NSS Vertical Section Climbing Contest Load Analyses

Gene Harrison

Chair NSS Vertical Section bats@starpower.net C-703-585-4565

> Version 1.0 15 June 2020 © G. Harrison





Load Analyses Overview

- BACKGROUND: The Vertical Section (VS) Climbing Contests are one of the most popular and exciting events at each annual NSS Convention, and they attract both National and International participation. They are called the "Rope Climbing Olympics!" Also, additional ropes and anchors are employed for Vertical Skills practice & training, but they involve significantly less loading.
- PURPOSE: The VS established a Experiment Team to pro-actively assess the stresses on facilities supporting these Contests, to evaluate any potential issues, optimize our techniques, and to minimize any impacts.
- METHOD: These analyses provide definitive technical assessments of actual stress loading of the high and low anchors, based on scientific tests and direct empirical measurements, and by employing industry standard and appropriate methodologies & instrumentation, including real-time dynamometers ("dynos").
- CONCLUSIONS: <u>Climbing Contest operational stresses to the ceiling anchors</u> <u>are relatively not a significant factor</u>. They are quite modest, and they are significantly less than typical regional snow loading for roofs in almost all areas of the Continental US. Furthermore, VS rigging practices are well proven, carefully implemented, temporary, passive, and leave no traces. (Details follow)
- Should Users or Facilities desire more definitive assessments of such issues, we encourage them to engage a Local Licensed PE Structural Engineer.

Climbing Contests

- SITUATION: During the Climbing Contests, the VS Team essentially simulates a very deep vertical pit cave, with a long and unobstructed "free" drop, while under very controlled and safe conditions.
- In this unique environment, Climbers are challenged to climb a typical caving rope, employing their specialized caving "rig" (vertical rope climbing system), for their best time over a measured distance.
- Each Climber often strives for their own "personal best" performance, over a measured climb of 30 or 120 meters of rope.
- Furthermore, for about half a century, the NSS VS has been responsible for recognizing and documenting the National and International Rope Climbing Contest Records.
- DESCRIPTION: The Climbing Contest Rope System employs a 600 foot 11mm nylon caving rope, with calibrated segments of 30 and 120 meters, plus 30 meter interval marks. It is fed by a Belayer (rope manager) through a "rappel rack" (rope control device) at a low anchor, up to a high anchor, through a rope pulley, down to the Climber, through their climbing rig, and down to the floor, often to a "rope puller".

Climbing Contests

- Operationally, the Belayer manually controls the rope at the rack and feeds it smoothly into the System, in order to maintain the Climber at a reasonably stable position at a safe distance above the floor.
- When this rope control system is skillfully operated by the Belayer, the Climber is not impacted by apparent motion, and they experience a simulated & desirable "static" rope in space (like a cave "free drop"), which does not noticeably move.
- Of special focus for these analyses, the Rope System configuration employs a high anchor, usually from the gym ceiling trusses or equivalent assets, etc. Such high structures are typically very robust, and they are well engineered to sustain much greater stresses, such as snow loads.
- The System also employs a low and laterally displaced anchor, usually from gym bleachers or other strong and suitable structures, to attach the rappel rack and position the Belayer.

Rope System Design



Climbing Contest...



Rope Climbers...

Lots of Cave Vertical Skills

High Anchor Pulley - Beam

High Anchor Pulley - Truss

Rappel Rack System

Rappel Rack Control

Analysis Considerations

- Total loading on a high truss anchor is the vector sum of
- a) the forces in the <u>vertical</u> climbing rope, and
- b) the forces in the <u>sloping</u> feed rope.
- These rope sections have <u>equal</u> tensions, due to the pulley.
- This upper directional device is usually assimed to be <u>frictionless</u>.
 Best ride (maximal loading) occurs with a large and smooth pulley.
 - -Note Loading results diminish significantly IF the pulley is replaced with a simple bend over a carabiner, or a Munter hitch or similar knot. These implementations all present major friction losses, & much <u>lower</u> loading.
- The primary vertical rope loading is the Climber's static weight.
- When climbing, the motions of the Climber produce <u>dynamic</u> surges, which are known to modestly increase these rope loads.
- Various rope climbing systems employ different motions, and thus each will vary the amount of these dynamic surges

