Nylon Highway

Issue #62

... especially for the Vertical Caver

#62

Contents

Return to
NH Issues Page

Overleaf

Return to the Top of the Page

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Nylon Highway

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Christiansburg, VA 24073
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INFORMATION AND DISCLAIMER

The *Nylon Highway* is published by the Vertical Section of the National Speleological Society on a regular basis pending sufficient material. Material is posted on the Vertical Section's web site soon after being received by the Website Coordinator. A volume of all material is printed and distributed to those not having access to the electronic version on an annual basis.

It is the intent of this publication to provide a vehicle for papers on vertical work. All submitted articles containing unsafe practices will be returned to the author. Opinions expressed herein are credited to the author and do not necessarily agree with those of the Editor, the Vertical Section, its members or its Executive Committee. The reader should understand that some material presented in the *Nylon Highway* may be of an experimental nature and is presented herein for peer review. The reader should exercise good judgment and use common sense when attempting new vertical techniques or using new equipment.

WARNING: The reader must acknowledge that caving, climbing, mountaineering, rappelling, rescue work and other rope activities expressed in the *Nylon Highway* are inherently dangerous activities and serious injury or death could result from use and/or misuse of techniques and equipment described in this publication.

See our web page at: http://www.caves.org/section/vertical

[Return to the Top of the Page](#)

NSS Vertical Section

Vertical Events

Gym Layout

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NSS Vertical Section

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C-703-585-4565

Version 1.0

15 June 2020

Gym Layout Overview

- BACKGROUND: The Vertical Section (VS) Vertical Events are some of the most popular and exciting events at each annual NSS Convention, and they attract both National and International participation. They include the Vertical Techniques Orientation Workshop, the Rebelay Course, and the Vertical Climbing Contests, known as the "Rope Climbing Olympics!"

- ISSUES: The VS creates a simulated vertical cave environment, typically in the host facility gym, and employs caving ropes and rigging for these events. This includes the necessary requirements for multiple ropes, rigged at high (ceiling trusses) points, scaffolding for safe rebelay and rappelling, VS Staff tables, and accommodations for Staff, Participants, and Spectators. Operational areas also require reasonable Safety Zones.

- PURPOSE: This document presents the key safety and configuration elements necessary to craft a suitable gym layout. It also considers required Safety Zones, people and process flows, operational effectiveness and efficiency, and other issues. A suitable example is also presented for consideration.

- CONCLUSIONS: *Vertical Events are major NSS Convention attractions, and they can be implemented safely and effectively, and with essentially zero impact to the host facility*. VS rigging practices are temporary, passive, and leave no traces. Furthermore, the actual implementation in any specific facility will and must be uniquely crafted by qualified and experienced VS Technical Staff. (Details follow)

Gym Layout Criteria

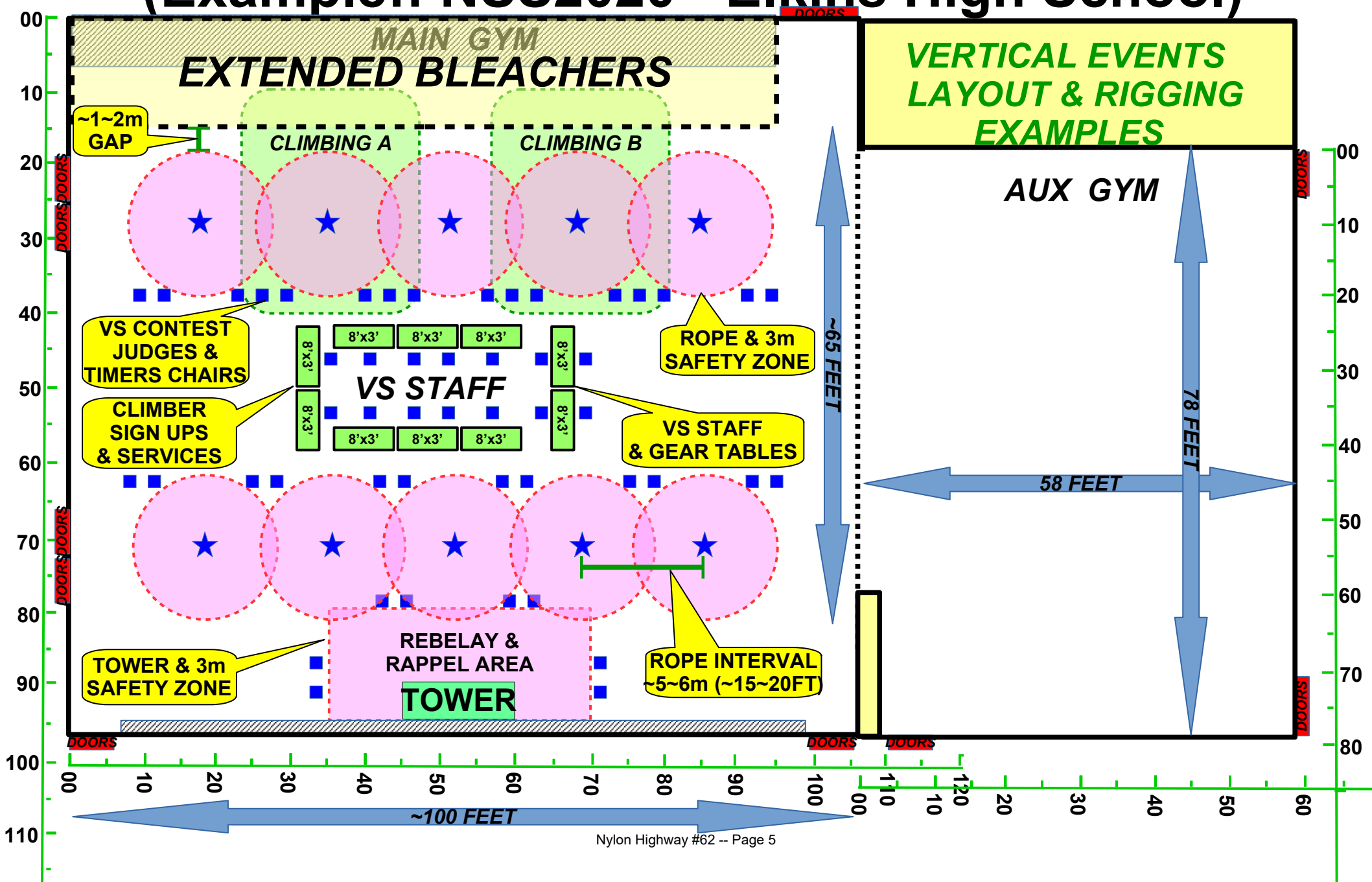
- CUSTOM DESIGNS: Every facility is different! Therefore, each year's Vertical Events Gym Layout must be uniquely crafted by qualified and experienced VS Technical Staff.
- ACTIVITIES: There are basically seven types of activities and services to be supported: (Please also see associated VS Planning Guides)
  - Vertical Section Staff Management and Participant Support & Services
  - The Vertical Climbing Contests (Mon & Tues)
  - The Rebelay Course (Tues)
  - The Vertical Techniques Orientation Workshop (Weds)
  - A Small Party Assisted Rescue Workshop (SPAR) (Thur – Optional)
  - The Junior Speleological Society (JSS) Orientation (Mon – Optional
  - Other unscheduled activities, individual training, and other services, as needed.
- During each Annual NSS Convention, the Vertical Section is assigned the management of the Gym during most of the week.
- The VS also provides caving ropes, rigging and other gear necessary to create a simulated vertical cave environment.

Gym Safety Criteria

- The gym environment and equipment are only employed under the supervision of, or in coordination with, the Vertical Section Staff.
- In operation, all environment Users, and all Persons in the gym, must comply with the approved VS Safety Policies. This includes use of standard safety practices and equipment, such as helmets, safe knots, and other gear, when required.
  - JSS, SPAR, NCRC and Others may have their own Safety Policies and requirements, but in addition to, and not release from, VS Safety Policies.
- Furthermore, a Safety Zone, with a radius of at least 3m (10ft), shall be defined around each rope rig, and the tower, and respected when in action with an active Climber, or with Persons at height.
- PLACEMENTS: Based on experience, traditional placements are:
  - VS Staff Area: Tables & chairs, in central area, away from climbing Safety Zones, and considering efficient people and process flows
  - Rope Spots: Beneath ceiling anchors, attached to trusses etc, with at least ~5-6m (~15~20ft) intervals between ropes, and >> 3m (10ft) from extended bleachers.
  - Rope Spot & Tower Chairs: About 2-6 per rope, just outside the Safety Zones.
  - Staging & Gear Areas: Reasonable accommodations for VS Staff, Climbers, Users, and other Persons, preferably away from people and process flows, with no blocking or trip hazards, and especially away from Safety Zones and activity areas.

Vertical Events in Gyms

(Example:: NSS2020 - Elkins High School)



References

NSS Vertical Section Documents

- VS Safety Procedures
- VS Climbing Contest Rules
- VS Climbing Contest Planning Guide
- VS Vertical Techniques Workshop Planning Guide
- VS Rebelay Course Planning Guide

- .

