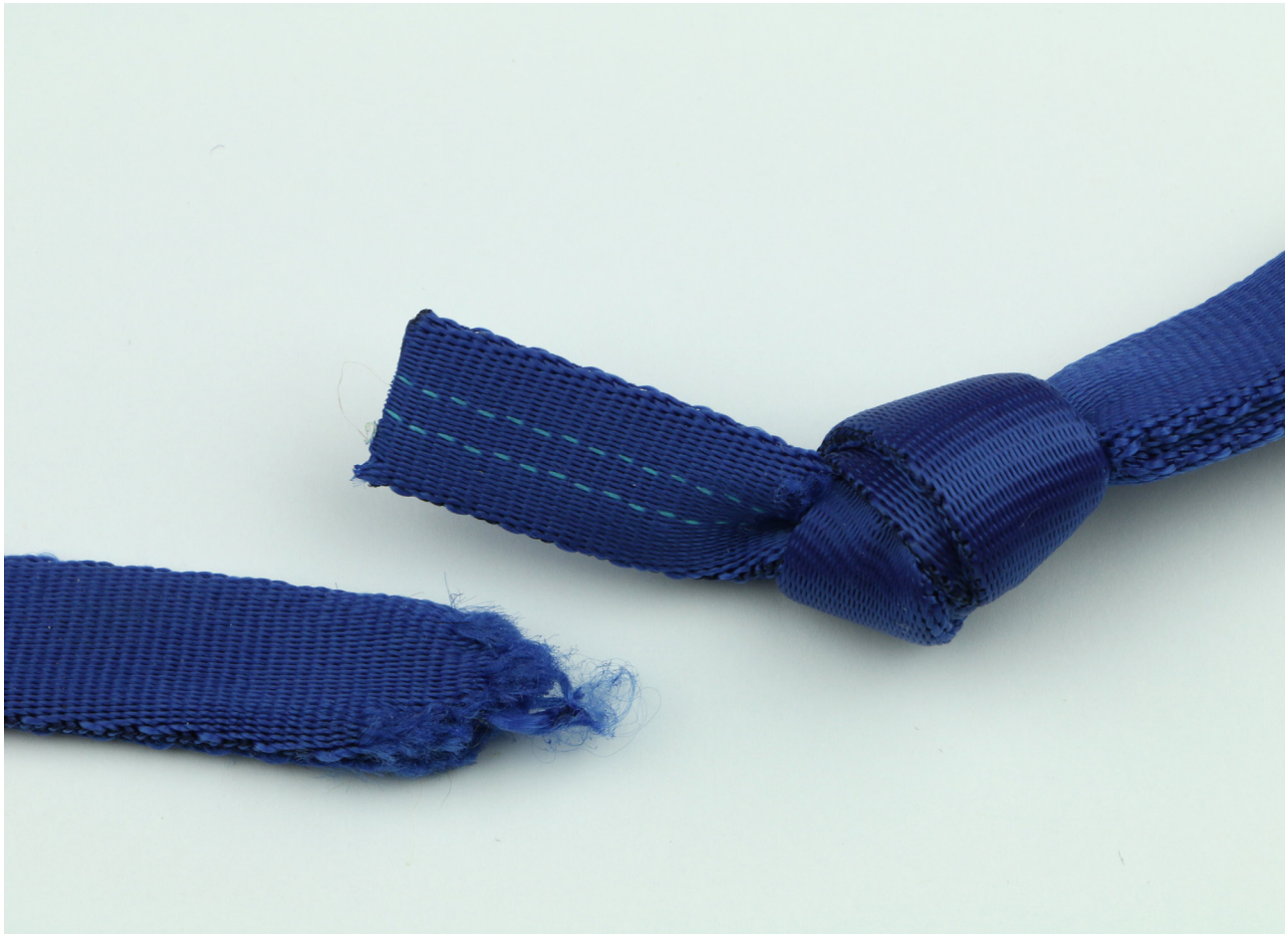
Tested by: Grant Prattley

Signed:

Machine has a current calibration certificate. www.aspiring.co.nz


#: 8 Date: 23/06/22
Test: Slow Pull 100mm/min
Type: Single strand, tied overhand loops
Webbing: 16mm Nylon Aspiring
Force: 9.17kN (73%)



16mm webbing, sling, tape bend

Materials

Webbing	– Aspiring Nylon Webbing 16mm (12.5kN)

Test setup

Bends	– Joined with a tape bend

Test parameters

Speed	– Slow pull 100mm/minute
Tested between	– 12mm pins

Results

Date	#	Max force (kN)	%	Comments
15/06/22	4	21.39	86%	Broke at one side of the tape bend
15/06/22	5	19.00	76%	Broke at one side of the tape bend
15/06/22	6	22.44	90%	Broke at one side of the tape bend
23/06/22	10	20.70	83%	Broke at one side of the tape bend
23/06/22	11*	20.08	80%	Broke at one side of the tape bend
Average		**20.72**	**83%**	

* Sample 23/06/22 #11 shown on the following pages.