Analysis Considerations

- A "Frog" refers to a "sit-stand" Climbing System
- A "Rope Walker" refers to a "step-step" Climbing System
- When a Climber is at rest, the static load is identical for both.
- When a Climber is climbing, the "Frog" Systems were expected to present modestly greater <u>dynamic</u> surge loads, than those with the "Rope Walker" Systems.
- The key results of interest will be the maximum <u>Peak Truss Loads</u>. This result is expected from Heavy & Energetic Froggers!.
- As noted, such maximum loads will be compared to the estimated annual snow loading, etc.
- Other results of interest to the Vertical Caving Community will be the amount and variation of loading and dynamic surges, across the varied climbing rigs and climb event distances, the ranges of performance vs body weights, climber characteristics, and other fascinating and esoteric results...!

Testing Process

- The NSS Vertical Section Experiment Team conducted scientific testing during the Vertical Events at the NSS2019 Conference in Cookeville, TN, 17-18 June 2019.
- A total of 29 individual rope climbs were examined and documented
- Climbing Event Distances
 - <u>30m</u>: 13 (72%) // <u>120m</u>: 5 (28%)
 - 18 climbs (100%). 11 distances not recorded
- Climbing <u>Systems</u> Employed
 - <u>Frog</u>: 22 (79%) // <u>Rope Walker</u>: 6 (21%)
 - 28 climbs (100%). 1 system not recorded

Special Thanks to The Vertical Section Experiment Team:: Ray Sira Mike Rusin Ric Thompson Gene Harrison

 Some Climbers climbed more than once (one climbed three times!), and they usually varied their Climbing System, Event Distance, or both

Testing Data Collection

- The VS Experiment Team observed and recorded:
 - Dates and Start Times,
 - Climbing System Types (Frog or Rope Walker),
 - Event Distances (30m or 120m),
 - Static Loads (the Climber weight), and
 - Climbing Dynamic Peak Loads
- They did not record Climber Name, Gender, Group, or other information...
- The VS Experiment Team logged data manually, but employed an Electronic Dynamometer, which provided a digital display of the Static & Peak Loads
- The Dynamometer was rigged in-line with the Rappel Rack at the Low Anchor, ensuring direct and accurate measurement of Feed Rope Forces.
- Belayer rope control forces were considered insignificant.

DYNAMOMETER (600 lb Max) Displays <u>STATIC</u> & <u>DYNAMIC</u> Loads (with <u>PEAK HOLD</u>) (Used in Tests) DYNAMOMETER (2000 lb Max) Displays <u>STATIC</u> & <u>DYNAMIC</u> Loads (FYI - Not Used)

Results of Analyses

- The VS Team Analyst created a software based Data Analytical Engine to tabulate and reduce the test data, and to provide the desired Test Results for Assessment & Reporting
- A Digital Inclinometer measured the Feed Rope Angle:: about 27 degrees elevation
- Climber Weights, All Events (pounds) -
 - Min 118.8 // Average 145.91 // Max 209.00
- Climber Weights, Frog (pounds)
 - Min 118.8 // Average 145.91 // Max 209.00
- Climber Weights, Rope Walker (pounds)
 - Min 121.00 // Average 140.80 // Max 191.40

Results of Analyses

- Climber Dynamic Loading, Peaks (pounds) [Climber Weight] –<u>Frog 222.20</u> [209 lb] // Rope Walker 196.24 [191 lb]
- Climbing System Dynamic <u>Surges</u>, <u>Peaks</u> & <u>Averages</u> [Climber]
 - <u>Peaks</u>: <u>Frog +34%</u> [132 lb] // Rope Walker +17% [147 lb]
 - <u>Averages</u>: <u>Frog +13%</u> // Rope Walker +7% [RW about <u>twice</u> Frog]
 - Maximum Increased Load About <u>1/3</u> if Frog
- Surprise!! The Maximum Dynamic Peak Surges in each Climbing System were accomplished by Energetic yet "<u>Average Weight</u>" Climbers, on <u>most challenging 120m</u> climbs!
- Maximum Truss Loading, Peak (pounds) [Climber]
 - Peak Vector << <u>400</u> pounds!
 - Frog 378.91 Vector // 323.08 Vertical // 197.98 Horizontal [209 lb]
 - Rope Walker 334.64 Vector// 285.33 Vertical// 174.85 Horizontal[191 lb]
 - Truss Anchor Load Vector Angle about 58.8 degrees