NSS Vertical Section

Vertical Events

Beam Anchors

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Chair

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Version 1.0

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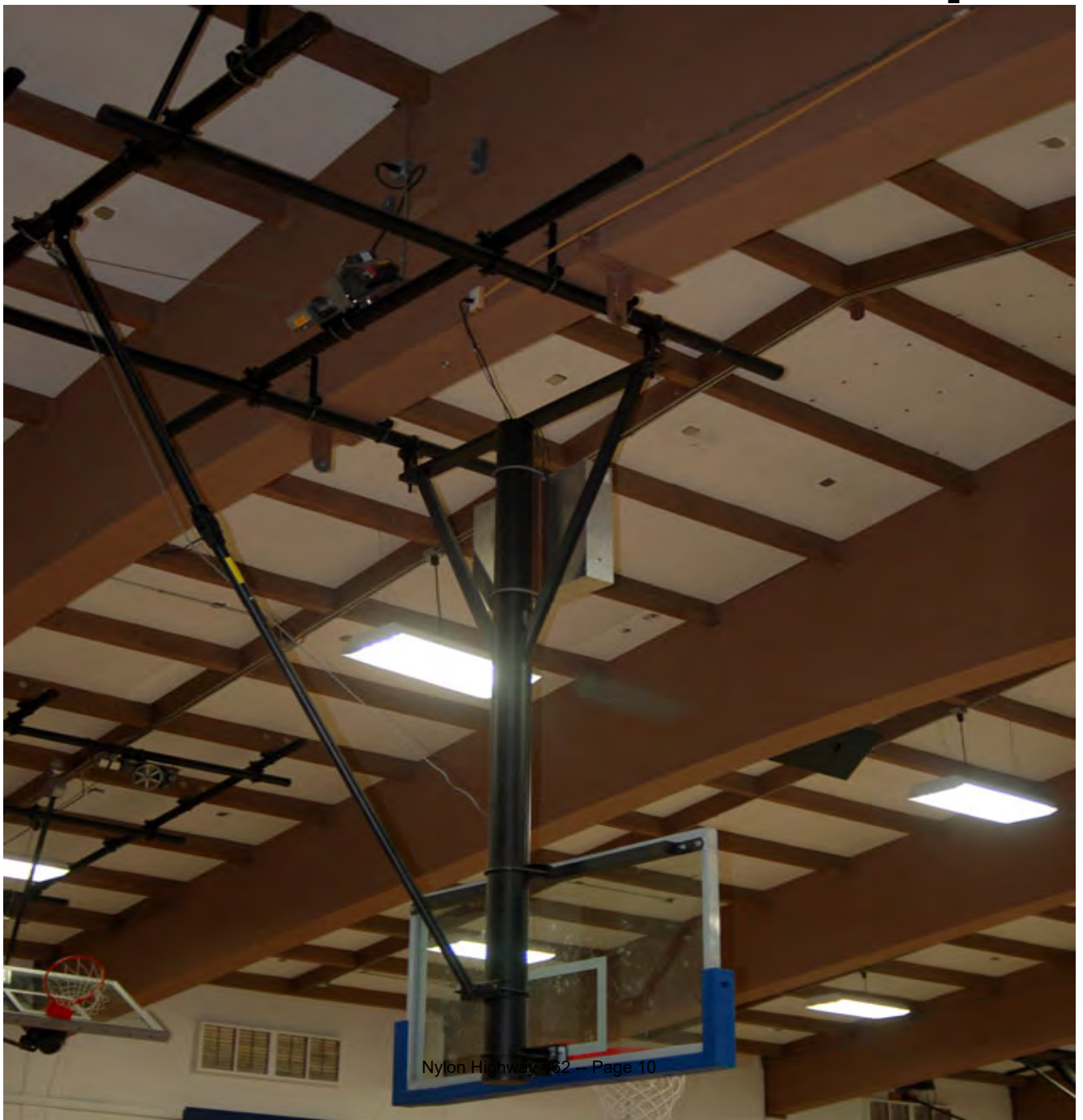
Vertical Events Overview

- BACKGROUND: The Vertical Section (VS) Vertical Events at each Annual NSS Convention include the Vertical Climbing Contests, the Rebelay Course and the Vertical Techniques Orientation Workshop.
- The VS Vertical 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.
- ISSUES: The VS creates a simulated vertical cave environment and employs caving ropes and rigging for the event. This includes the necessary requirement for both high (ceiling trusses...) and low (bleachers, etc...) anchor points.
- In this case, we address solid beams, which do not provide the familiary simple mechanical elements for rigging attachments. This also supports the NSS2021 in Weed, CA, plus future needs.

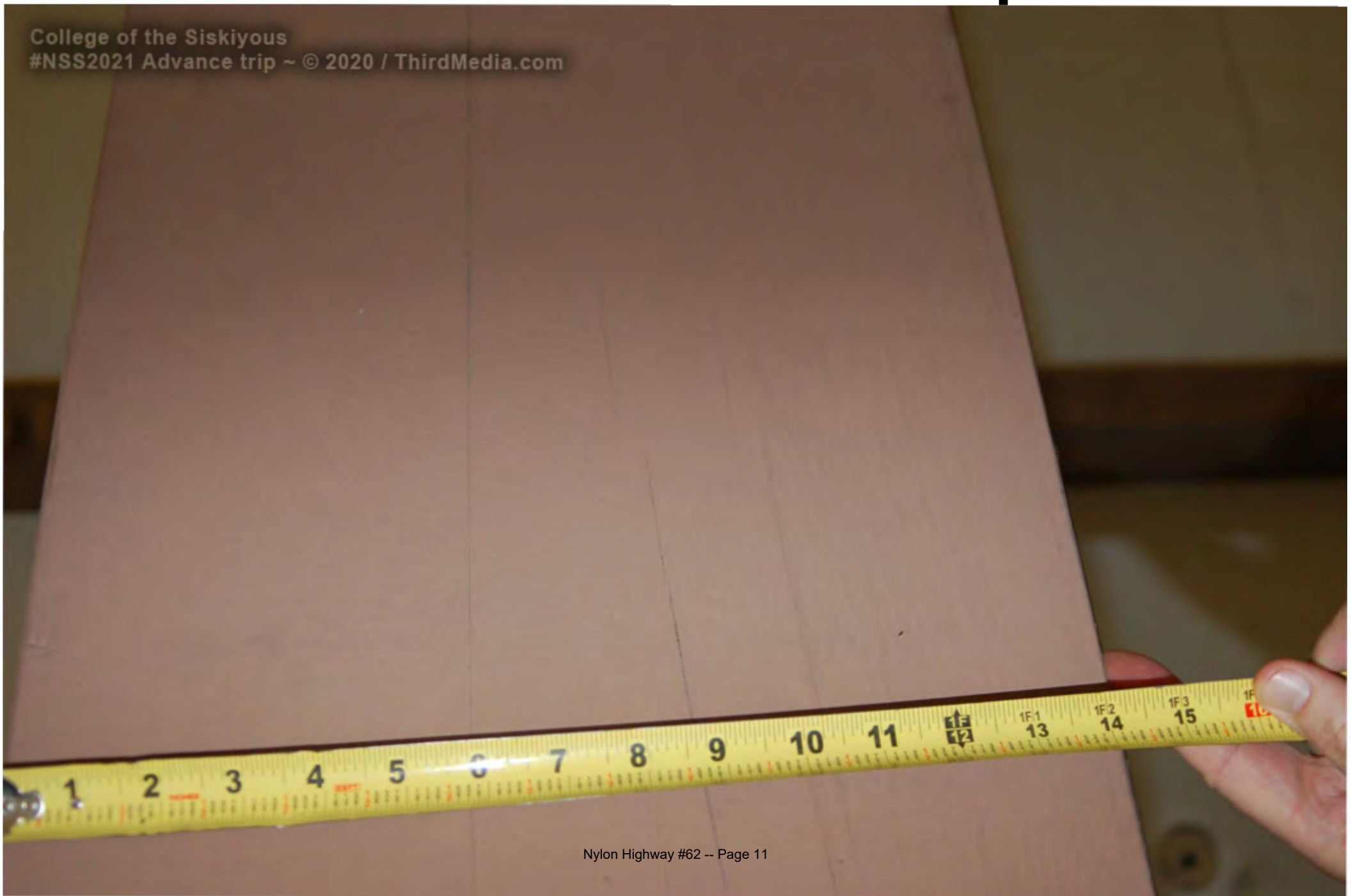
Beam Anchors Overview

- PURPOSE: These analyses provide definitive technical design requirements for the construction of the high (ceiling) anchors, based on scientific tests, direct empirical measurements, and good engineering practices. A candidate implementation for beams is also provided for consideration.
- Essential Prerequisite Document: Please read the NSS Vertical Section Climbing Contest Load Analyses *First!*
- For these analyses, we have initially considered large engineered wood beams, and it is expected that concrete, steel, or other materials would offer equivalent or better performance, with reasonably similar anchors.
- CONCLUSIONS: *Climbing Contest, and other Vertical Events, operational stresses to the ceiling anchors are relatively not a significant factor*. And from these analyses, safe and reliable ceiling anchors in typical beams are easily constructed using readily available materials and methods. Also, they provide a beneficial residual upgrade in facility capability. Furthermore, VS rigging practices are well proven and carefully implemented, and traditionally are 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.

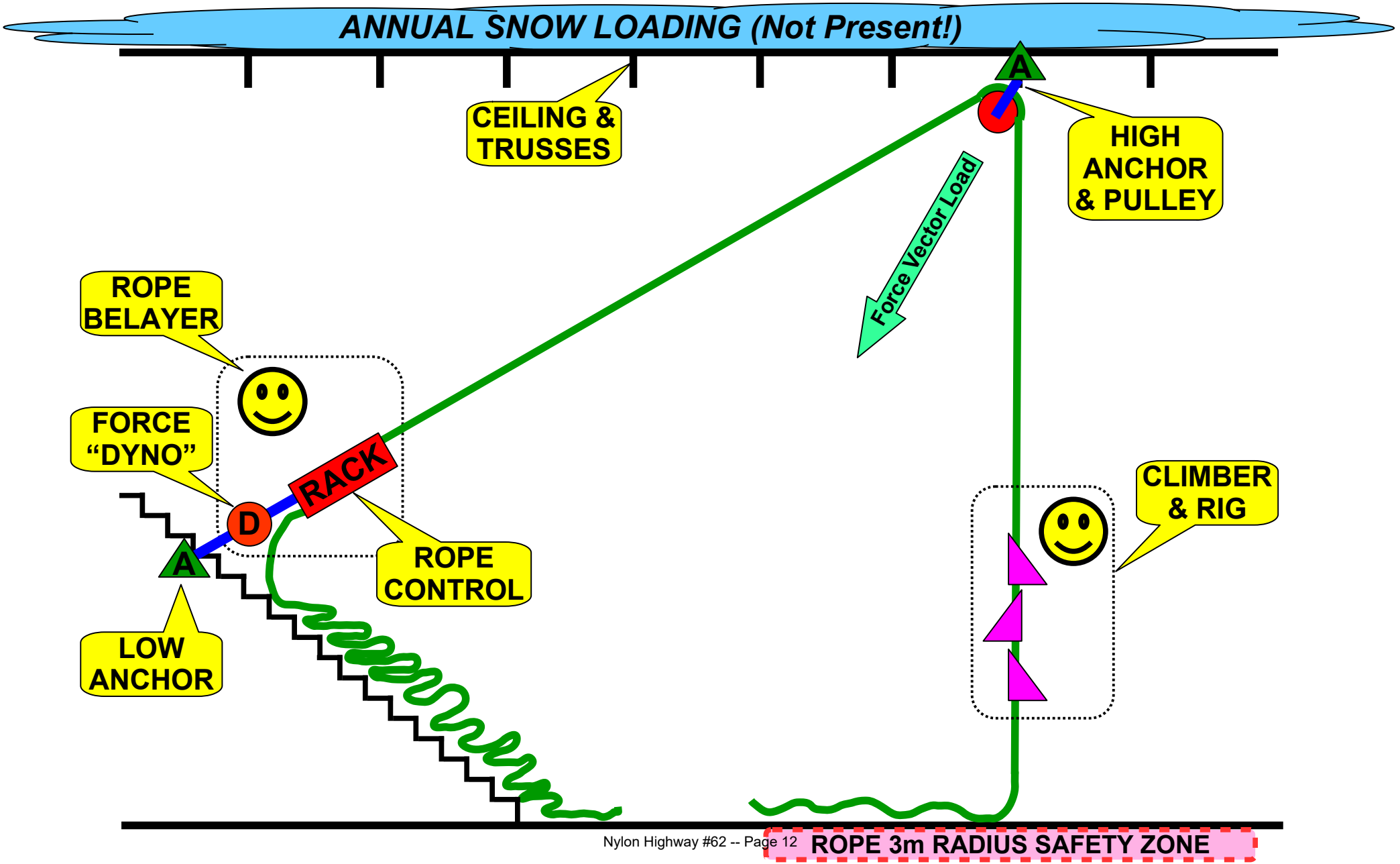
Solid Beam Example



Solid Beam Example



Rope System Design



Climbing Contest...