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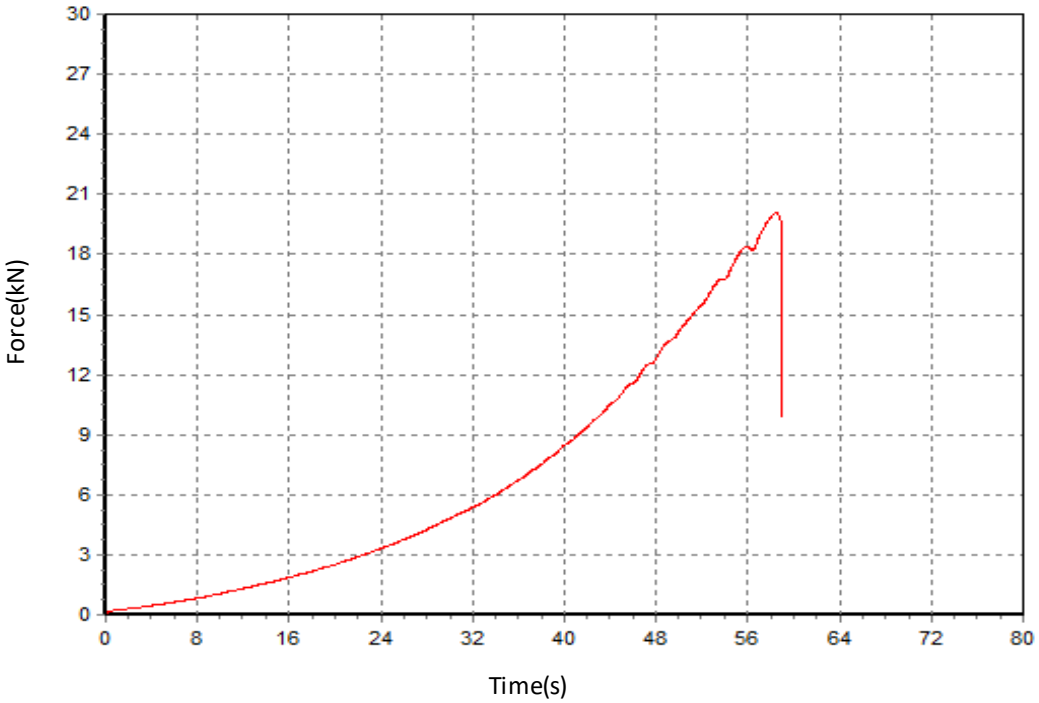
Test Date: Monday, 27 June 2022
Max Force (kN): 20.08
Product Name: Sling, tape bend
Test #: 11
Material: 16mm Aspiring Nylon webbing

Force-Time Curve



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#: 11 Date: 23/06/22
Test: Slow Pull 100mm/min
Type: Sling, tied tape bend
Webbing: 16mm Nylon Aspiring
Force: 20.08kN (80%)

16mm webbing, single strand, sewn

Materials

Webbing	– Aspiring Nylon Webbing 16mm (12.5kN)

