Rigging the Larkin Rescue Frame

to Minimise Step-Back

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Rescuers “footing” an LRF showing a strong tendency to step-back during a training exercise at Gibraltar Rocks.

Executive Summary

The Larkin Rescue Frame (LRF) has become a popular edge management machine.

- The Larkin Rescue Frame tends to “step-back” from the edge, rather than fall over the edge. While this is a safety feature of the design, it also presents risks to the stretcher attendant and casualty in some circumstances depending on the severity of the step-back.
- Step-back of the Larkin Frame can be controlled with simple precautions and intelligent rigging.
- Positive location of the LRF feet is the most effective way to prevent step-back. This can be done with pickets or bolts through the LRF soft feet, or substantial anchors forward of the feet. Specially made “L” shaped feet have been shown to be effective on square edges.
- To minimise the tendency to step-back, if positive foot location is not possible, the LRF should be rigged as follows:
    - Attach a counterweight (e.g. sturdy bag of rocks) to the loaded foot, and deploy over the edge (Mandatory);
    - Edge Manager should “foot” the loaded foot of the LRF (highly recommended);
    - Rig the back guy relatively short and angled down from the lack of the LRF;
    - Rig the back guy slightly towards the load line side;
    - Luff out till top member is horizontal. Use more luff only if it is necessary. Do not exceed the manufacturer’s advice on maximum luff distance of the LRF.
- Some organizations have chosen to use the LRF simply as a high redirection to avoid the tendency of the LRF to step-back. This is a valid way to use a LRF, but it negates the big advantages that a LRF can provide:
    - Ability to luff approximately 2m clear of the face of a vertical pitch
    - Ability to luff the rescue load inside the LRF to land it.

Introduction

The Larkin Rescue Frame (LRF) has become a popular edge management machine for Vertical Rescue not only in Australia but also in other countries around the world.

One of the “features” of the LRF is that it tends to fail safe in that it tends to “walk away” from the edge rather than towards it if overloaded. Of course the proviso on this is the Back Guy of the LRF is bombproof!

Most users of the LRF will have experienced the LRF “stepping back” at some stage if they are using it in the manner in which it was designed. It is not an uncommon phenomena.

In the many instances the author has witnessed the LRF stepping back, there have been a few occasions when the size of the step back has been of concern.

For example, on a training exercise at Gibraltar Rocks some years ago, two volunteer rescuers from Oberon SES were the stretcher attendant and casualty on a free hanging pitch when the LRF stepped back a full 2.5 metres and layed with the front on the ground! No damage was done, but the guys on the end of the rope were far from happy – having dropped close to 6 metres! In different circumstances, the consequences could have been serious.

On another occasion at a night exercise on Mt Keira near Wollongong, the LRF stepped back approximately half a metre, but the stretcher and attendant were at the time just off the ground. This resulted in dropping the loaded stretcher across the stretcher attendant on the ground. No serious injury resulted, but the risk to the stretcher attendant and casualty was duly noted.

So why use a Larkin Rescue Frame? The LRF not only offers edge protection, but greatly simplifies the negotiation of the edge, and can provide effective isolation of the rope from the whole face of a vertical pitch, and so reduce friction, the risk of debris fall, and protect the load line. While the risk of the LRF stepping back is significant, the risk of a step back resulting in injury or damage is very low. Step-back of the LRF is manageable, but widespread knowledge of all the factors is lacking.

Through experience VR operators have learned a number of tricks to manage the risk of step-backs when using LRFs. This report is about quantitatively assessing some of the rigging factors that affect step-back, so operators can rig the LRF with these factors in mind and so minimise the risk of the LRF stepping back.

Method of Analysis

The Larkin Rescue Frame was modelled in a Finite Element Analysis (FEA) package – Cadre-Pro. FEA is an engineering analysis tool that allows complex structures to be modelled, and the stresses, forces and deflections developed in those structures to be analysed.

The LRF was modelled with a range of luff angles, back guy directions and back guy angles to determine what effects each has on the tendency to step back.

All models were based on a 200 kg rescue load applied to the load line, and the LRF has only been modelled in the manner of operation for which the designer intended.