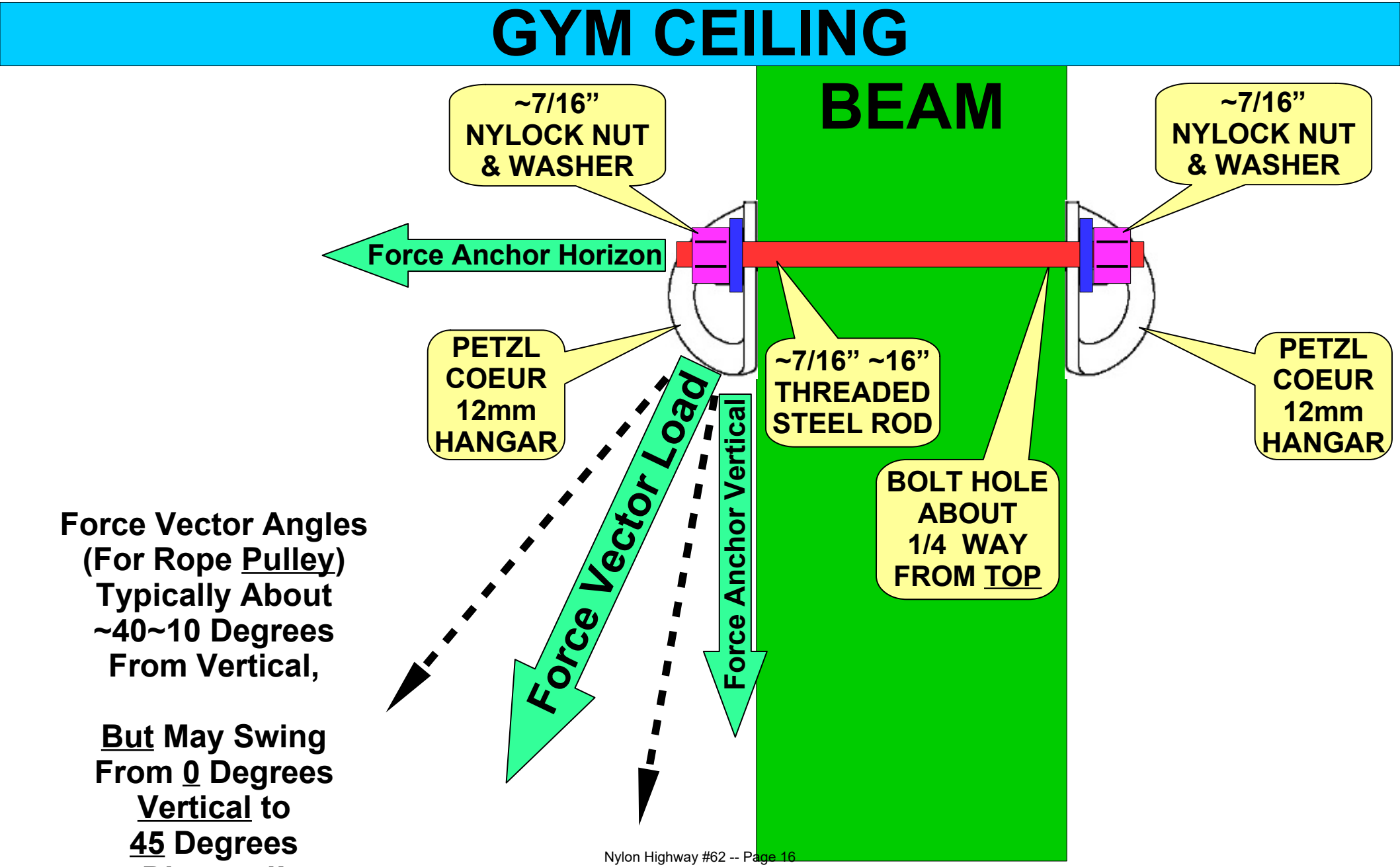
Analysis of Anchor Forces

- Please read the NSS Vertical Section Climbing Contest Load Analyses *First!*
- Actual Measurements at NSS2019 – Most Stressing Metrics
  - Most Dynamic System Peaks – Frog +34% [Rope Walker +3% max]
  - Most Dynamic Surges – Frog // 132 lbs // 176.2 lbs // +34%
  - Heaviest Climber – Frog // 209 lbs // Peak 222 lbs // +6%
  - Feed Rope Angle – 27 degrees from horizontal (very modest)
- **Empirical Maximum Anchor Loading**, Peak (pounds)
  - **Peak Vector << 400 pounds**
  - **Frog 378.91** Vector // 323.08 Vertical // 197.98 Horizontal [Climber 209 lb]
  - Truss Anchor Load Vector Angle 31.2 degrees from vertical (very modest)

Analysis of Anchor Forces

- Theoretical Worst Case Scenario – Most Stressing Metrics
  - Consider a Mythical Super Vertical Caver, very Heavy 250 lb, Strong & Fast, for Max Loading!
  - Plus consider rigging variants for Worst Case Feed Rope Angles, Vertical or Horizontal
    - 0 to 90 degrees from horizontal
  - Plus consider the Most Dynamic System Peaks – Frog +50% (far more than actually experienced!)
- **Theoretical Worst Case Anchor Loading**, Peak (pounds)
  - **Worst Case:: Heavy Climber – Frog // 250 lbs // Peak 375 lbs // +50%!! (that rare gorilla caver!)**
  - **Frog // 750 lb Vector // 750 lb Vertical // 375 lb Horizontal [Climber 250 lb]**
  - **Peak Truss Anchor Load Vector << 800 pounds**
  - **Truss Anchor Load Vector 0-45 degrees from vertical (Worst Case Limits)**
- Should Users or Facilities desire more definitive assessments of such issues, we encourage them to engage a Local Licensed PE Structural Engineer.

Beam Anchor Design



Petzl Coeur Hangar

PETZL Part Number
P36AA-12 ~$40 / 20

ROCK ANCHOR TYPE BOLT FOR ILLUSTRATION ONLY (NOT EMPLOYED IN THESE DESIGNS)

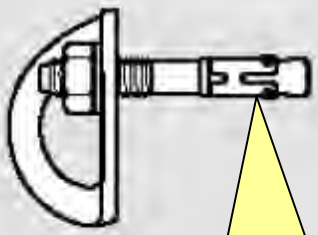
Petzl Hangar Strength

PETZL NOTES THAT STRENGTHS ARE TYPICALLY LIMITED BY THE PLACEMENT AND MATERIAL (ROCK OR CONCRETE) VS THE HANGAR OR THE ANCHOR BOLT

Strength Resistance

	STEEL		STAINLESS		HCR
	∅ 10	∅ 12	∅ 10	∅ 12	∅ 12
50 Mpa	23 kN	25 kN	25 kN	25 kN	25 kN
	SHEAR	*5620*	*LBS*		
50 Mpa	15 kN	18 kN	15 kN	18 kN	18 kN
	TENSION	*4047*	*LBS*		

CŒUR BOLT



DID WE MENTION THAT WE ARE NOT USING THIS ROCK ANCHOR?

Assessing Petzl Hangar

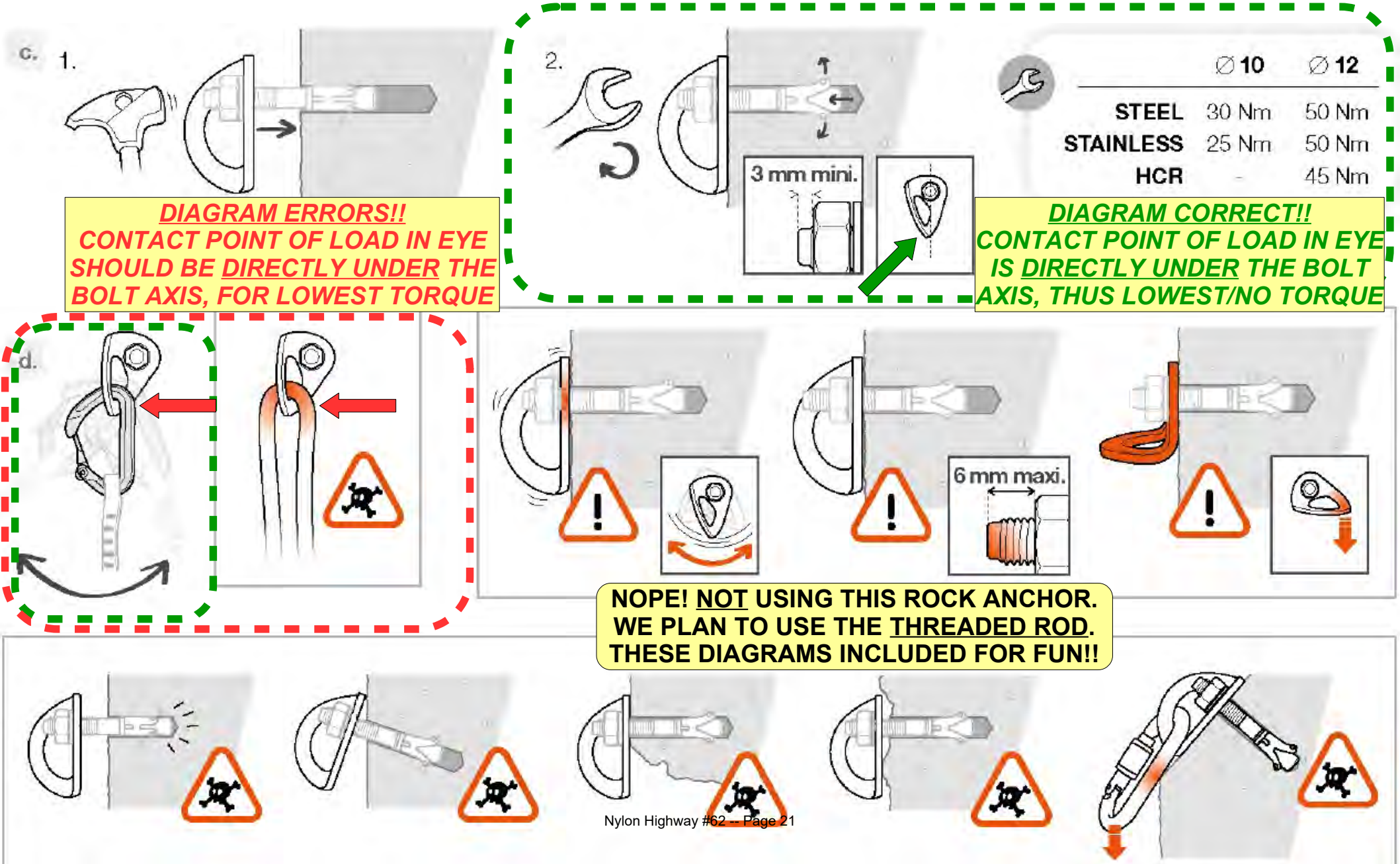
- Need to Provide Significant Safety Margin Beyond Presented Loading
- Petzl Hangar Performance Characteristics::
- Theoretical Worst Case Anchor Loading Analyses::
  - (Please see attached data and analyses)
  - Peak Vector << 800 pounds
  - 750 lbs Vector // 750 lbs Vertical // 375 lbs Horizontal
  - Truss Anchor Load Vector 0-45 degrees from vertical (Worst Case Limits)
- Petzl Hangar Performance Characteristics::
  - Vertical (Shear) >= 5620 lbs (25 kN)
  - Horizontal (Tension) >= 4047 lbs (18 kN)