Test setup

Sewn	– Loops sewn on each end

Test parameters

Speed	– Slow pull 100mm/minute
Tested between	– 12mm pins

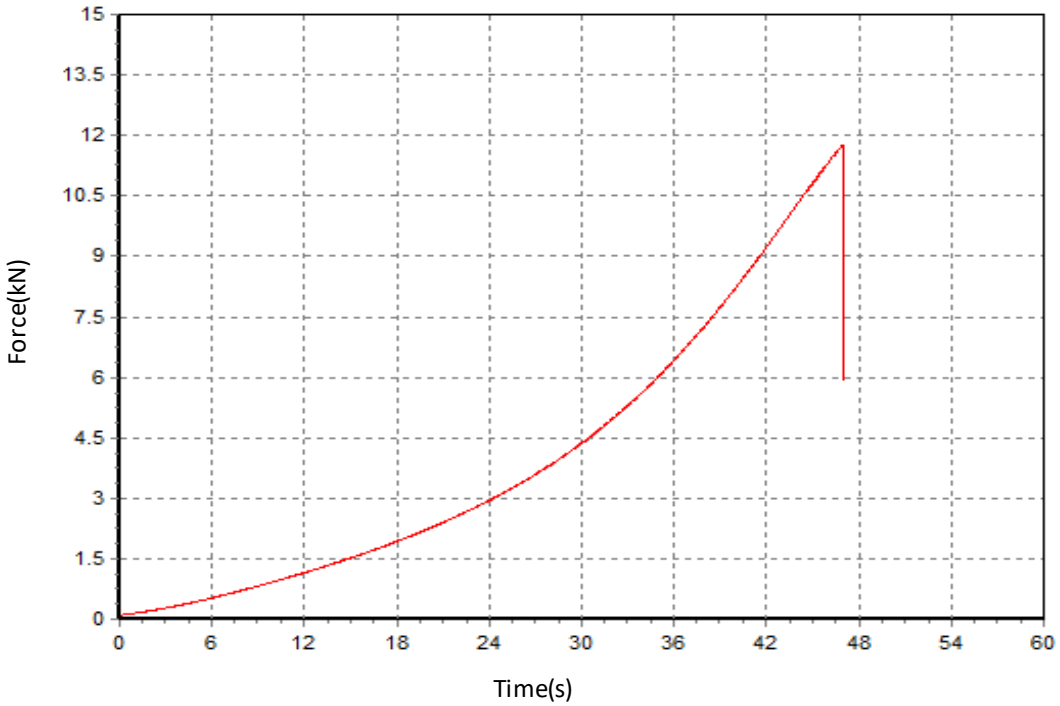
Results

Date	#	Max force (kN)	%	Comments
23/06/22	1*	11.75	94%	Broke at one side of the overhand on a bight, single strand side
23/06/22	2	12.02	96%	Broke at one side of the overhand on a bight, single strand side
23/06/22	3	11.05	88%	Broke at one side of the overhand on a bight, single strand side
23/06/22	6	11.80	94%	Broke at one side of the overhand on a bight, single strand side
23/06/22	7	11.33	91%	Broke at one side of the overhand on a bight, single strand side
Average		**11.59**	**93%**	

* Sample 23/06/22 #1 shown on the following pages.

Test Date:	Monday, 27 June 2022
Max Force (kN):	11.75
Product Name:	Single strand, two sewn loops
Test #:	1
Material:	16mm Aspiring Nylon webbing

Force-Time Curve



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#: 1 Date: 23/06/22
Test: Slow Pull 100mm/min
Type: Single strand, sewn loops
Webbing: 16mm Nylon Aspiring
Force: 11.75kN (94%)

16mm webbing, sling, sewn

Materials

Webbing	– Aspiring Nylon Webbing 16mm (12.5kN)

Test setup

Sewn	– Sewn on one side to make a loop

Test parameters

Speed	– Slow pull 100mm/minute
Tested between	– 12mm pins

Results

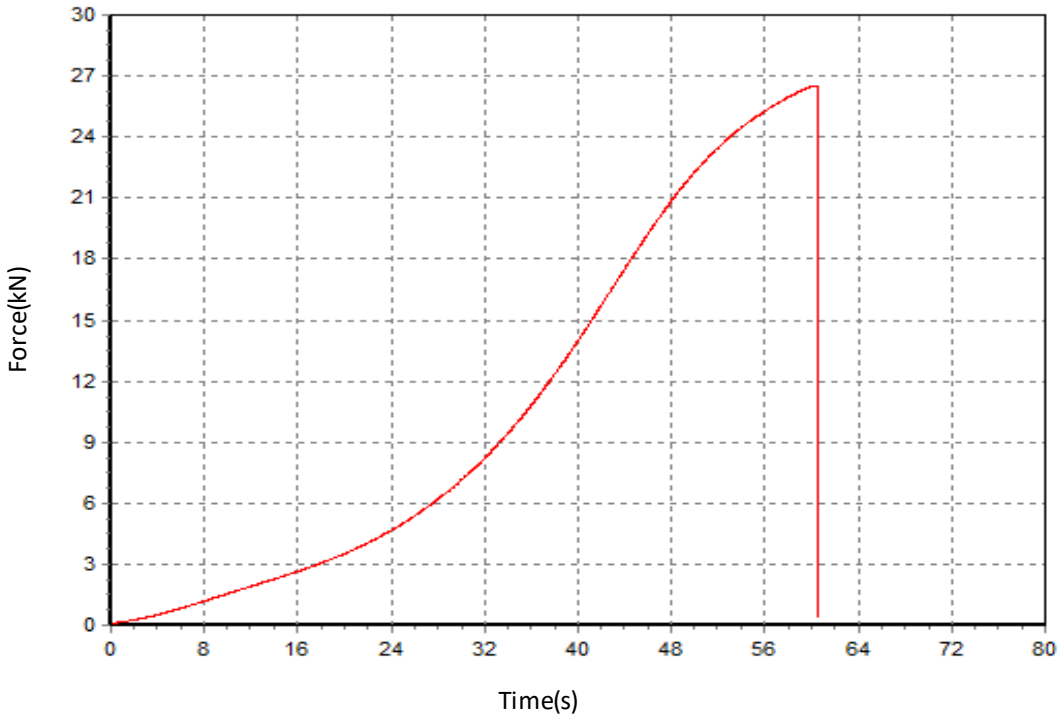
Date	#	Max force (kN)	%	Comments
15/06/22	7	25.92	104	Broke at one side of the stitching block
15/06/22	8	26.49	106	Broke at one side of the stitching block
15/06/22	9	25.95	104	Broke at one side of the stitching block
23/06/22	12*	26.52	106	Broke at one side of the stitching block
23/06/22	13	25.55	102	Broke at one side of the stitching block
Average		**26.09**	**104**	

* Sample 23/06/22 #12 shown on the following pages.