Summary of FEA Results

Test 1: LRF Luffed out 20 degrees past horizontal.

Conditions:

- LRF luffed out 20 degrees past horizontal (top tension member).
- Back Guy in line with centreline of LRF.
- Load Line hauled horizontally, parallel with the centreline of the LRF.
- 200 kg rescue load on the load line.

Back Guy Angle	Back Guy Reaction	Loaded Foot H Reaction	Loaded Foot V Reaction	Loaded Foot H/V	Free Foot H Reaction	Free Foot V Reaction	Free Foot H/V
degrees	kgf	kgf	kgf		kgf	kgf	
41	180	266	160	166%	70	158	44%
30	171	272	144	189%	76	141	54%
16	169	279	124	225%	84	122	69%
0	180	288	101	285%	93	99	94%
-1	181	288	100	288%	93	97	96%
-17	214	300	70	429%	104	67	155%

In the above and subsequent tables of results, the following definitions and explanations apply:

- Back Guy Angle is measured positive from horizontal where the back guy pulls the LRF down.
- Back Guy Reaction is the tension force in the Back Guy system.
- Loaded Foot relates to the LRF Foot to which the load line redirection is rigged.
- Free Foot relates to the LRF Foot not attached to the load line.
- H Reaction is the horizontal force needed to stop the foot from walking back. Note that friction between the foot and the ground is included in this figure.

- V Reaction is the vertical force pushing the LRF foot down onto the ground.
- Loaded / Free Foot H/V is the ratio of the horizontal and vertical forces for the relevant foot. It corresponds to the coefficient of friction. A high result for this H/V ratio indicates a strong tendency to step-back.

Test 2: LRF Luffed out 14 degrees past horizontal.

Conditions:

- LRF luffed out 14 degrees past horizontal (top tension member).
- Back Guy in line with centreline of LRF.
- Load Line hauled horizontally, parallel with the centreline of the LRF.
- 200 kg rescue load on the load line.

Back Guy Angle	Back Guy Reaction	Loaded Foot H Reaction	Loaded Foot V Reaction	Loaded Foot H/V	Free Foot H Reaction	Free Foot V Reaction	Free Foot H/V
degrees	kgf	kgf	kgf		kgf	kgf	
39	162	260	152	171%	65	150	43%
28	158	267	138	193%	72	136	53%
13	162	276	120	230%	82	118	69%
0	177	286	101	283%	91	99	92%
-3	182	288	96	300%	93	94	99%

Test 3: LRF Luffed out till top member is horizontal.

Conditions:

- LRF luffed out horizontal (top tension member).
- Back Guy in line with centreline of LRF.
- Load Line hauled horizontally, parallel with the centreline of the LRF.
- 200 kg rescue load on the load line.

Back Guy Angle	Back Guy Reaction	Loaded Foot H Reaction	Loaded Foot V Reaction	Loaded Foot H/V	Free Foot H Reaction	Free Foot V Reaction	Free Foot H/V
degrees	kgf	kgf	kgf		kgf	kgf	
39	126	246	140	176%	52	139	37%
25	130	256	128	200%	62	128	48%
8	150	271	110	246%	77	110	70%
0	166	280	100	280%	86	100	86%
-12	205	298	80	373%	103	79	130%

Test 4: LRF Luffed out horizontal, Back Guy towards Load Line.

Conditions:

- LRF luffed out horizontal (top tension member).
- Back Guy 10 degrees to the load line side of centreline.
- Load Line hauled horizontally, parallel with the centreline of the LRF.
- 200 kg rescue load on the load line.

Back Guy Angle	Back Guy Reaction	Loaded Foot H Reaction	Loaded Foot V Reaction	Loaded Foot H/V	Free Foot H Reaction	Free Foot V Reaction	Free Foot H/V
degrees	kgf	kgf	kgf		kgf	kgf	
39	127	225	164	137%	72	115	63%
25	132	231	157	147%	87	99	88%
8	152	240	147	163%	109	73	149%
0	168	245	141	174%	121	59	205%
-12	208	255	129	198%	146	30	487%

Test 5: LRF Luffed out horizontal, Back Guy away from Load Line.