Assessing Petzl Hangar

	WORST CASE LOADING	HANGAR RATINGS	RATIOS	SAFETY MARGINS
Units	Pounds	Pounds (kiloNewtons)	percent	Multiples
VERTICAL (Shear)	750	5620 (25)	13.3 %	*7.5 X*
HORIZONTAL (Tension)	375	4047 (18)	9.3 %	*10.8 X*

CONCLUSIONS:: THE PETZL 12mm COEUR HANGAR PROVIDES AN EXCELLENT MARGIN OF SAFETY FOR THIS ANCHOR PLACEMENT

Petzl Hangar Guidance



Petzl Hangar Issues

4. Compatibility

Verify that this product is compatible with the other elements of the system in your application (compatible = good functional interaction).
The carabiner used with the hanger must meet current standards in your country (e.g. EN 362 or EN 12275 connector depending on the type of application).
Use a bolt diameter that is appropriate for the hanger (e.g. 10 mm diameter bolt for 10 mm diameter hanger).
Warning: do not combine bolts, nuts, washers or hangers of dissimilar metals.
To use a COEUR hanger with any anchor device other than the BOLT bolt, be sure that the anchor system is strong enough, and compatible with the chosen hanger.

Suitable environment:

COEUR STEEL: indoor use, climbing gyms.
COEUR STAINLESS: outdoor environment, not aggressive enough to cause stress corrosion cracking (SCC).
COEUR HCR: aggressive SCC environment.
For anchor installations on a sea cliff, or in any other highly corrosive environment, the lifetime of the anchor is significantly reduced. It is preferable to use a material with good corrosion resistance so that the lifetime of the installation is satisfactorily long.

Petzl Hangar Install

5. Installing the anchor

Before installation, verify that the hanger and its means of attachment to the supporting medium (e.g. the bolt) are made of the same material.
Example of installation with an expansion bolt:
Check the quality of the supporting medium around the anchor. Make sure the rock is solid and uniform.
a. After cleaning the drilling area of any friable rock, drill a hole of the appropriate diameter and depth.
b. Clean the hole with a brush, then with a blower.
c. Push the bolt with the hanger into the hole and tighten the nut to the recommended torque.
d. After each installation, verify that the quickdraw moves freely in the hanger. Warning: if the bolt protrudes too much, it can hinder free movement of the quickdraw in the bolt hanger.
Hanger removal:
Unscrew the nut and remove the hanger. Before reusing the hanger, carry out a detailed inspection of it.

Strength

Test results obtained in 50 MPa concrete (high quality concrete, or rock). Common concrete has a weaker compressive strength, about 25 MPa.
The anchor breaking strength values depend on the quality of the supporting medium and on the quality of the placement.
Warning: in soft rock, the anchor strength may be reduced. It might be necessary to use a longer or different type of anchor, and to conduct strength tests in the field.
Warning: anchor strength can be near zero if poorly installed.

Steel Bolt Strengths

- **Proof Load** - is the maximum tensile force that can be applied to a bolt that will not result in plastic deformation
- **Clamp load** - equals to 75% of proof load

Example for 7/16" Steel Bolts:: We initially considered a Group 5 bolt, using 120 kpsi steel, and clearly sufficient for the load. BUT a long 15-16" bolt is simply unavailable!! Thus, we next consider a long threaded rod…

US Bolts - Coarse Threads

Proof Load

PROOF LIMIT
5850 lbs (Gd2)
9050 lbs (Gd5)

Nom Bolt Size *(in)*	Grade			
	2	5	8	Lamalloy
	Proof Load (lb_f) (kN)			
1/4	1750	2700	3800	4600
5/16	2900	4450	6300	7600
3/8	4250	6600	9300	11250
7/16	5850	9050	12800	15400
1/2	7800	12100	17000	20600
9/16	10000	15500	21800	26400

Clamp Load

CLAMP LOAD
4388 lbs (Gd2)
6788 lbs (Gd5)

Nom Bolt Size *(in)*	Grade			
	2	5	8	Lamalloy
	Clamp Load (lb_f) (kN)			
1/4	1313	2025	2850	3450
5/16	2175	3338	4725	5700
3/8	3188	4950	6975	8438
7/16	4388	6788	9600	11550
1/2	5850	9075	12750	15450
9/16	7500	11625	16350	19800

Steel Rod Strengths

Weight rating of threaded hanger rods

Load capacities of threaded hanger rods are indicated below:

Nominal Rod Diameter (in)	Root Area of Thread (in^2) (mm2)	Maximum Load [1]	
		lb	kg
3/8	0.07	600	270
1/2	0.13	1100	500
5/8	0.20	1800	820
3/4	0.30	2700	1220
7/8	0.42	3800	1720
1	0.55	4900	2220

7/16” 7/16 0.105

[1] The maximum loads in the table above are based on allowable tensile stress of *12 kpsi* - re *kpsi* allowable stress.

Example for 7/16” “Hanger” Steel Threaded Rods::
- Method shown here, but with 12 kpsi low strength steel
- Expect 120 kpsi medium strength steel to be about 10x stronger
- Which will be in the same range as a Group 5 bolt.

Analysis of Steel Rod

- A 7/16” diameter bolt or rod is a very good fit for the 12mm Petzl Coeur Hangar, and is available in very long sizes to accommodate thick (14”) beams (likely cut to 15”-16”)
- For sufficient load capacity, we select B7 medium strength steel with 120 kpsi tensile strength, equivalent to the desired Grade 5 bolts
- As a good practice, we derate the strength by 25% to 90 kpsi to provide a generous margin below Proof and Maximum Loading
- The bolt cross section for 7/16” dia stock solid shank is ~0.150 sqin
- But for a threaded rod we use the thread root cross section, which is ~70% bolt area, for ~0.105 sqin
- Thus 90 kpsi x 0.105 sqin = 9475 lbs Maximum Tension
- In common practice, the perpendicular loading strength is considered to be about 60% of tensile strength, thus ~5685 lbs Maximum Shear

RESULTS for a 7/16” B7 Medium Steel Threaded Rod::
Maximum Load : ~9475 lbs (Tension), ~5685 lbs (Shear)

Assessing Steel Rod

- Need to Provide Significant Safety Margin Beyond Presented Loading
- Steel Rod Performance Characteristics::
- Theoretical Worst Case Rod Loading Analyses::
  - 750 lbs Vertical (Shear)
  - 375 lbs Horizontal (Tension)
- Steel Rod Performance Characteristics::
  - Vertical (Shear) ~5685 lbs (B7 ~Gd5)
  - Horizontal (Tension) ~9475 lbs (B7 ~Gd5)
  - WARNING: Safe & reliable performance is critically dependent on equivalent high quality self-locking Grade 5 nuts, and washers!!
- ***Recommendations:***
  - ***Procure B7 Medium Strength Steel Threaded Rods and***
  - ***Grade 5 Nylon Lock Nuts***
  - ***And buy only from reliable industry sources, such as McMaster-Carr, and not the local hardware store!!***

Assessing Steel Rod

	WORST CASE LOADING	ROD RATINGS	RATIOS	SAFETY MARGINS
Units	Pounds	Pounds	percent	Multiples
VERTICAL (Shear)	750	5685	13.2 %	*7.6 X*
HORIZONTAL (Tension)	375	9475	3.96 %	*25.3 X*

CONCLUSIONS:: THE 7/16" B7 THREADED STEEL ROD PROVIDES AN EXCELLENT MARGIN OF SAFETY FOR THIS ANCHOR PLACEMENT

Beam Anchor System Parts

	DESCRIPTION *For TEN High Anchor Sets*	QTY	COST EACH	COST TOTAL
1	Threaded Rod, Steel, Plated – 7/16”-14 UNC ~16” Long Each – Medium Strength B7 McMaster Part 98957A610 www.mcmaster.com/98957A610	10 (Buy & Cut <u>Five</u> 3-Foot Rods)	$5	$25
2	Lock Nut, Steel, Plated, Nylon Insert – 7/16”-14 UNC Grade 5 McMaster Part 95615A180 www.mcmaster.com/95615A180	20	$12/100	$12
3	Washer, Steel, Plated – 7/16”	20		
4	Hangar, Steel, Petzl Coeur – 12mm Part P36AA-12 - (uses 7/16” bolt)	20	$40/20	$40
5	Drill, 7/16” – Metal or Wood - > 15” Reach	1		
	TOTALS	71 items		

References

- NSS Vertical Section Documents
  - NSS Vertical Section Climbing Contest Load Analyses – G. Harrison
- Engineering Toolbox
  - www.engineeringtoolbox.com/steel-bolts-sae-grades-d_1426.html
  - www.engineeringtoolbox.com/us-bolts-tensile-proof-load-d_2066.html
  - www.engineeringtoolbox.com/loads-hanging-rods-d_1341.html
- Portland Bolt & Manufacturing
  - www.portlandbolt.com/technical/fastener-identification-markings
  - www.portlandbolt.com/technical/faqs/bolt-shear-strength-considerations
- Hardware Sources – McMaster-Carr
  - Grade B7 Medium-Strength Steel Threaded Rod
  - 7/16"-14 Thread Size, 3 Feet Long
  - Part 98957A610 ~$5 / 3ft
  - www.mcmaster.com/98957A610
  - Medium-Strength Steel Nylon-Insert Locknut
  - Grade 5, Zinc-Plated, 7/16"-14 Thread Size
  - Part 95615A180 ~$12 / 100ctt
  - www.mcmaster.com/95615A180
- Petzl Technical Data
  - Petzl Coeur Hangar 12mm Steel – Part P36AA-12 ~$40 / 20ct
  - www.petzl.com
  - www.petzl.com/US/en/Sport/Anchors/COEUR-STEEL

Analytical Data...