ASPIRING

Test Date:	Monday, 27 June 2022
Max Force (kN):	26.52
Product Name:	Sling, sewn
Test #:	12
Material:	16mm Aspiring Nylon webbing

Force-Time Curve



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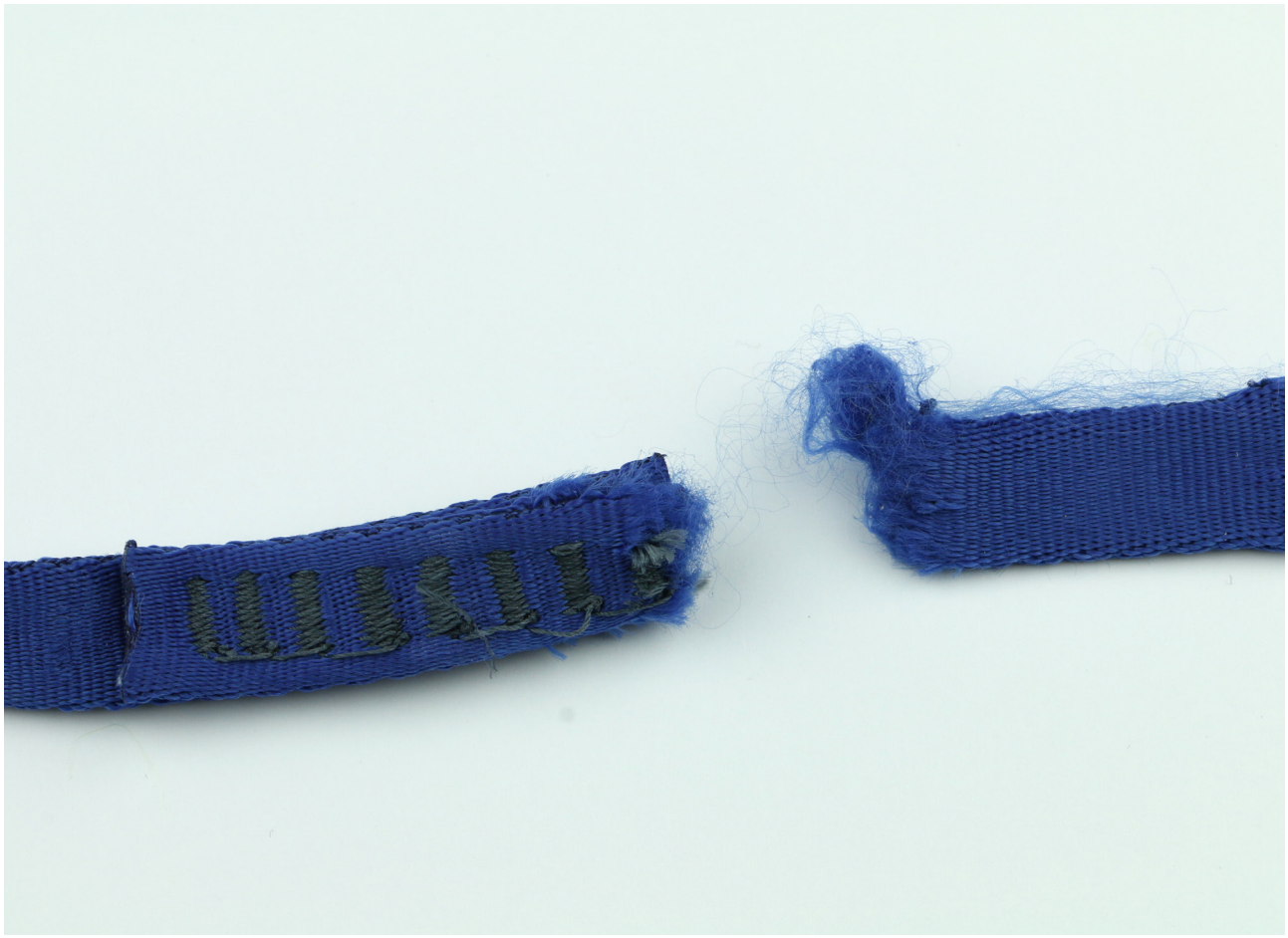
#: 12 Date: 23/06/22
Test: Slow Pull 100mm/min
Type: Sling, sewn
Webbing: 16mm Nylon Aspiring
Force: 26.52kN (106%)

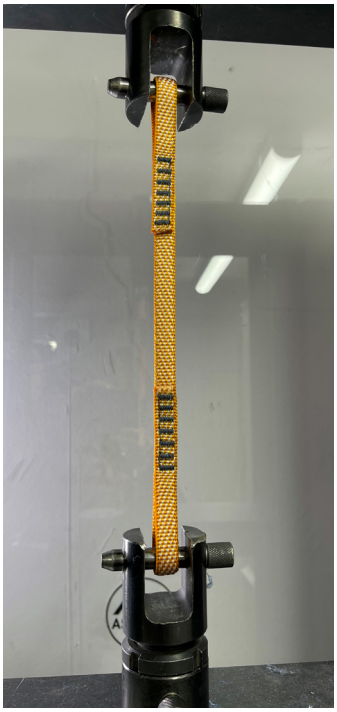


Appendix 2: 13mm Dyneema Webbing Tests

13mm webbing, single strand, sewn

Materials

Webbing	– Aspiring Dyneema Webbing 13mm (17kN)