Conditions:

- LRF luffed out horizontal (top tension member).
- Back Guy 10 degrees away from the load line side of centreline.
- Load Line hauled horizontally, parallel with the centreline of the LRF.
- 200 kg rescue load on the load line.

Back Guy Angle	Back Guy Reaction	Loaded Foot H Reaction	Loaded Foot V Reaction	Loaded Foot H/V	Free Foot H Reaction	Free Foot V Reaction	Free Foot H/V
degrees	kgf	kgf	kgf		kgf	kgf	
39	127	267	116	230%	31	163	19%
25	132	281	99	284%	37	156	24%
8	152	302	74	408%	46	146	32%
0	167	314	61	515%	50	141	35%
-12	208	340	30	1133%	61	128	48%

Discussion

The Larkin Rescue Frame is supplied with a choice of feet: the default set with a rock spike on the bottom and a set of “soft” feet which attach under these which can be fastened to the ground with pickets or similar.

One thing that is evident from the FEA analysis of the LRF is that action must be taken to secure the feet from stepping back. The coefficient of friction of steel (rock spike) on concrete is between 0.2 and 0.6 (or to put it into the same units at our H/V ratio: between 20% and 60%). The H/V ratio for the loaded foot of the LRF is always well above this, so the LRF will always step-back unless something is done to prevent the step back.

With the soft feet on, the feet can be secured by driving a picket through each foot. Rock and concrete surfaces present more of a challenge unless it is acceptable to bolt the soft feet to the rock/concrete (which may be entirely acceptable particularly in industrial scenarios).

So what do most operators do to secure the LRF feet on rock?

Rock Spikes

The first option is usually to locate the rock spike into a crack or hole in the rock. Many crews carry a hammer and chisel in their LRF kits in order to make the appropriate holes for the rock spikes if necessary. This is rarely enough however.

Forward Anchors and Counterweights

Secondly, many crews fill a rope or cave pack with rocks and hang it over the edge after attaching it to the LRF foot with the load line redirection on it. The weight of the rocks and friction of the bag and tape or rope on the rock helps to hold the foot in place.

"Foot" the Frame

The third option which is common is for the Edge Manager to "foot" the LRF: that is, to stand with their weight on the LRF foot on the load line side. This increases the vertical downward force on the foot by the weight of the Edge Manager and so improves (reduces) the H/V ratio of forces. Remember, the higher the H/V ratio, the greater the tendency is for the LRF to step-back.

For most operators, this is about the limit of knowledge as far as preventing LRF step-back, but there are other factors, mainly to do with the rigging of the LRF, that once understood can help to control the tendency to step-back.

Specialist Feet

Before we get into discussing the effects of rigging on the LRF, one other development is worthy of note. A few years ago Oberon State Emergency Service (SES), whom the author is a volunteer rescuer with, was asked to perform a vertical rescue demonstration at Darling Harbour in Sydney. The site was the top of the Convention Centre. The edge was such that we could not afford our LRF to step back – if it did, it would be damaged and could, possibly, subsequently collapse. Not a good look in front of thousands of onlookers! We were also concerned about hanging a bag of rocks over the edge of the roof while people walked about below - the site would only be closed for short periods of time during the displays.

So one of our members devised and made a set of feet which bolt onto the bottom of the LRF rock feet. They projected about 150mm in front of the rock feet and then about 150mm down the front face of the edge of the building. They were fitted with steel spikes to grip the masonry. They have proved to work marvellously on square edges to prevent step-back, and have subsequently been dubbed "Jim's Feet" in honour of their developer.

Luff

Now back to the rigging effect on LRF step-back. Firstly, lets look at the amount of luff – i.e. how far the LRF is leaned out over the edge. Appendix V shows 3 graphs of the H/V ratio (representing the tendency to step-back) versus the Back Guy angle for various luffs.

Popular myth would have people believe that the more the LRF is luffed, the more it wants to step-back. This may be the case outside the range tested for this report but the results of this analysis do not support the myth for the luffs that were modelled. The FEA results show there is very little difference between the LRF luffed out 20 degrees, 14 degrees and 0 degrees (or horizontal).