- Actual Test Data from Selected NSS2020 Rope Contest Climbs
  - Vertical Section Climbing Contest Load Analyses
- Examination of Significant Loading Parameters
- Creation of the Worst Case Scenario
- Analyses of Worst Case Loading

WORST CASE ANCHOR LOADING ANALYSES				DYNAMIC STATUS >>>		STATIC FEED ROPE LOAD	PEAK FEED ROPE LOAD	STATIC FEED ROPE LOAD	PEAK FEED ROPE LOAD
RECORD INDEX	DATE DAY	TIME START	CLIMBER NAME	CLIMBING SYSTEM	ROPE RUN DISTANCE	FRL Static	FRL Peak	FRL Static	FRL Peak
						.	.	P=2.2xkg	P=2.2xkg
Case	x	x		"Rig"	meters	kilograms	kilograms	pounds	pounds
1	17 June	1441	n/a	Frog	30	95.00	101.00	209.00	222.20
4	17 June	1553	n/a	Frog	120	60.00	80.10	132.00	176.22
13	18 June	1200	n/a	Rope Walker	n/a	87.00	89.20	191.40	196.24
A	HEAVY CLIMBER & FROG			Frog	n/a	95.00	101.00	209.00	222.20
B	ROPE FEED HORIZONTAL			Frog	n/a	95.00	101.00	209.00	222.20
C	ROPE FEED VERTICAL			Frog	n/a	95.00	101.00	209.00	222.20
D	HEAVY CLIMBER & FROG			Frog	n/a	95.00	127.30	209.00	280.06
E	HIGHER 1.34 SURGE			Frog	n/a	95.00	127.30	209.00	280.06
F				Frog	n/a	95.00	127.30	209.00	280.06
G	HEAVIEST CLIMBER & FROG			Frog	n/a	113.64	152.27	250.00	335.00
H	HIGHER 1.34 SURGE			Frog	n/a	113.64	152.27	250.00	335.00
J				Frog	n/a	113.64	152.27	250.00	335.00
K	HEAVIEST CLIMBER & FROG			Frog	n/a	113.64	170.45	250.00	375.00
L	HIGHEST 1.5 SURGE			Frog	n/a	113.64	170.45	250.00	375.00
M	*THE WORST CASE COMBO			Frog	n/a	113.64	170.45	250.00	375.00

WORST CASE ANCHOR LOADING ANALYSES				STATIC FEED ROPE LOAD	PEAK FEED ROPE LOAD	STATIC FEED ROPE LOAD	PEAK FEED ROPE LOAD
COLOR CODES	Fixed Fields	Sequence Fields	Data Inputs	FRL Static kilograms	FRL Peak kilograms	FRL Static pounds	FRL Peak pounds
	Data Into Formulas	Formula Results	Notable Results	PEAKS 113.64	PEAKS 170.45	PEAKS 250.00	PEAKS 375.00

		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
1.34	27	157.01	80.00	157.01	256.22	300.50	58.50
1.03	27	174.85	89.09	174.85	**285.33**	**334.64**	58.50
1.06	27	197.98	100.88	197.98	323.08	378.91	58.50
1.06	**0**	222.20	0.00	**222.20**	222.20	314.24	45.00
1.06	**90**	0.00	222.20	0.00	**444.40**	**444.40**	90.00
1.34	27	249.54	127.14	249.54	407.20	477.58	58.50
1.34	**0**	280.06	0.00	**280.06**	280.06	396.06	45.00
1.34	**90**	0.00	280.06	0.00	**560.12**	**560.12**	90.00
1.34	27	298.49	152.09	298.49	487.09	571.27	58.50
1.34	**0**	335.00	0.00	**335.00**	335.00	473.76	45.00
1.34	**90**	0.00	335.00	0.00	**670.00**	**670.00**	90.00
1.50	27	334.13	170.25	334.13	545.25	639.48	58.50
1.50	**0**	375.00	0.00	**375.00**	375.00	530.33	45.00
1.50	**90**	0.00	375.00	0.00	**750.00**	**750.00**	90.00

		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
PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS	PEAKS
1.50	**90.00**	**375.00**	**375.00**	**375.00**	**750.00**	**750.00**	**90.00**

NSS Vertical Section

Climbing Contest Load Analyses

Gene Harrison

Chair

NSS Vertical Section

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C-703-585-4565

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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: *Climbing Contest operational stresses to the ceiling anchors are relatively not a significant factor*. 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.

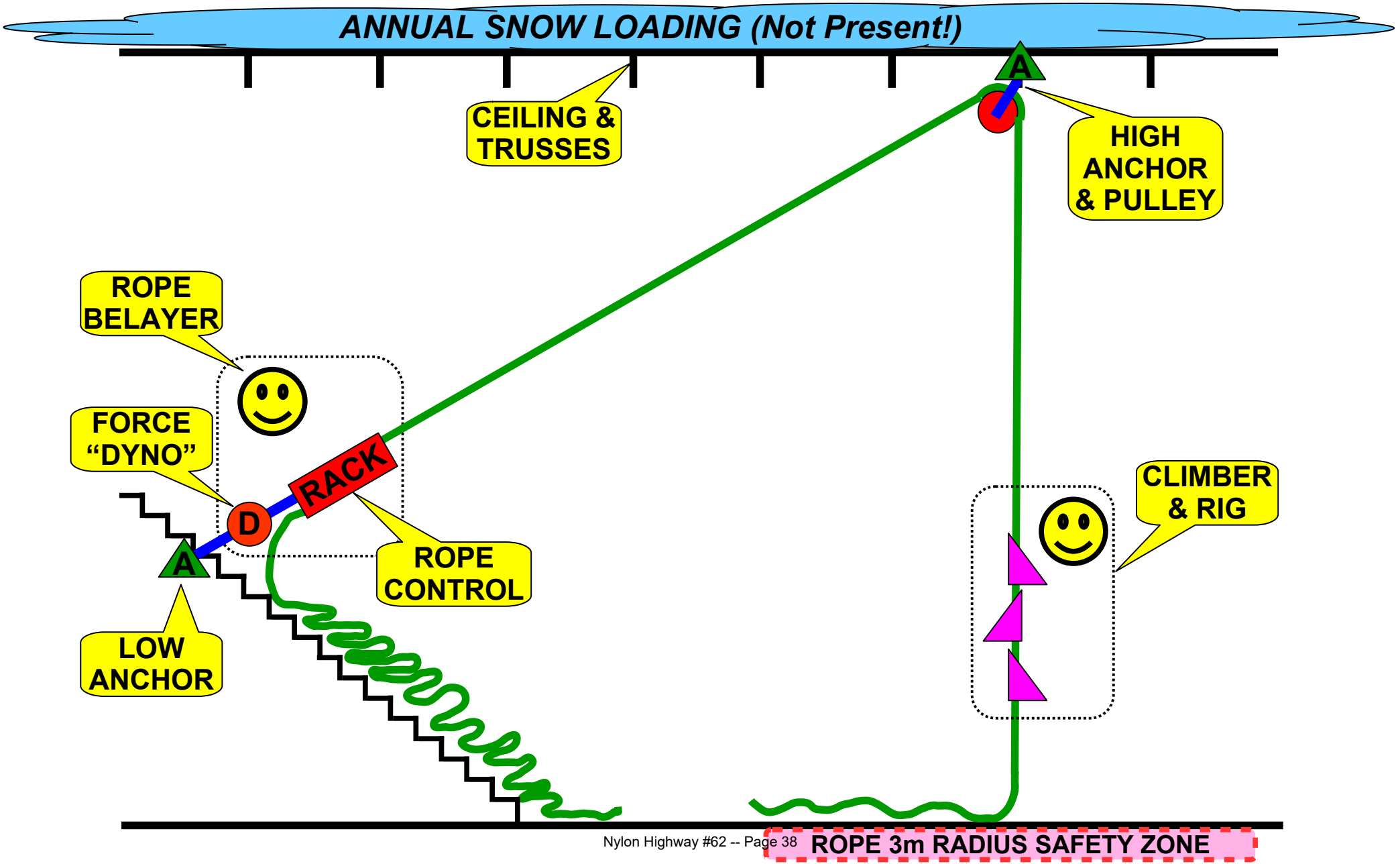
Climbing Contests

- 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...