Test setup

Sewn	– Loops sewn on each end

Test parameters

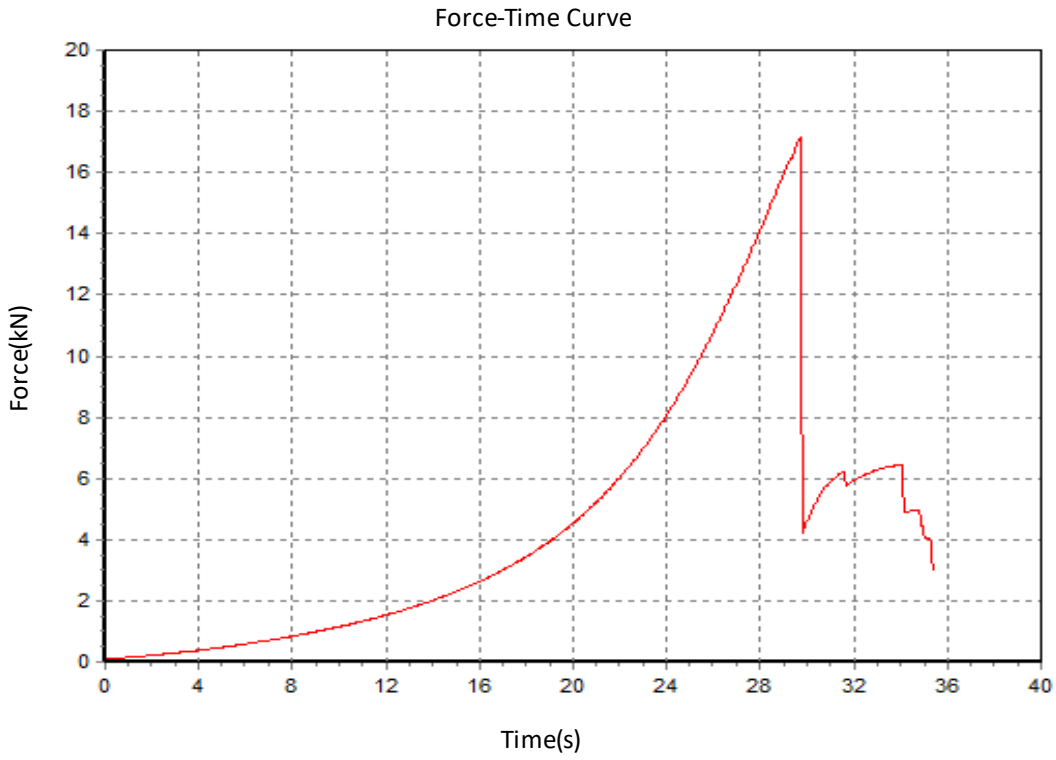
Speed	– Slow pull 100mm/minute
Tested between	– 12mm pins

Results

Date	#	Max force (kN)	%	Comments
15/06/22	10	16.56	97	Permanent deformation of webbing on the single strand
15/06/22	11	17.14	101	Permanent deformation of webbing on the single strand
15/06/22	12	16.82	99	Permanent deformation of webbing on the single strand
23/06/22	4*	17.14	101	Permanent deformation of webbing on the single strand
23/06/22	5	17.00	100	Broke webbing on the single strand
Average		**16.93**	**100**	

* Sample 23/06/22 #4 shown on the following pages.

Test Date:	Monday, 27 June 2022
Max Force (kN):	17.14
Product Name:	Single strand, two sewn loops
Test #:	4
Material:	13mm Aspiring Dyneema webbing