Max Surge <u>Ratio</u> vs Climber Weight - <u>Frog</u>

MAX SURGE RATIO vs CLIMBER WEIGHT - FROG

Max Surge <u>Ratio</u> vs Climber Weight - <u>RW</u>

Rigging vs Snow Loading

- Gyms often incorporate flat roofs, and they are required to withstand regional snow loading
- Gyms commonly employ long (>100ft) Warren trusses, typically arranged crosswise, and sometimes lengthwise
- Per US Forest Service Snow Load Information (please see references):
- Recommends use of IBC 2003 as minimums for construction
- Loading ranges for States of VA, TN, OH, KY average 10-25 pounds per square feet (psf)
- WV local areas evidently set their own standards, however
- Per West Virginia Extension Service, regarding WV "severe snow loading" conditions:
 - -"...Two feet of "wet" snow will exert a load of about <u>40 lb/ft2</u> on a flat surface..."
 - -"...Three feet of "wet" snow will approach about <u>70 lb/ft2</u>..."

Rigging vs Snow Loading

- Any long standing gym roof has evidently survived these extreme snow loads, and likely worse!
- <u>Givens</u>: Typical truss spacing at least 4 feet, and snow load tolerance of <u>at least</u> 40-70psf. And, <u>point</u> loading is different from <u>area</u> loading...
- <u>Assumptions</u>: The ceiling anchor forces at a <u>single point</u> are reasonably <u>distributed</u> over at least a 10 ft (+-5ft) distance, for an <u>equivalent loading area</u> of <u>at least 40 sqft</u>, and likely more.
- Thus the <u>equivalent area</u> snow loading design <u>tolerance should</u> <u>exceed 1600-2800 pounds</u>
- Per actual tests & measurements, the truss peak loading of <u>under</u> <u>400 pounds</u> can be safely accommodated, with a <u>safety margin of at</u> <u>least 4x to 7x</u>, & likely very much greater.
- Therefore, per empirical testing results, and reasonable pragmatic engineering, it is evident that the impact to building structural integrity is relatively not a significant factor.
- Should Facilities desire definitive assessments of such issues, we encourage them to engage a Local Licensed PE Structural Engineer.

References

- National Snow Load Information
- https://www.fs.fed.us/t-d/snow_load/
- AK Use IBC 2003-25 psf-300 psf
- AL Use IBC 2003—0 psf-10 psf with Case Study Areas at higher elevations
- CA Use IBC 2003—0 psf-450 psf with Case Study Areas at higher elevations
- CO Use IBC 2003—10 psf-20 psf with Case Study Areas
- KY Use IBC 2003—15 psf-20 psf with Case Study Areas at higher elevations
- NC Use IBC 2003—10 psf-25 psf with Case Study Areas at higher elevations
- OH Use IBC 2003—20 psf-25 psf with Case Study Areas
- TN Use IBC 2003—10 psf-25 psf with Case Study Areas at higher elevations
- VA Use IBC 2003—10 psf-25 psf with Case Study Areas at higher elevations
- W V n/a (reportedly local areas set their own construction standards)
- Cornell University Engineering Steel Truss Design Calculator
- https://courses.cit.cornell.edu/arch264/calculators/steel-truss-design/index.htm
- West Virginia University Extension Service Agricultural Engineering
- https://extension.wvu.edu/community-business-safety/home-safety/snow-roofoverload

Experimental Test Data...

- All Climbs
- Frog Climbs (sit-stand)
- Rope Walker Climbs (step-step)