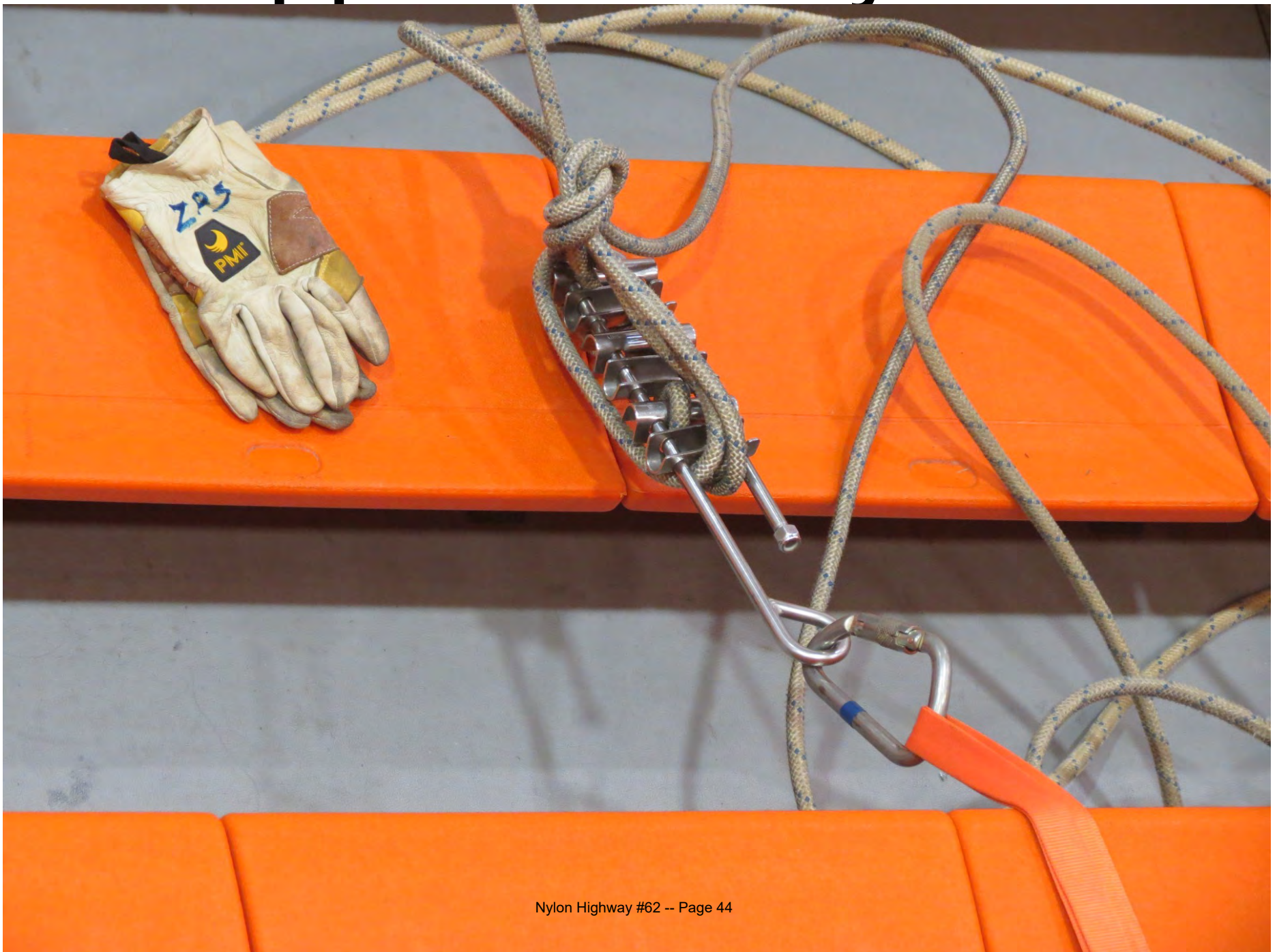
Rope Climbers…

Lots of Cave Vertical Skills

High Anchor Pulley - Beam

High Anchor Pulley - Truss

Rappel Rack System



Rappel Rack Control

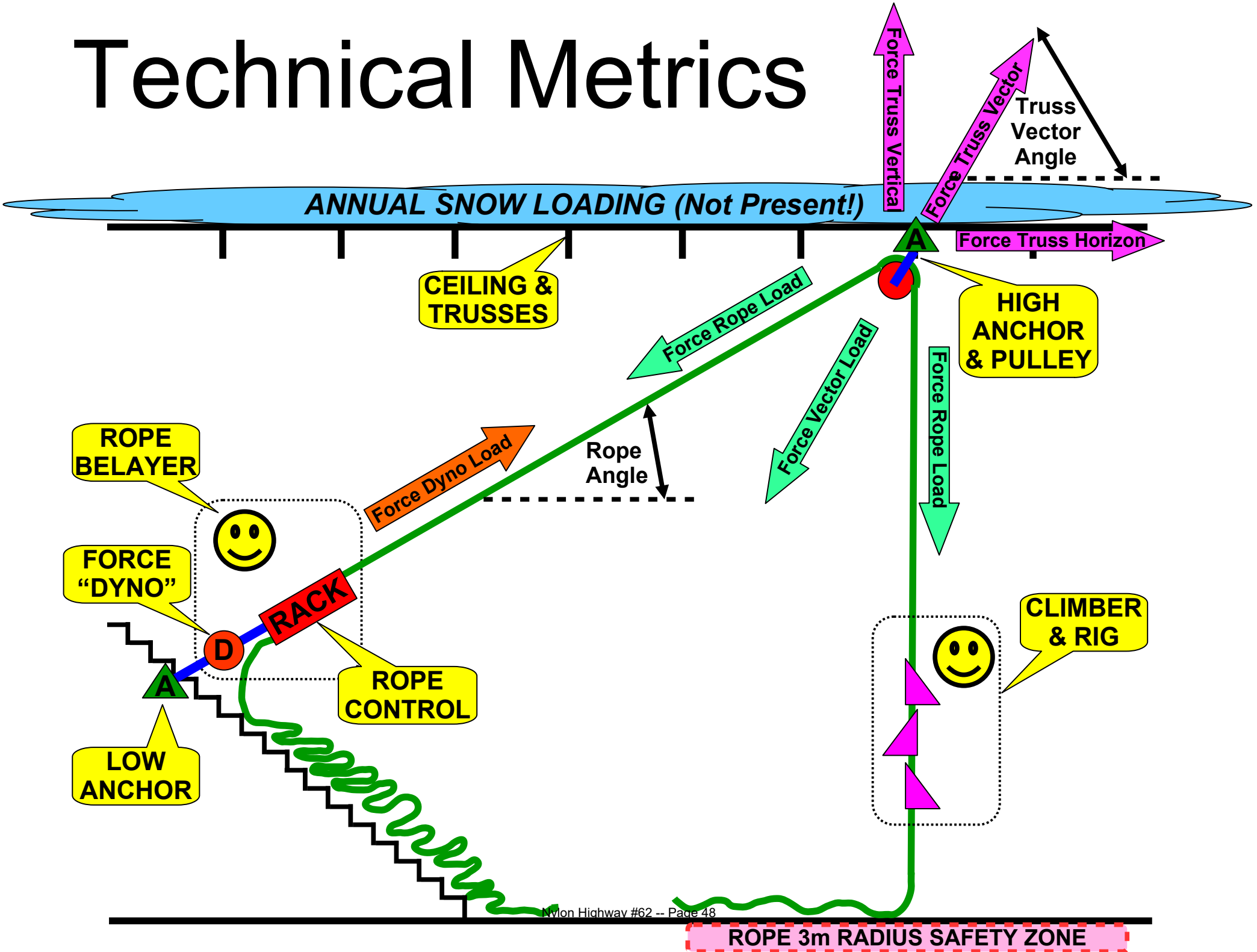
Analysis Considerations

- Total loading on a high truss anchor is the vector sum of
- a) the forces in the vertical climbing rope, and
- b) the forces in the sloping feed rope.
- These rope sections have equal tensions, due to the pulley.
- This upper directional device is usually assimed to be frictionless.
  - 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 lower loading.
- The primary vertical rope loading is the Climber's static weight.
- When climbing, the motions of the Climber produce dynamic 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 dynamic surge loads, than those with the “Rope Walker” Systems.
- The key results of interest will be the maximum Peak Truss Loads. 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…!

Technical Metrics



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 –
  - 30m: 13 (72%) // 120m: 5 (28%)
  - 18 climbs (100%). 11 distances not recorded
- Climbing Systems Employed –
  - Frog: 22 (79%) // Rope Walker: 6 (21%)
  - 28 climbs (100%). 1 system not recorded
- Some Climbers climbed more than once (one climbed three times!), and they usually varied their Climbing System, Event Distance, or both

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

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 STATIC
& DYNAMIC Loads
(with PEAK HOLD)
(Used in Tests)
DYNAMOMETER
(2000 lb Max)
Displays STATIC
& DYNAMIC Loads
(FYI - Not Used)
KLAU
CE
STB ZERO
0.0
N
lb
kg
HOLD
UNIT
TARE
ZERO
Cap.300kg
CRANE SCALE
CE
0
25 lb
HOLD
UNIT
TARE
ZERO