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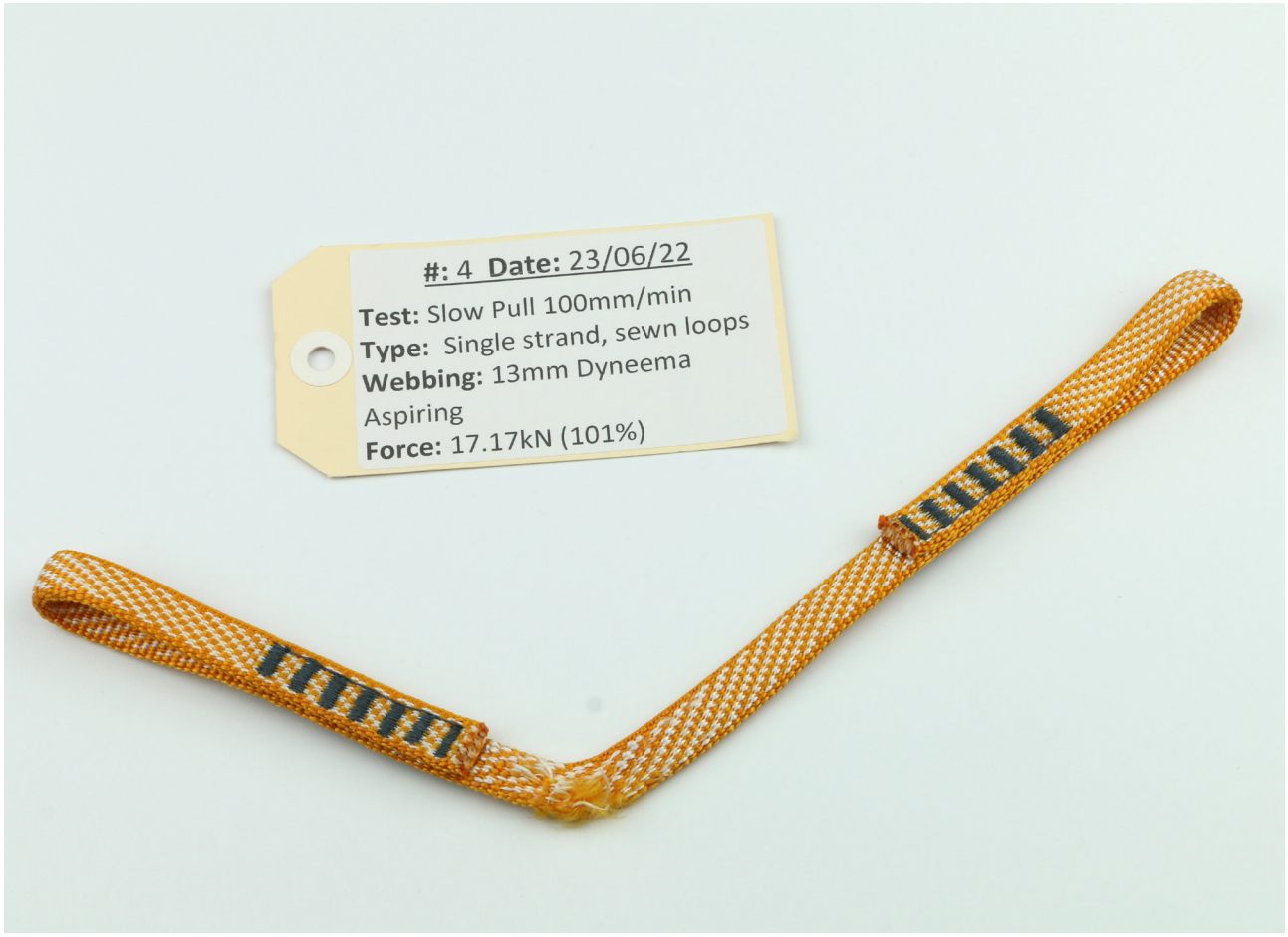
#: 4 Date: 23/06/22
Test: Slow Pull 100mm/min
Type: Single strand, sewn loops
Webbing: 13mm Dyneema
Aspiring
Force: 17.17kN (101%)

13mm webbing, sling, sewn, 12mm pins

Materials

Webbing	– Aspiring Dyneema Webbing 13mm (17kN)

Test setup

Sewn	– Sewn on one side to make a loop

Test parameters

Speed	– Slow pull 100mm/minute
Tested between	– 12mm pins

Results

Date	#	Max force (kN)	%	Comments
15/06/22	13	27.24	80%	Mostly broke except a few strands at 12mm pin
15/06/22	14	26.29	77%	Mostly broke except a few strands at 12mm pin
15/06/22	15	26.43	78%	Mostly broke except a few strands at 12mm pin
23/06/22	14*	27.36	80%	Mostly broke except a few strands at 12mm pin
23/06/22	15	26.67	78%	Mostly broke except a few strands at 12mm pin
Average		**26.80**	**79%**	

* Sample 23/06/22 #14 shown on the following pages.