An interesting thing to note about the Luff graph (Appendix V) is the change in shape of the Horizontal luff curve when the back guy is angled upwards (negative angle). The back guy tension is now tending to lift weight off the feet of the LRF, and so the H/V ratio worsens. As well as this, when luffed horizontal, the line of the tension force in the back guy approaches the LRF feet. This reduction in the “moment-arm” of the back guy means the back guy force has less leverage to counteract any tendency for the LRF to step-back.

Back Guy Angle

The obvious characteristic from the Luff graph is the effect of the Back Guy Angle. With a horizontal back guy, the H/V ratio is about 280% to 290%. If the back guy pulls down at 40 degrees below horizontal this reduces to about 166% to 176%. So it is highly desirable to ensure that the back guy pulls down on the back of the LRF.

Back Guy Angle was a contributing factor in both the incidents mentioned in the introduction. At Mt Keira the back guy was long and so approaching horizontal, while at Gibraltar Rocks, it was both long and pulling up instead of down. This was a result of the available anchors and the terrain, which sloped downhill towards the edge.

Back Guy Direction

A less obvious factor affecting the tendency of LRFs to step-back, is that of Back Guy Direction. The manufacturers advise that the back guy should be in line with the LRF, and while that is essentially true to avoid toppling or violent slewing of the LRF, there is some leeway that operators can afford to use. Many operators have the opinion that unless the back guy is accurately in line the thing is unsafe, and this is simply not true.

Appendix IV shows a graph comparing different Back Guy directions. The Back Guy was modelled in three directions: in line with the LRF, and 10 degrees each side of in line.

If the Back Guy is directed away from the load line side, it increases the tendency of the LRF to slew in that direction because both the load line and the back guy are trying to turn the LRF that way. Operators need to be aware of this and avoid rigging so the back guy is directed away from the load line.

So angling the back guy towards the load line side should reduce the tendency to slew the LRF. Now the back guy is tending to counteract the tendency of the load line to slew the LRF. This shows up as the H/V ratio of the loaded and free feet approaching each other. So the loaded foot is less likely to step-back, but the free foot increases in this tendency.

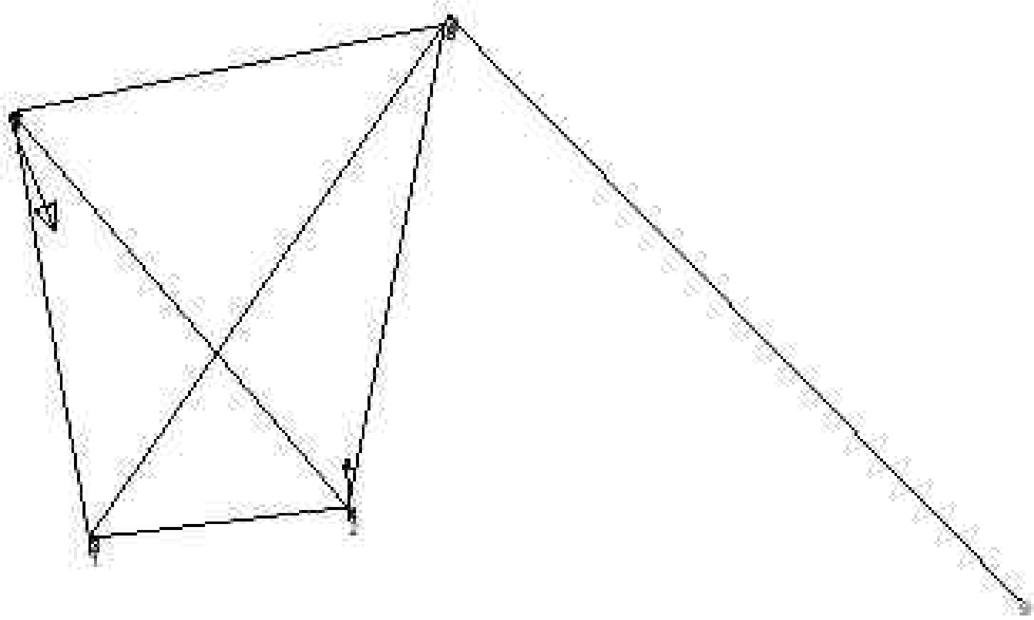
It is important that the back guy is pulling down below horizontal if it is to be rigged offset towards the load line side, however. The graph of the free foot H/V ratio for the back guy 10 degrees towards the load line side, shows a sharp increase in slope once the back guy angle gets to 0 and below. This means the back guy now no longer has any downward component to counteract toppling of the LRF, and so the combination of direction offset and upward angle is trying to lift the free foot. This increases the H/V ratio and so increases the likelihood of the free foot stepping back.