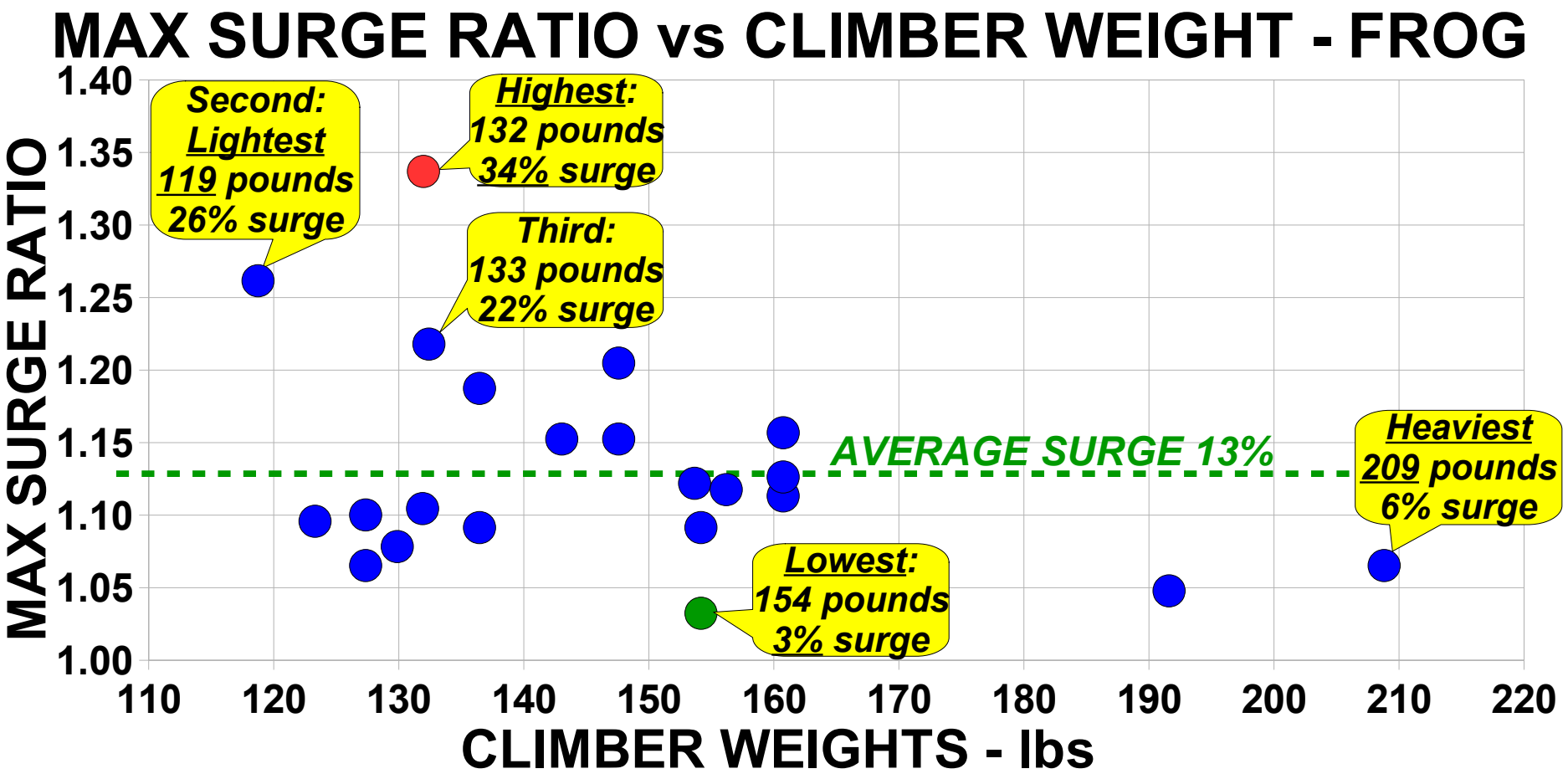
Results of Analyses

- 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

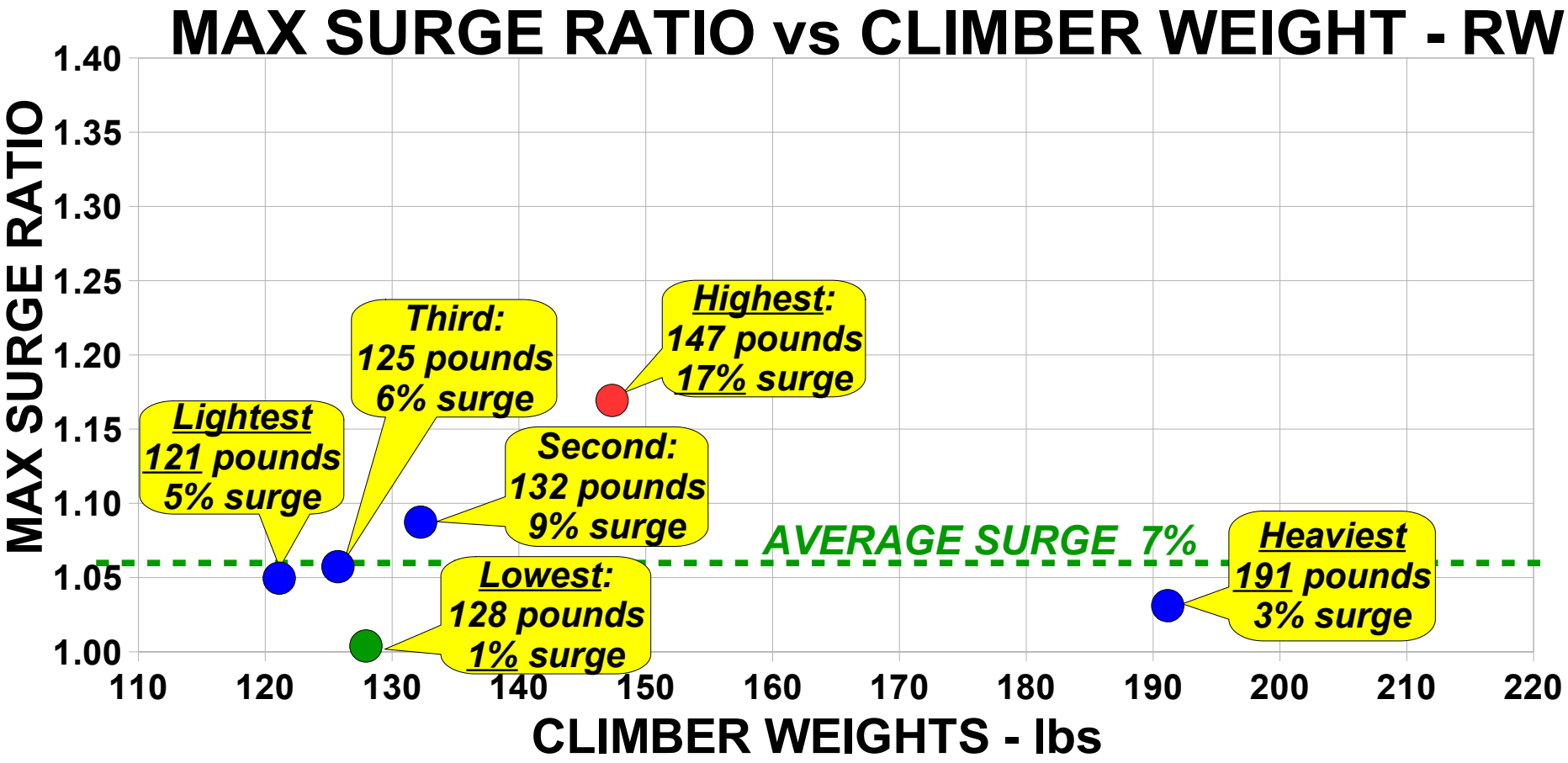
Results of Analyses

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



Max Surge *Ratio* vs Climber Weight - *RW*



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 40 lb/ft2 on a flat surface...”
  - “...Three feet of “wet” snow will approach about 70 lb/ft2...”

Rigging vs Snow Loading

- Any long standing gym roof has evidently survived these extreme snow loads, and likely worse!
- Givens: Typical truss spacing at least 4 feet, and snow load tolerance of at least 40-70psf. And, point loading is different from area loading...
- Assumptions: The ceiling anchor forces at a single point are reasonably distributed over at least a 10 ft (+-5ft) distance, for an equivalent loading area of at least 40 sqft, and likely more.
- Thus the equivalent area snow loading design tolerance should exceed 1600-2800 pounds
- Per actual tests & measurements, the truss peak loading of under 400 pounds can be safely accommodated, with a safety margin of at least 4x to 7x, & 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-roof-overload

Experimental Test Data...

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

ALL CLIMBS				DYNAMIC STATUS >>>		STATIC	PEAK	STATIC	PEAK
						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**
2	17 June	1534	n/a	Rope Walker	30	57.00	60.40	125.40	132.88
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
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

		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
1.06	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	61.22	120.16	196.09	229.97	58.50
1.09	27	132.90	67.72	132.90	216.88	254.36	58.50

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

FROG SYSTEMS				DYNAMIC STATUS >>>		STATIC	PEAK	STATIC	PEAK
						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

FROG SYSTEMS				STATIC FEED ROPE LOAD	PEAK FEED ROPE LOAD	STATIC FEED ROPE LOAD	PEAK FEED ROPE LOAD
COLOR CODES	Fixed Fields	Sequence Fields	Data Inputs	FRLStatic kilograms	FRLPeak kilograms	FRLStatic pounds	FRLPeak pounds
	Data Into Formulas	Formula Results	Notable Results	AVERAGES	AVERAGES	AVERAGES	AVERAGES
				66.83	75.42	147.03	165.92
				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
1.13	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

ROPE WALKERS				DYNAMIC STATUS >>>		STATIC FEED ROPE LOAD	PEAK FEED ROPE LOAD	STATIC FEED ROPE LOAD	PEAK FEED ROPE LOAD
RECORD INDEX	DATE DAY	TIME START	CLIMBER NAME	CLIMBING SYSTEM	ROPE RUN 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

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

		PEAK	PEAK	PEAK	PEAK	PEAK	
FEED ROPE LOAD RATIO	FEED ROPE ELEVATION ANGLE	FEED ROPE TRUSS LOAD Horizontal	FEED ROPE TRUSS LOAD Vertical	TRUSS ANCHOR LOAD Horizontal	TRUSS ANCHOR LOAD Vertical	TRUSS ANCHOR LOAD VECTOR	TRUSS ANCHOR LOAD 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 LOAD RATIO	FEED ROPE ELEVATION ANGLE	FEED ROPE TRUSS LOAD Horizontal	FEED ROPE TRUSS LOAD Vertical	TRUSS ANCHOR LOAD Horizontal	TRUSS ANCHOR LOAD Vertical	TRUSS ANCHOR LOAD VECTOR	TRUSS ANCHOR LOAD 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

Vertical Section Executive Committee Meeting
June 10th to 12th, 2020
E-Meeting

Minutes of the NSS Vertical Section Executive Committee / Board of Trustees E-Meeting June 10th -12th, 2020.

Announcement. This e-meeting was announced on June 10th, 2020 by Chairman Gene Harrison.

Purpose. The purpose of this e-meeting was to approve proposed Bylaw Revision 2nd Final Draft 2020_06-06.pdf as submitted to the EC by the VS Bylaws Committee.
http://caves.org/section/vertical/VS-Bylaws-2020-06-12.pdf

Attendance. 6 of the 7 active members of the Board replied "present" by email, and no one objected to suspending the Rules of Order. Gene Harrison had contacted Bill Cuddington by phone, and Bill gave Gene his verbal proxy, with no objections. The quorum of five was met, so the Chairman called the meeting to order on June 10th, 2020.

New Business. Bill Boehle motioned to " Approve the revisions to the VS Bylaws that are contained in the document http://caves.org/section/vertical/VS-Bylaws-2020-06-12.pdf." Ray Sira seconded the motion.

Discussion. There were no comments.

Vote & Adjournment. On June 11th, 2020, the Chairman closed the discussion period. On June 12th, 2020 Gene announced all EC members had responded and that the motion passed unanimously.

Respectfully submitted 07/19/2020 by Raymond Sira,
Secretary/Treasurer NSS Vertical Section

Vertical Section Executive Committee Meeting

June 30th, 2020

Online Via Zoom

1. The meeting was called to order at 8:10 pm by Chairman Gene Harrison. VSEC Members present were Chairman Gene Harrison, Secretary-Treasurer Ray Sira, member-at-large Bill Boehle, Member at Large Bonnie Armstrong and Vertical Techniques Workshop Coordinator Kurt Waldron. Also present were Webmaster-Rebelay Workshop Coordinator Gary Bush along with guests Terry Mitchell, Lynn Ott and our meeting host Rich Geisler. Vice Chairman Mike Rusin joined the meeting later and Contest Coordinator Bill Cuddington was absent. The positions of Website Coordinator and Education Coordinator are currently vacant. The quorum of 5 VSEC members has been met.

2. Reports

A. Chairman – Gene Harrison: This meeting replaces the normal Sunday pre-convention meeting. Gene encouraged us to do more outreach to find people who can understudy those of us who are actively running the different parts of the Vertical Section. John Bowling from California will be the VS liaison for the 2021 convention in Weed California. Special anchors will be installed for us to rig to. Bonnie will reach out to the 2022 convention staff. Rich suggested reaching out to Carol Tiderman for all thing's convention related. The 2020 annual VS Business meeting will be held online on Tuesday July 28th at 6:00 pm EST. It will be on Zoom and hosted by the 2020 virtual convention. Gene will have a couple of presentations after the meeting. He asked to let him know if anyone else has anything to present. Kurt mentioned he may not be present at the July 28th meeting. Bill asked Kurt to appoint a proxy if he cannot make it.