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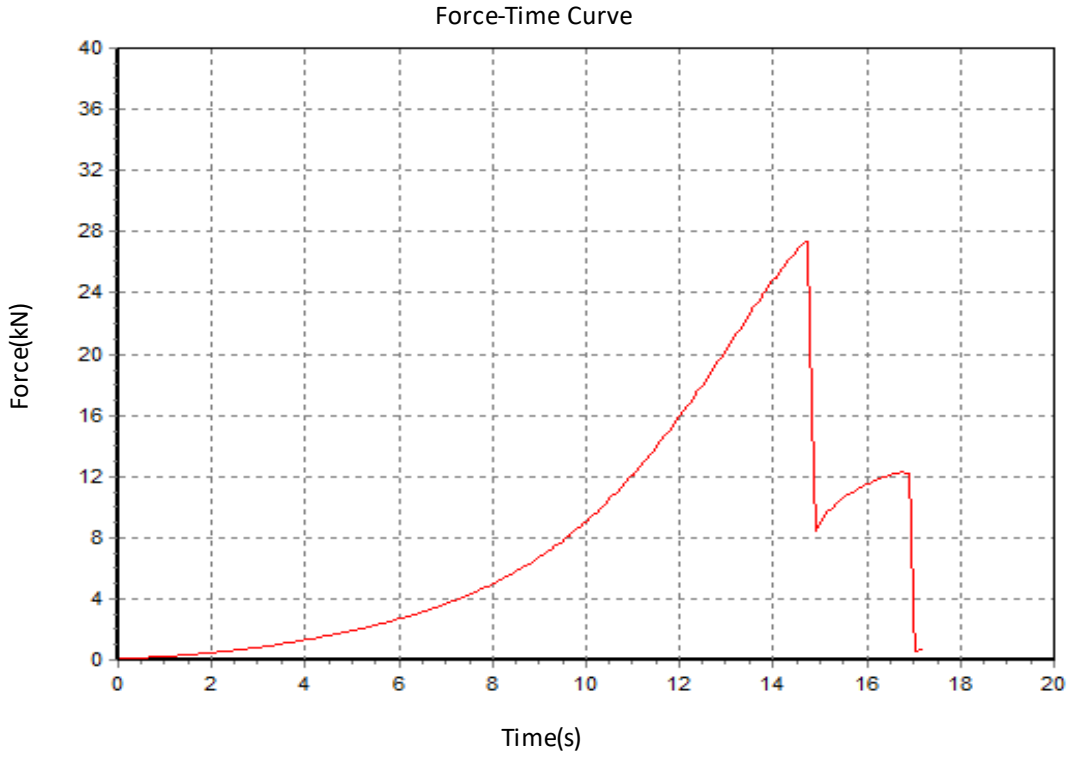
Test Date:	Monday, 27 June 2022
Max Force (kN):	27.36
Product Name:	Sling, sewn
Test #:	14
Material:	13mm Aspiring Dyneema webbing



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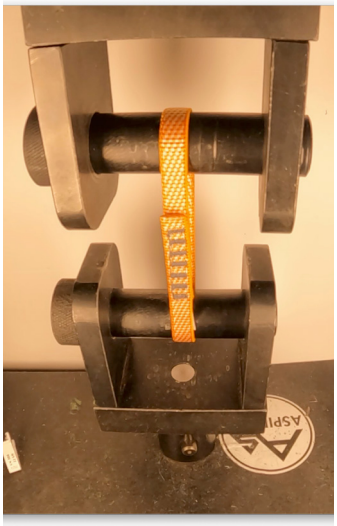
#: 14 Date: 23/06/22
Test: Slow Pull 100mm/min
Type: Sling, sewn, 12mm pins
Webbing: 13mm Dyneema
Aspiring
Force: 27.36kN (80%)

13mm webbing, sling, sewn, 30mm pins

Materials

Webbing	– Aspiring Dyneema Webbing 13mm (17kN)