				DYNAMIC S	TATUS >>>	STATIC	PEAK	STATIC	PEAK
	ALL C	LIMBS				FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE
						LOAD	LOAD	LOAD	LOAD
RECORD	DATE	TIME	CLIMBER	CLIMBING	ROPE RUN		÷		
INDEX	DAY	START	NAME	SYSTEM	DISTANCE	FRLStatic	FRLPeak	FRLStatic	FRLPeak
									D 0 0 1
NI-	2010			#D:			•	P=2.2xkg	P=2.2xkg
Number	2019	Local		Rig	meters	Kliograms	Kilograms	pounds	pounds
1	17 June	1441	n/a	Frog	30	95.00	101.00	209.00	222.20
2	17 June	1534	n/a	Rope Walker	30	57.00	60.40	125.40	132.88
3	1/June	1543	n/a	Frog	30	/3.00	84.60	160.60	186.12
4	17 June	1553	n/a	Frog	120	60.00	80.10	132.00	176.22
5	17 June	1613	n/a	Rope Walker	30	55.00	57.90	121.00	127.38
6	18 June	930	n/a	Rope Walker	30	58.00	58.30	127.60	128.26
7	18 June	953	n/a	Frog	30	58.00	63.70	127.60	140.14
8	18 June	1032	n/a	Frog	30	87.00	91.10	191.40	200.42
9	18 June	1045	n/a	Frog	30	65.00	74.90	143.00	164.78
10	18 June	1057	n/a	Rope Walker	120	67.00	78.40	147.40	172.48
11	18 June	n/a	n/a	n/a	n/a	69.00	70.00	151.80	154.00
12	18 June	1141	n/a	Frog	n/a	59.00	63.50	129.80	139.70
13	18 June	1200	n/a	Rope Walker	n/a	87.00	89.20	191.40	196.24
14	18 June	1302	n/a	Frog	n/a	67.00	80.80	147.40	177.76
15	18 June	1317	n/a	Frog	n/a	62.00	73.50	136.40	161.70
16	18 June	1348	n/a	Frog	n/a	73.00	81.40	160.60	179.08
17	18 June	1401	n/a	Frog	n/a	54.00	68.10	118.80	149.82
18	18 June	1414	n/a	Rope Walker	n/a	60.00	65.50	132.00	144.10
19	18 June	1420	n/a	Frog	n/a	70.00	72.20	154.00	158.84
20	18 June	1429	n/a	Frog	n/a	73.00	82.00	160.60	180.40
21	18 June	1438	n/a	Frog	n/a	71.00	79.40	156.20	174.68
22	18 June	1451	n/a	Frog	30	60.30	73.40	132.66	161.48
23	18 June	1458	n/a	Frog	30	60.00	66.40	132.00	146.08
24	18 June	1505	n/a	Frog	120	70.00	76.60	154.00	168.52
25	18 June	1528	n/a	Frog	120	67.00	77.30	147.40	170.06
26	18 June	1551	n/a	Frog	30	70.00	78.50	154.00	172.70
27	18 June	1608	n/a	Frog	30	58.00	61.60	127.60	135.52
28	18 June	1614	n/a	Frog	120	56.00	61.30	123.20	134.86
29	18 June	1636	n/a	Frog	30	62.00	67.80	136.40	149.16

and the second second		PEAK	PEAK	PEAK	PEAK	PEAK	
FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE	TRUSS	TRUSS	TRUSS	TRUSS
LOAD	ELEVATION	TRUSS LOAD	TRUSS LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD
RATIO	ANGLE	Horizontal	Vertical	Horizontal	Vertical	VECTOR	ANGLE
RatioPkSt	AngleR	FRLHoriz	FRLVert	TALHoriz	TALFRVert	TALVector	TALAngle
Contract of the		RFLPeak *				SqRt	ArcTan
FRPeak/		Cosine	RFLPeak * Sine	a series and a		((TALHoriz^2) +	(TALFRVert /
FRStatic		(AngleR)	(AngleR)	FRLHoriz	FRLVert + FRL	(TALVert^2))	TALHoriz)
(no units)	degrees	pounds	pounds	pounds	pounds	pounds	degrees
1.06	27	197.98	100.88	197.98	323.08	378.91	58.50
1.06	27	118.40	60.33	118.40	193.21	226.60	58.50
1.16	27	165.83	84.50	165.83	270.62	317.39	58.50
1.34	27	157.01	80.00	157.01	256.22	300.50	58.50
1.05	27	113.50	57.83	113.50	185.21	217.22	58.50
1.01	27	114.28	58.23	114.28	186.49	218.72	58.50
1.10	27	124.87	63.62	124.87	203.76	238.98	58.50
1.05	27	178.58	90.99	178.58	291.41	341.77	58.50
1.15	27	146.82	74.81	146.82	239.59	281.00	58.50
1.17	27	153.68	78.30	153.68	250.78	294.13	58.50
1.01	27	137.22	69.91	137.22	223.91	262.61	58.50
1.08	27	124.47	63.42	124.47	203.12	238.23	58.50
1.03	27	174.85	89.09	174.85	285.33	334.64	58.50
1.21	27	158.39	80.70	158.39	258.46	303.13	58.50
1.19	27	144.08	73.41	144.08	235.11	275.74	58.50
1.12	27	159.56	81.30	159.56	260.38	305.38	58.50
1.26	27	133.49	68.02	133.49	217.84	255.49	58.50
1.09	27	128.39	65.42	128.39	209.52	245.73	58.50
1.03	27	141.53	72.11	141.53	230.95	270.87	58.50
1.12	27	160.74	81.90	160.74	262.30	307.63	58.50
1.12	27	155.64	79.30	155.64	253.98	297.88	58.50
1.22	27	143.88	73.31	143.88	234.79	275.37	58.50
1.11	27	130.16	66.32	130.16	212.40	249.11	58.50
1.09	27	150.15	76.51	150.15	245.03	287.37	58.50
1.15	27	151.52	77.21	151.52	247.27	290.00	58.50
1.12	27	153.88	78,40	153.88	251.10	294.50	58,50
1.06	27	120.75	61.52	120.75	197.04	231.10	58.50
1.09	27	120.16	61.23	120.16	196.09	229.97	58.50
1.09	27	132.90	67.72	132.90	216.88	254.36	58 50
1.00	E11	102.00	01.12	102.00	210.00	201.00	00.00