B. Secretary Treasurer – Ray did not have the previous meeting minutes ready yet for approval. They will be ready soon and they can be approved at another online meeting. We currently have 272 people on the membership list with 117 of those memberships due to or have already expired. Emails will be sent out in the next few days to all members we have email addresses to announce the July 28th meeting. It will include a note if their membership has expired and to please contact me to renew it. Gary asked to send him the list and he will update the website membership list. Ray said the list is on the VS Google Docs page and all VSEC members should have access to it. Most of our important documents are now on this page including the trailer inventory and old meeting minutes. There is also a VSEC Google Group that includes all VSEC members. Gene and Mike's VSEC positions will be up this year. Ray asked to have the online membership form changed to remove the option for paying $10.00 to have the Nylon Highways mailed to them. Bonnie asked if we are not sending out an annual publication, what are the incentives to join the VS. Gary said the Nylon Highways will still be published online. Ray would like to do away with the VS Yahoo Group and change it to a Google Group. Gene and others agreed. Several comments were made about why people should join the Vertical Section that basically boiled down to we are a community of like-minded individuals with a similar interest.

C. Symbolic Items – Christa Hay has taken over this position. We have not received a report from Christa. Bill mentioned that On-Rope 1 would be willing to take over sales of our symbolic Items.

It was suggested to add a note in the email Ray will be sending out about the availability of symbolic items. Ray asked if we would still share the profits from sales if On-Rope 1 took over sales. Bill said yes. Gene asked if our logo is trademarked. Gary relied no.

D. Awards – Ken Alwin was not present. No one has heard from Ken and no one was aware of any current action being done. Terry mentioned that the retiring Chairman traditionally receives a plaque.

E. Education/Training – Terry said not much has been done except Tim White presented the committee with a revised Vertical Training Lesson Plan last year. Bonnie made some suggestions for changes, and Tim sent a new version for review. It still needs to be reviewed by the committee. Terry announced that he is resigning as leader of the training committee. Terry will send Tim's report out to everyone on the VSEC for review, and that we should go ahead and put it on the website after. Gene thanked Terry for all his hard work and asked if there were any recommendations for a replacement. Ray suggested we should have these online meetings quarterly to remind ourselves of things we should be doing. Gene agreed and will consider possible dates. (At this point Ray lost his data connection for a few minutes.) Bonnie is going to reach out to Jon Schow, who set up the VS Facebook page to see about reactivating it and may know some people to moderate it.

F. Climbing Contest – Bill Cuddington was unable to attend the meeting. Bonny recalled someone wanting to climb barefoot last year. Ray has made a sign saying proper footwear is required with a photo of what can happen if you do not.

G. Rebelay Workshop – Gary Bush reported there will not be a rebelay course this year 😊. He would like to get some of the cavers who have a lot of experience with rebelay's to help or take over running it. Bonnie mentioned it can be hard to find someone who consistently attends conventions and is not already actively involved in other aspects of the convention.

H. Vertical Techniques Workshop – Kurt Waldron has not been able to attend the last couple of conventions but believes we are in good shape. Terry said we have been updating some of the gear. Gene asked that the guides for each station be looked at to see if the need updating. Ray said each climbing system has been individually inventoried with a photo of each system and it is on the Google Drive. We will be adding a fourth frog system and some chest harnesses for the knots systems.

I. Website Coordinator – Vacant. Gene said the last issue of the Nylon Highway was from 2016 and that the climbing world records need to be updated. Ray will send Gary the latest climbing contest world records. Ray asked if there might be a way for someone to look up their history of climbing times.

J. Bylaws Committee – Terry said the final draft of the revised constitution will be presented for vote during new business. Bill Boehle went ahead and made a motion to "Approve the proposed constitutional amendments for presentation to the membership at the annual business meeting for final ratification". Mike Rusin seconded the motion. The motion was unanimously approved.

K. **Special Events** – Gene suggested adding some different events at the convention, but Terry stated we would probably have trouble finding people to run them. We often have problems finding adequate people to help with the vertical contest.

3. **Old Business**

A. None.

4. **New Business**

A. **Polling Test** – We attempted to figure out how test voting for when we need to elect new officers at the business meeting. We were unsuccessful at this. Ray will investigate it and we can try in again at another meeting before the virtual convention business meeting.

5. **Adjournment** – The meeting was adjourned at 10:15 PM.

NSS Vertical Section

Secretary's Report

07/17/2020

By Raymond Sira

Number of Current Members as of 07/17/2019	277
Number of Subscribers as of 07/17/2020	10
Number of Pending Dropped Memberships 2019	106
Number of Memberships due to Drop 2020	31

Exp Date	Members	Subscribers
2019	105	6
2020	31	0
2021	22	0
2022	51	4
2023	31	0
2024	6	0
2025	31	0

NSS VERTICAL SECTION
TREASURER'S REPORT (06/01/2019 to 06/31/2020)

By Raymond Sira

INCOME:

2019 Convention Workshop Registration…….	$900.00
Bank Interest (Ally) June 2019 – June 2020…….	$98.14
TOTAL INCOME:	**$998.14**

Expenses:

2019 Vertical Workshop Transportation Expense Subsidy (Ray Sira)……..	$0.00
Webbing 1" Tubular……..	$70.00
Personal Property Tax for Trailer……..	$24.28
2019 Climbing Contest Prizes……...	$116.50
NSS – Website hosting fees (2019) (***Bill not received***)……	$0.00
TOTAL EXPENSES:	**$210.78**

ACCOUNT BALLANCES:

Well Fargo (Ray's account as of 06/30/2020)……...	$1,637.36
ALLY Demand Notes (as of 06/30/2020)…….	$5,978.54
Cash on Hand……	$75.00
TOTAL 06/30/2020:	**$7,690.90**
2019 Total:	$6,903.54

Vertical Section Executive Committee Meeting

July 21st, 2020

Online Via Zoom

1. The meeting was called to order at 8:07 pm by Chairman Gene Harrison. VSEC Members present were Chairman Gene Harrison, Vice Chairman Mike Rusin, Secretary-Treasurer Ray Sira, member-at-large Bill Boehle, member-at-large Bonnie Armstrong, and Vertical Techniques Workshop Coordinator Kurt Waldron. Also present were former chairman Terry Mitchell, Webmaster. Contest Coordinator Bill Cuddington was absent. The positions of Website Coordinator and Education Coordinator are currently vacant. The quorum of 5 VSEC members was met.

2. Reports

A. Chairman – Gene Harrison reviewed the agenda.

B. Minutes Approval – Bill noted that Gary Bush's title was wrong on the minutes, and the position Website Coordinator should be Nylon Highway Editor, as these minutes were before the title changed. Ray will make the corrections. There was also an incorrect date on the Treasurers report, and Ray did not have the current balance for the Symbolic Items account. Bill made a motion to except the corrected 2019 VSEC meeting minutes. We tested the Zoom polling function, and the minutes were approved unanimously. The minutes of the VSEC E-meeting were also approved unanimously. We found that the host of the meeting running the poll does not have the ability to vote. Also Zoom shows how many people voted for each answer but does not name who voted or did not vote.

C. Training – Gene converted the PDF file from Tim White to a document file for easier editing and will send it out to everyone. Bonnie suggested we wait for a new Education Coordinator to be elected. Bonnie has reached out people who might be interested in the position. It was suggested the document be put online were everyone could edit the same document instead of having multiple versions. Terry suggested sending edits to Tim. Gene as Chairman had recently appointed Hazel Barton as the new Education Coordinator and requested VSEC affirmation. Bonnie made a motion to appoint Hazel Barton as the new Education Coordinator. Bill Boehle seconded the motion and all approved.

D. Website Coordinator – Gary Bush has agreed to be the Website Coordinator. (Formerly Nylon Highway Editor).

E. 2022 Convention – Bonnie reached out to the chair of the convention, Dan Austin. A facilities manager has not been appointed yet, so Bonnie sent the documents for the Vertical Section's requirements to Dan.

F. Gene mentioned Derick Bristol's training videos and suggested we might want to reach out to him about becoming involved with the training committee.

3. Adjournment – The meeting was adjourned at 9:00 PM.

Vertical Section Executive Committee Meeting

September 3rd, 2020

Online Via Zoom

Purpose: After the July 28th, 2020 Vertical Section business meeting it was brought to Gene Harrison's attention the voting for the 2 At-large positions for the Vertical Section Executive Committee may not have been properly done as per our By-laws. There was much discussion about this among members of the Executive committee prior to this meeting, and it was decided to have a formal meeting consisting of the VSEC members prior to the July 28th, 2020 business meeting to decide the validity of the elections and what should be done.

The meeting was called to order at 7:00 PM EST.

Attendance:

Gene Harrison – Chairman
Ray Sira – Secretary/Treasurer
Bonny Armstrong – Vice Chairman
William Boehle – At-Large Member
Hazel Barton – Education Coordinator
Kurt Waldron – Vertical Techniques Workshop Coordinator
Gary Bush – Website Coordinator
Terry Mitchell – By-laws committee

Gene Harrison held proxy for missing Contest Coordinator Bill Cuddington and Ray Sira held proxy for missing At-Large Member Mike Rusin.

Discussion: During the meeting it was determined that the By-laws were vague on how voting should take place and who is eligible to run for office. Our By-laws committee (Bill Boehle & Terry Mitchell) was asked to investigate changes that should be made to the By-laws in the near future, clarifying our voting procedures.

Vote: Gary Bush made a motion that "Rachel Sacker was a viable candidate at the time of the VS Elections on 07/28/20". The motion passed unanimously and a revote will not take place.

Meeting was adjourned at 7:49 PM EST.

Vertical Section Executive Committee Meeting

October 21st, 2020

Online Via Zoom

Purpose: This meeting was called to review and changes to the Vertical Section By-laws purposed by the By-laws committee (Bill Boehle and Terry Mitchell).

The meeting was called to order at 8:10 PM EST.

Attendance:

Gene Harrison – Chairman
Bonny Armstrong – Vice Chairman
Ray Sira – Secretary/Treasurer
William Boehle – At-Large Member
Rachel Saker – At-Large Member
Gary Bush – Website Coordinator
Kurt Waldron – Vertical Techniques Workshop Coordinator
Hazel Barton – Education Coordinator
Terry Mitchell – By-laws committee

Gene Harrison held proxy for missing Contest Coordinator Bill Cuddington.

Discussion: The purposed changes were reviewed one at a time and discussed. The proposed addition of section 2, B, iv regarding a 180-day membership qualification prior to being eligible to vote or run for office was objected to by Rachel Saker. A subsequent vote for the proposed change was 6 for, 1 against and 1 abstained.

Vote: Gary Bush motioned to "accept the revisions in version 3.5 of the By-laws". Bonnie Armstrong seconded the motion. The motion was passed with 7 in favor and 1 abstained.

Discussion: Gene Harrison has asked that the VSEC appoint NSS legal Advisor Jay Clark to be the official legal advisor to the Vertical Section Executive Committee. Jay has been very helpful in the past when the Vertical Section needed legal advice.

Vote: Gary Bush motioned that "Jay Clark be appointed as General Council ex-officio member of the Vertical Section" Bonnie Armstrong seconded the motion. The motion was passed with 7 in favor and 1 abstained.

Meeting was adjourned at 10:21 PM EST.