Test setup

Sewn	– Sewn as a loop on one side

Test parameters

Speed	– Slow pull 100mm/minute
Tested between	– 30mm pins

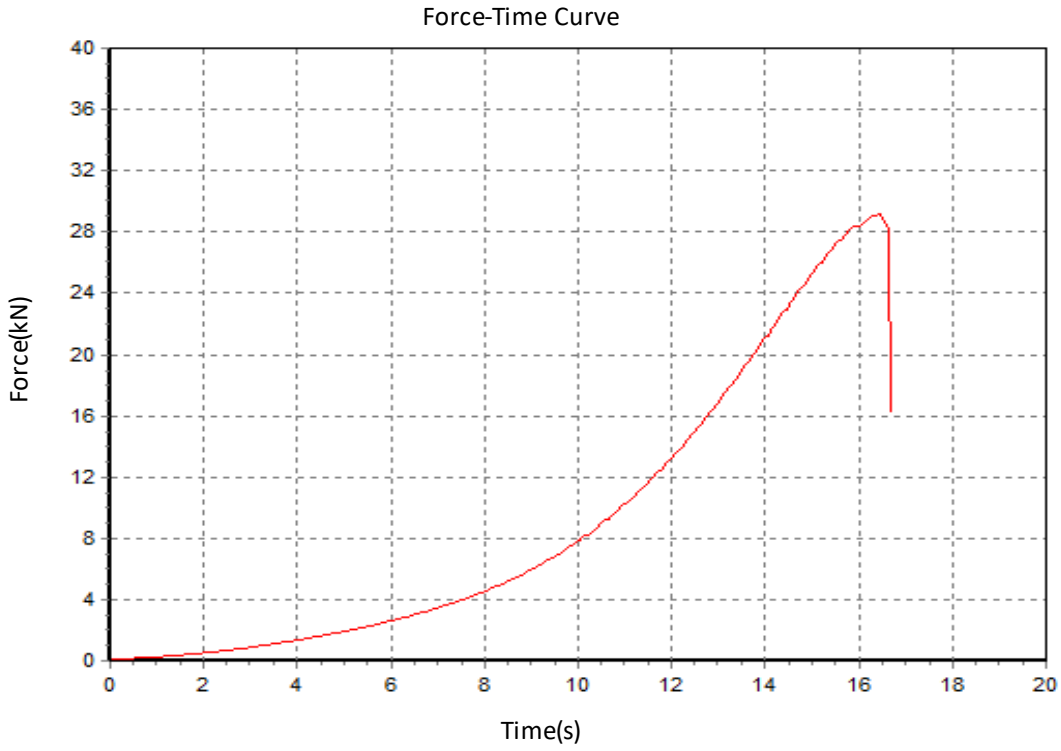
Results

Date	#	Max force (kN)	%	Comments
23/06/22	16	30.37	89%	Permanent deformation in webbing on opposite side to stitching
23/06/22	17*	29.14	86%	Broke the stitching block
23/06/22	18*	29.28	86%	Mostly broke except a few strands in webbing on opposite side to stitching
23/06/22	19	30.13	89%	Broke webbing on opposite side to stitching
23/06/22	20	29.89	88%	Broke the stitching block apart
Average		**29.76**	**88%**	

* Sample 23/06/22 #17 and #18 shown on the following pages.

ASPIRING

Test Date:	Monday, 27 June 2022
Max Force (kN):	29.14
Product Name:	Sling, sewn, 30mm pins
Test #:	17
Material:	13mm Aspiring Dyneema webbing



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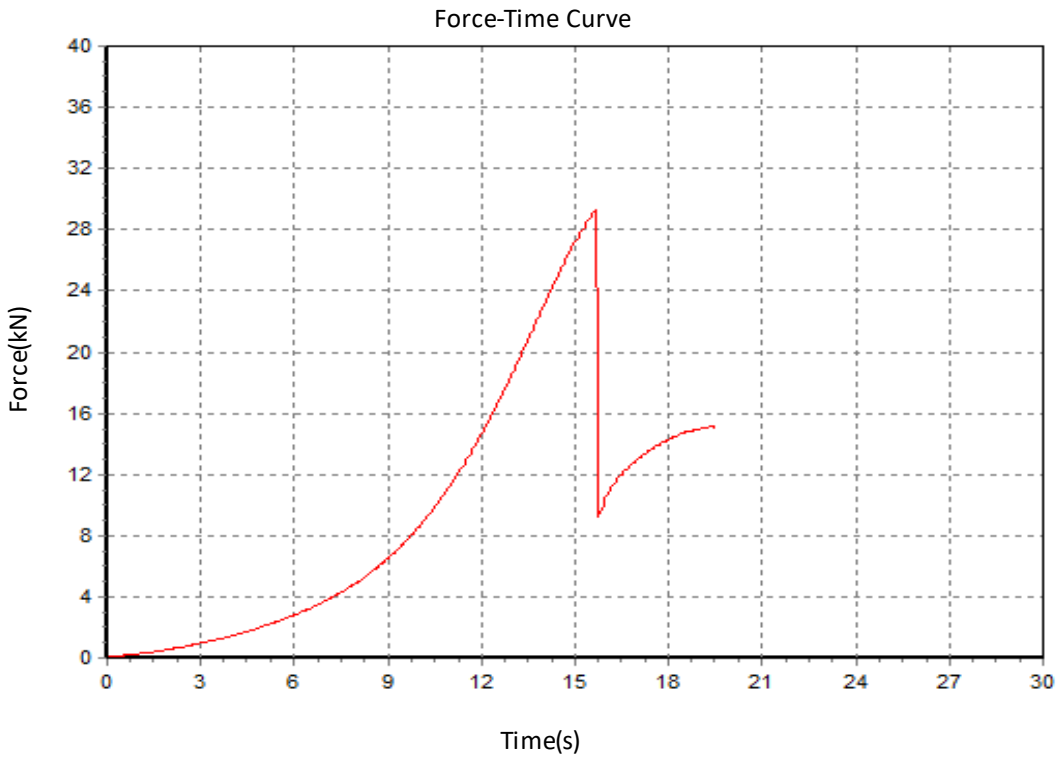
#: 17 Date: 23/06/22
Test: Slow Pull 100mm/min
Type: Sling, sewn, 30mm pins
Webbing: 13mm Dyneema
Aspiring
Force: 29.14kN (86%)


2021
EN 566
22 kN

ASPIRING

Test Date:	Monday, 27 June 2022
Max Force (kN):	29.28
Product Name:	Sling, sewn, 30mm pins
Test #:	18
Material:	13mm Aspiring Dyneema webbing



ECAAS ISO 9001 CERTIFIED QUALITY MANAGEMENT

Tested by: Grant Prattley

Signed: Grant Prattley

Machine has a current calibration certificate. www.aspiring.co.nz


#: 18 Date: 23/06/22
Test: Slow Pull 100mm/min
Type: Sling, sewn, 30mm pins
Webbing: 13mm Dyneema
Aspiring
Force: 29.28kN (86%)