				STATIC	PEAK	STATIC	PEAK
	ALL	CLIMBS		FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE
				LOAD	LOAD	LOAD	LOAD
COLOR	Fixed	Sequence	Data	FRLStatic	FRLPeak	FRLStatic	FRLPeak
CODES	Fields	Fields	Inputs	kilograms	kilograms	pounds	pounds
	Data Into	Formula	Notable	AVERAGES	AVERAGES	AVERAGES	AVERAGES
	Formulas	Results	Results	66.32	73.76	145.91	162.26
	2	ŝ		PEAKS	PEAKS	PEAKS	PEAKS
				95.00	101.00	209.00	222.20

		PEAK	PEAK	PEAK	PEAK	PEAK	
FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE	TRUSS	TRUSS	TRUSS	TRUSS
LOAD	ELEVATION	TRUSS LOAD	TRUSS LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD
RATIO	ANGLE	Horizontal	Vertical	Horizontal	Vertical	VECTOR	ANGLE
RatioPkSt	AngleR	FRLHoriz	FRLVert	TALHoriz	TALFRVert	TALVector	TALAngle
(no units)	degrees	pounds	pounds	pounds	pounds	pounds	degrees
AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES
1.11	27.00	144.58	73.67	144.58	235.93	276.70	58.50
PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS
1.34	27.00	197.98	100.88	197.98	323.08	378.91	58.50

				DVNAMIC STATUS		CTATIC	DEAK	CTATIC	DEAK
		VOTENO		DTNAMIC 5	IAIUS >>>	STATIC	PEAK	STATIC	PEAK
	FROGS	YSTEMS				FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE
						LOAD	LOAD	LOAD	LOAD
RECORD	DATE	TIME	CLIMBER	CLIMBING	ROPE RUN				· · ·
INDEX	DAY	START	NAME	SYSTEM	DISTANCE	FRLStatic	FRLPeak	FRLStatic	FRLPeak
								P=2.2xkg	P=2.2XKg
Number	2019	Local		"Rig"	meters	kilograms	kilograms	pounds	pounds
1	17 June	1441	n/a	Frog	30	95.00	101.00	209.00	222.20
3	17 June	1543	n/a	Frog	30	73.00	84.60	160.60	186.12
4	17 June	1553	n/a	Frog	120	60.00	80.10	132.00	176.22
7	18 June	953	n/a	Frog	30	58.00	63.70	127.60	140.14
8	18 June	1032	n/a	Frog	30	87.00	91.10	191.40	200.42
9	18 June	1045	n/a	Frog	30	65.00	74.90	143.00	164.78
12	18 June	1141	n/a	Frog	n/a	59.00	63.50	129.80	139.70
14	18 June	1302	n/a	Frog	n/a	67.00	80.80	147.40	177.76
15	18 June	1317	n/a	Frog	n/a	62.00	73.50	136.40	161.70
16	18 June	1348	n/a	Frog	n/a	73.00	81.40	160.60	179.08
17	18 June	1401	n/a	Frog	n/a	54.00	68.10	118.80	149.82
19	18 June	1420	n/a	Frog	n/a	70.00	72.20	154.00	158.84
20	18 June	1429	n/a	Frog	n/a	73.00	82.00	160.60	180.40
21	18 June	1438	n/a	Frog	n/a	71.00	79.40	156.20	174.68
22	18 June	1451	n/a	Frog	30	60.30	73.40	132.66	161.48
23	18 June	1458	n/a	Frog	30	60.00	66.40	132.00	146.08
24	18 June	1505	n/a	Frog	120	70.00	76.60	154.00	168.52
25	18 June	1528	n/a	Frog	120	67.00	77.30	147.40	170.06
26	18 June	1551	n/a	Frog	30	70.00	78.50	154.00	172.70
27	18 June	1608	n/a	Frog	30	58.00	61.60	127.60	135.52
28	18 June	1614	n/a	Frog	120	56.00	61.30	123.20	134.86
29	18 June	1636	n/a	Frog	30	62.00	67.80	136.40	149.16