Conclusion

Through experience, a number of things have been learned about how to rig a Larkin Rescue Frame to minimise the tendency to step-back. This report has been aimed at verifying and quantifying those learnings.

Step-back of a LRF is both a safety feature of the design, and a risk to the rescue load. Generally the benefits of using the LRF outweigh the risks, but through understanding the factors that affect step-back, operators can better manage the risk by rigging to minimise that tendency.

Appendix I: Example Larkin Rescue Frame Model



Appendix II: Example FEA Input

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Larkin Frame

Basic data:

Structrual nodes	9
Reference nodes	2
Number of elements	11
Number of beam elements	11
Number of plate elements	0
Properties per element	8
Number of bounds	3
Number of loaded nodes	2
Number of preloads	0

Nodal coordinates:

Ident	X	Y	Z
1	3	0	0
2	3	0	1.62
3	3	0.07	0
4	3	0.07	1.62
5	0.989	2.363	0.81
6	0.949	2.393	0.81
7	5.011	2.363	0.81
8	5.051	2.333	0.81
9	-2	0	0.81
10	0	1000	0
11	0	0	1000

Element definition data: (connections)

Ident	Type	Origin	Axis	Reference	Library
C3.4.10	C	3	4	10	Al tube 50OD, 44ID
P3.5.10	P	3	5	10	Al tube 50OD, 44ID
P4.5.10	P	4	5	10	Al tube 50OD, 44ID
P3.7.10	P	3	7	10	Al tube 50OD, 44ID
P4.7.10	P	4	7	10	Al tube 50OD, 44ID
C5.7.10	C	5	7	10	Al tube 50OD, 44ID
C5.6.10	C	5	6	10	Steel, 50 x 20
C7.8.10	C	7	8	10	Steel, 50 x 20
C1.3.11	C	1	3	11	Steel, 75 x 50
C2.4.10	C	2	4	10	Steel, 75 x 50
W9.6.10	W	9	6	10	None

Element definition data: (properties)

Ident	AE	EIy	EIz	JG
C3.4.10	3.101E+07	8.596E+03	8.596E+03	6.386E+03
P3.5.10	3.101E+07	8.596E+03	8.596E+03	6.386E+03
P4.5.10	3.101E+07	8.596E+03	8.596E+03	6.386E+03
P3.7.10	3.101E+07	8.596E+03	8.596E+03	6.386E+03
P4.7.10	3.101E+07	8.596E+03	8.596E+03	6.386E+03
C5.7.10	3.101E+07	8.596E+03	8.596E+03	6.386E+03
C5.6.10	2.000E+08	6.667E+03	4.167E+04	1.933E+04
C7.8.10	2.000E+08	6.667E+03	4.167E+04	1.933E+04
C1.3.11	7.500E+08	1.563E+05	3.516E+05	2.031E+05
C2.4.10	7.500E+08	1.563E+05	3.516E+05	2.031E+05
W9.6.10	1.000E+10	0.000E+00	0.000E+00	0.000E+00

Element definition data: (additional properties)