		PEAK	PEAK	PEAK	PEAK	PEAK	
FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE	TRUSS	TRUSS	TRUSS	TRUSS
LOAD	ELEVATION	TRUSS LOAD	TRUSS LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD
RATIO	ANGLE	Horizontal	Vertical	Horizontal	Vertical	VECTOR	ANGLE
RatioPkSt	AngleR	FRLHoriz	FRLVert	TALHoriz	TALFRVert	TALVector	TALAngle
FRPeak/ FRStatic	•	RFLPeak * Cosine (AngleR)	RFLPeak * Sine (AngleR)	FRLHoriz	FRLVert + FRL	SqRt ((TALHoriz^2) + (TALVert^2))	ArcTan (TALFRVert / TALHoriz)
(no units)	degrees	pounds	pounds	pounds	pounds	pounds	degrees
1.06	27	197.98	100.88	197.98	323.08	378.91	58.50
1.16	27	165.83	84.50	165.83	270.62	317.39	58.50
1.34	27	157.01	80.00	157.01	256.22	300.50	58.50
1.10	27	124.87	63.62	124.87	203.76	238.98	58.50
1.05	27	178.58	90.99	178.58	291.41	341.77	58.50
1.15	27	146.82	74.81	146.82	239.59	281.00	58.50
1.08	27	124.47	63.42	124.47	203.12	238.23	58.50
1.21	27	158.39	80.70	158.39	258.46	303.13	58.50
1.19	27	144.08	73.41	144.08	235.11	275.74	58.50
1.12	27	159.56	81.30	159.56	260.38	305.38	58.50
1.26	27	133.49	68.02	133.49	217.84	255.49	58.50
1.03	27	141.53	72.11	141.53	230.95	270.87	58.50
1.12	27	160.74	81.90	160.74	262.30	307.63	58.50
1.12	27	155.64	79.30	155.64	253.98	297.88	58.50
1.22	27	143.88	73.31	143.88	234.79	275.37	58.50
1.11	27	130.16	66.32	130.16	212.40	249.11	58.50
1.09	27	150.15	76.51	150.15	245.03	287.37	58.50
1.15	27	151.52	77.21	151.52	247.27	290.00	58.50
1.12	27	153.88	78.40	153.88	251.10	294.50	58.50
1.06	27	120.75	61.52	120.75	197.04	231.10	58.50
1.09	27	120.16	61.23	120.16	196.09	229.97	58.50
1.09	27	132.90	67.72	132.90	216.88	254.36	58.50

				STATIC	PEAK	STATIC	PEAK
	FROG	SYSTEMS		FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE
	2020 CENTRE 1012			LOAD	LOAD	LOAD	LOAD
	e de la compañía						
COLOR	Fixed	Sequence	Data	FRLStatic	FRLPeak	FRLStatic	FRLPeak
CODES	Fields	Fields	Inputs	kilograms	kilograms	pounds	pounds
	Data Into	Formula	Notable	AVERAGES	AVERAGES	AVERAGES	AVERAGES
	Formulas	Results	Results	66.83	75.42	147.03	165.92
10				PEAKS	PEAKS	PEAKS	PEAKS
				95.00	101.00	209.00	222.20