Ident	Prop 5	Prop 6	Prop 7	Prop 8
C3.4.10	0.000E+00	0.000E+00	0.000E+00	0.000E+00
P3.5.10	1.000E+00	1.000E+00	1.000E+00	0.000E+00
P4.5.10	1.000E+00	1.000E+00	1.000E+00	0.000E+00
P3.7.10	1.000E+00	1.000E+00	1.000E+00	0.000E+00
P4.7.10	1.000E+00	1.000E+00	1.000E+00	0.000E+00
C5.7.10	1.000E+00	0.000E+00	1.000E+00	0.000E+00
C5.6.10	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C7.8.10	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C1.3.11	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C2.4.10	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W9.6.10	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Boundary conditions:

Node	X	Y	Z	Rx	Ry	Rz
1	Fixed	Fixed	Fixed	Fixed	Fixed	Free
9	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
2	Fixed	Fixed	Fixed	Fixed	Fixed	Free

Loading condition:

Node	Fx	Fy	Fz	Mx	My	Mz
4	-7.020E+01	1.432E+02	-5.120E+01	0.000E+00	0.000E+00	0.000E+00
8	-1.298E+02	-3.432E+02	5.120E+01	0.000E+00	0.000E+00	0.000E+00

Appendix III: Example FEA Results

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Results: Larkin Frame

Nodal Displacements:

Node	X	Y	Z	Rx	Ry	Rz
1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	3.3446E-04
2	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	9.1543E-04
3	-2.3393E-05	-1.3000E-08	1.1406E-09	1.3670E-07	-4.3664E-07	3.3365E-04
4	-6.4026E-05	-1.3062E-08	-3.2102E-08	-1.4197E-06	-1.1467E-06	9.1309E-04
5	3.9206E-05	6.5123E-05	-5.0787E-05	-9.4480E-05	1.7584E-05	1.4703E-03
6	-4.9831E-06	6.2167E-06	-5.2918E-05	-9.4492E-05	1.7568E-05	1.4740E-03
7	6.1399E-05	-1.2530E-04	9.0015E-05	-2.2533E-04	-2.8182E-04	-2.4005E-03
8	-1.0807E-05	-2.2162E-04	1.0837E-04	-2.3106E-04	-2.8945E-04	-2.4111E-03
9	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Element Nodal Forces