24		PEAK	PEAK	PEAK	PEAK	PEAK	2
FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE	TRUSS	TRUSS	TRUSS	TRUSS
LOAD	ELEVATION	TRUSS LOAD	TRUSS LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD
RATIO	ANGLE	Horizontal	Vertical	Horizontal	Vertical	VECTOR	ANGLE
RatioPkSt	AngleR	FRLHoriz	FRLVert	TALHoriz	TALFRVert	TALVector	TALAngle
(no units)	degrees	pounds	pounds	pounds	pounds	pounds	degrees
AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES
1.13	27.00	147.84	75.33	147.84	241.25	282.94	58.50
PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS
1.34	27.00	197.98	100.88	197.98	323.08	378.91	58.50

1		and the second		DYNAMIC ST	TATUS >>>	STATIC	PEAK	STATIC	PEAK
	ROPE W	ALKERS				FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE
						LOAD	LOAD	LOAD	LOAD
RECORD	DATE	TIME	CLIMBER	CLIMBING	ROPE RUN				
INDEX	DAY	START	NAME	SYSTEM	DISTANCE	FRLStatic	FRLPeak	FRLStatic	FRLPeak
								P=2.2xkg	P=2.2xkg
Number	2019	Local		"Rig"	meters	kilograms	kilograms	pounds	pounds
2	17 June	1534	n/a	Rope Walker	30	57.00	60.40	125.40	132.88
5	17 June	1613	n/a	Rope Walker	30	55.00	57.90	121.00	127.38
6	18 June	930	n/a	Rope Walker	30	58.00	58.30	127.60	128.26
10	18 June	1057	n/a	Rope Walker	120	67.00	78.40	147.40	172.48
13	18 June	1200	n/a	Rope Walker	n/a	87.00	89.20	191.40	196.24
18	18 June	1414	n/a	Rope Walker	n/a	60.00	65.50	132.00	144.10

				STATIC	PEAK	STATIC	PEAK
	ROPE	WALKERS		FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE
				LOAD	LOAD	LOAD	LOAD
			2				
COLOR	Fixed	Sequence	Data	FRLStatic	FRLPeak	FRLStatic	FRLPeak
CODES	Fields	Fields	Inputs	kilograms	kilograms	pounds	pounds
	Data Into	Formula	Notable	AVERAGES	AVERAGES	AVERAGES	AVERAGES
1	Formulas	Results	Results	64.00	68.28	140.80	150.22
					PEAKS	PEAKS	PEAKS
				87.00	89.20	191.40	196.24

	S1 1 5 1 5 1 5 1 5 1	PEAK	PEAK	PEAK	PEAK	PEAK	5.
FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE	TRUSS	TRUSS	TRUSS	TRUSS
LOAD	ELEVATION	TRUSS LOAD	TRUSS LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD
RATIO	ANGLE	Horizontal	Vertical	Horizontal	Vertical	VECTOR	ANGLE
RatioPkSt	AngleR	FRLHoriz	FRLVert	TALHoriz	TALFRVert	TALVector	TALAngle
FRPeak/ FRStatic		RFLPeak * Cosine (AngleR)	RFLPeak * Sine (AngleR)	FRLHoriz	FRLVert + FRL	SqRt ((TALHoriz^2) + (TALVert^2))	ArcTan (TALFRVert / TALHoriz)
(no units)	degrees	pounds	pounds	pounds	pounds	pounds	degrees
1.06	27	118.40	60.33	118.40	193.21	226.60	58.50
1.05	27	113.50	57.83	113.50	185.21	217.22	58.50
1.01	27	114.28	58.23	114.28	186.49	218.72	58.50
1.17	27	153.68	78.30	153.68	250.78	294.13	58.50
1.03	27	174.85	89.09	174.85	285.33	334.64	58.50
1.09	27	128.39	65.42	128.39	209.52	245.73	58.50

		PEAK	PEAK	PEAK	PEAK	PEAK	
FEED ROPE	FEED ROPE	FEED ROPE	FEED ROPE	TRUSS	TRUSS	TRUSS	TRUSS
LOAD	ELEVATION	TRUSS LOAD	TRUSS LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD	ANCHOR LOAD
RATIO	ANGLE	Horizontal	Vertical	Horizontal	Vertical	VECTOR	ANGLE
RatioPkSt	AngleR	FRLHoriz	FRLVert	TALHoriz	TALFRVert	TALVector	TALAngle
(no units)	degrees	pounds	pounds	pounds	pounds	pounds	degrees
AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES	AVERAGES
1.07	27.00	133.85	68.20	133.85	218.42	256.17	58.50
PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS
1.17	27.00	174.85	89.09	174.85	285.33	334.64	58.50