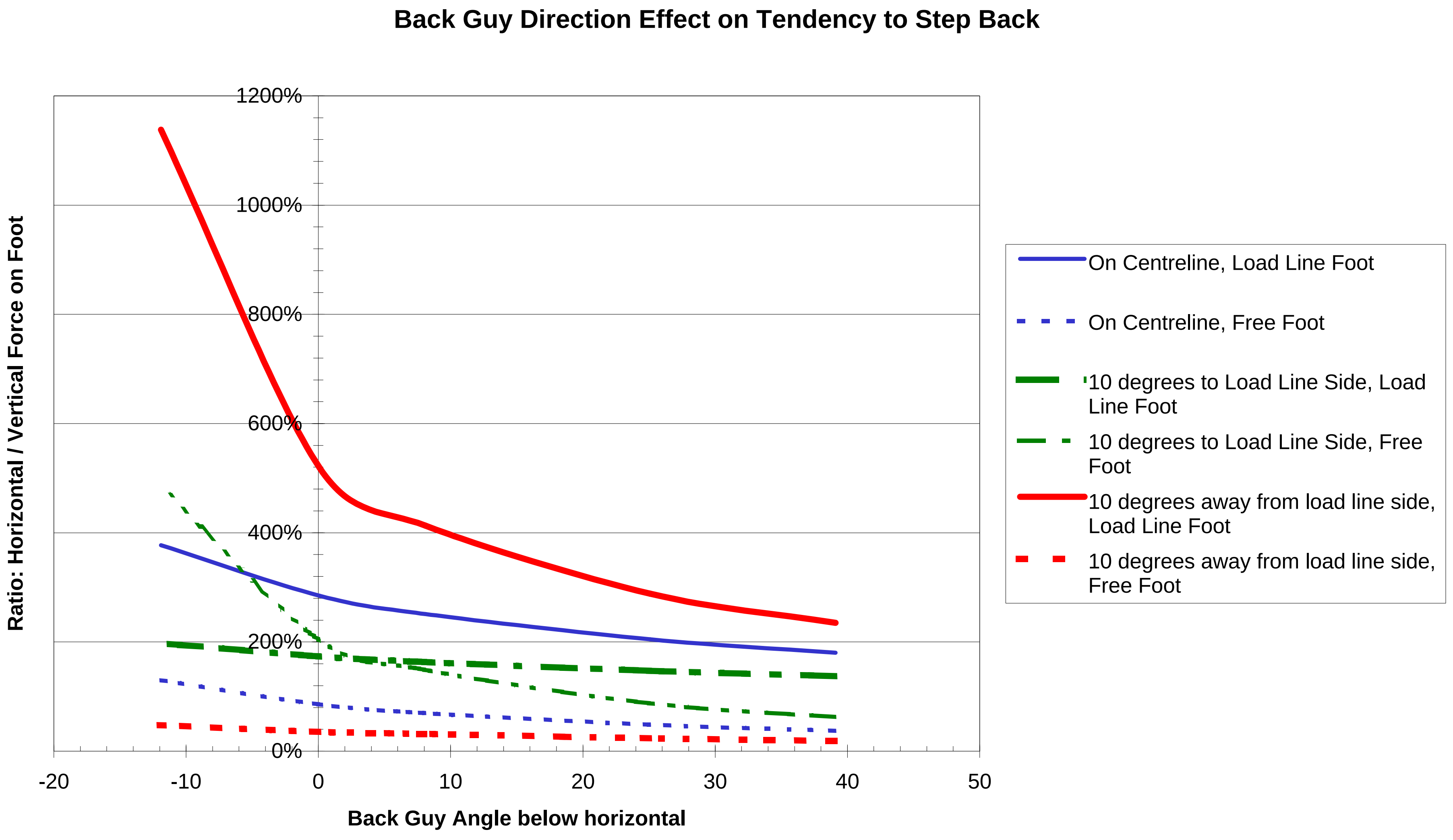
Element	Coord	Node	X	Y	Z	Mx	My	Mz
C3.4.10	Global	Origin	9.547E-01	2.522E-02	6.363E-01	-1.217E-02	7.771E-01	-2.284E+00
		Axis	-9.547E-01	-2.522E-02	-6.363E-01	-2.868E-02	7.696E-01	2.284E+00
	Local	Origin	6.363E-01	2.235E-02	-9.548E-01	-2.284E+00	7.771E-01	9.835E-03
		Axis	-6.363E-01	-2.235E-02	9.548E-01	2.284E+00	7.696E-01	2.637E-02
P3.5.10	Global	Origin	-3.669E+01	3.937E+01	1.182E+01	-7.333E-01	-2.829E+00	3.308E+00
		Axis	3.669E+01	-3.937E+01	-1.182E+01	-4.047E+00	-3.112E+00	1.639E+00
	Local	Origin	5.502E+01	-8.839E-01	2.741E+00	-7.389E-01	-3.340E+00	-2.789E+00
		Axis	-5.502E+01	8.839E-01	-2.741E+00	7.389E-01	-5.311E+00	-3.185E-16
P4.5.10	Global	Origin	-3.678E+01	3.720E+01	-1.120E+01	6.044E-01	3.547E+00	7.989E+00
		Axis	3.678E+01	-3.720E+01	1.120E+01	3.839E+00	3.717E+00	1.543E+00
	Local	Origin	5.335E+01	-2.278E+00	-3.350E+00	1.419E-01	5.009E+00	-7.187E+00
		Axis	-5.335E+01	2.278E+00	3.350E+00	-1.419E-01	5.560E+00	-2.236E-16

P3.7.10	Global	Origin	8.747E+01	9.989E+01	3.217E+01	-1.496E+00	3.319E+00	2.597E+00
		Axis	-8.747E+01	-9.989E+01	-3.217E+01	-5.661E+00	2.843E+00	-2.269E+00
	Local	Origin	1.366E+02	9.392E-01	-2.844E+00	2.125E+00	2.588E+00	2.964E+00
		Axis	-1.366E+02	-9.392E-01	2.844E+00	-2.125E+00	6.385E+00	3.912E-16
P4.7.10	Global	Origin	2.134E+02	2.460E+02	-8.399E+01	2.324E+00	-9.896E-01	6.940E+00
		Axis	-2.134E+02	-2.460E+02	8.399E+01	4.333E+00	-3.006E+00	-1.723E+00
	Local	Origin	3.363E+02	2.315E+00	1.852E+00	-1.020E+00	-3.897E-01	7.305E+00
		Axis	-3.363E+02	-2.315E+00	-1.852E+00	1.020E+00	-5.453E+00	-5.334E-17
C5.7.10	Global	Origin	-1.711E+02	-2.664E+00	6.192E-01	2.078E-01	-6.054E-01	2.916E+00
		Axis	1.711E+02	2.664E+00	-6.192E-01	-2.078E-01	-1.885E+00	-1.363E+01
	Local	Origin	-1.711E+02	-2.664E+00	6.171E-01	2.078E-01	-6.077E-01	2.916E+00
		Axis	1.711E+02	2.664E+00	-6.171E-01	-2.078E-01	-1.874E+00	-1.363E+01
C5.6.10	Global	Origin	9.764E+01	7.923E+01	-9.684E-12	-1.431E-13	-1.169E-13	-6.099E+00
		Axis	-9.764E+01	-7.923E+01	9.684E-12	-1.379E-13	-2.370E-13	-2.931E-12
	Local	Origin	-3.057E+01	1.220E+02	-1.239E-01	4.433E-14	6.194E-03	6.099E+00
		Axis	3.057E+01	-1.220E+02	1.239E-01	-3.187E-14	-2.694E-13	2.931E-12
C7.8.10	Global	Origin	1.298E+02	3.432E+02	-5.120E+01	1.536E+00	2.048E+00	1.762E+01
		Axis	-1.298E+02	-3.432E+02	5.120E+01	1.422E-13	4.623E-13	2.693E-12
	Local	Origin	-1.021E+02	3.525E+02	-5.084E+01	2.455E-13	2.542E+00	1.762E+01
		Axis	1.021E+02	-3.525E+02	5.084E+01	-1.636E-13	4.524E-13	2.693E-12
C1.3.11	Global	Origin	5.174E+01	1.393E+02	4.462E+01	8.821E-01	1.267E+00	-2.296E-13
		Axis	-5.174E+01	-1.393E+02	-4.462E+01	2.242E+00	-1.267E+00	-3.621E+00
	Local	Origin	1.393E+02	4.447E+01	5.187E+01	1.267E+00	-2.646E-03	8.821E-01
		Axis	-1.393E+02	-4.447E+01	-5.187E+01	-1.267E+00	-3.628E+00	2.231E+00
C2.4.10	Global	Origin	2.459E+02	1.399E+02	-4.462E+01	-2.242E-01	3.327E+00	-3.246E-12
		Axis	-2.459E+02	-1.399E+02	4.462E+01	-2.900E+00	-3.327E+00	-1.721E+01
	Local	Origin	1.399E+02	-1.952E+02	-1.561E+02	3.327E+00	1.973E-01	1.065E-01
		Axis	-1.399E+02	1.952E+02	1.561E+02	-3.327E+00	1.073E+01	-1.377E+01
W9.6.10	Global	Origin	-9.764E+01	-7.923E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
		Axis	9.764E+01	7.923E+01	-5.292E-35	-9.449E-35	1.757E-35	1.474E-33
	Local	Origin	-1.257E+02	-2.810E-13	-2.998E-16	0.000E+00	0.000E+00	0.000E+00
		Axis	1.257E+02	2.810E-13	2.998E-16	-6.230E-35	7.164E-35	1.474E-33

Reaction Loads

Node	Fx	Fy	Fz	Mx	My	Mz
1	5.174E+01	1.393E+02	4.462E+01	8.821E-01	1.267E+00	0.000E+00
9	-9.764E+01	-7.923E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2	2.459E+02	1.399E+02	-4.462E+01	-2.242E-01	3.327E+00	0.000E+00

Appendix IV: Effect of Back Guy Direction and Angle on Tendency to Step-Back.



Appendix V: Effect of Luff on Tendency to Step-Back