ETNZ Entertainment Technology New Zealand Incorporated

Safe Rigging Practices for the Entertainment Industry in New Zealand

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Scope

The aim of this guide is to provide an overview of good rigging practices for entertainment venues throughout New Zealand. We intend that this guide is to be used by equipment suppliers, rigging practitioners and venue managers to ensure the right information is asked for and supplied to each party. There are significant differences between entertainment rigging and other forms of industrial rigging including the fast turnaround and the temporary nature of the rigging as well as the risk profile of the stage environment. There are a number of well written entertainment rigging texts on the market and it is not our intent to create another of these.

For the purposes of this document the term venue extends beyond the traditional theatre space and includes:

- Arenas;
- Ballrooms;
- Conference rooms;
- School halls;
- Theatres;
- Any other indoor area that is being used for the purposes of entertainment or events.

Outdoor structures, staging, and consideration for persons climbing or being suspended from trusses are not considered in this document. We propose to broaden the scope of this document to include these topics in future versions.

Administration

This guide has been produced for the Entertainment industry of New Zealand through ETNZ. The major contributors are:

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This guide has been presented to the industry in July 2013 during the ETNZ conference as a draft for industry feedback. Copies of the draft can be obtained via the ETNZ website (www.etnz.org).-Following consideration of the feedback, version one of this guide will be released in 2015

This document is to be reviewed again in 2016 and then reviewed every three years after that. The review committee are to be endorsed by the ETNZ Executive after the release of each version of the guide.

The Authors have endeavoured to provide information regarding current best practice for rigging in the entertainment industry and every effort has been made to make this document error free. The Authors take no responsibility for how the information in this document is used.

The Authors would like to thank the people who have taken the time to review this document and provide feedback; it is this collaboration that will ensure that this document fulfils its goals and is regarded as a useful resource in the entertainment industry. We would also like to thank Chris Higgs who has allowed us to reproduce his graphical means of calculating bridle loads.

Summary

As with all industries the health and safety of one's self, other work colleagues, and the general public must be at the forefront of any decision. The ability to share information efficiently and effectively between client, contractor, and the venue is one of the main ways to foresee and work through any potential issues that may arise with presenting a show in a given venue.

To this end, this guide is more about the communication between stakeholders with an introduction into some very basic rigging calculations than any 'how to' rigging manual. In writing this we recognise that there are often a number of acceptable solutions to most rigging problems that we as entertainment riggers encounter.

We have tried to introduce key topics and ideas, and then directed the reader where to find additional information. Where there is a unique situation a carefully considered management plan needs to be put in place and accepted by all the stakeholders.

Definitions

Below are the definitions of some key terms and organisations. The glossary at the end of the document has a more extensive list of terms.

Competent person: A person who has acquired, through a combination of qualifications, training, or experience, the knowledge and skill to perform the task required. (MBIE, 2012)

ETNZ: Entertainment Technology New Zealand –The industry association representing the entertainment and event sector in New Zealand.

LEENZ: Lifting Equipment Engineers New Zealand (www.leenz.org)

Lifting appliance: An appliance capable of being operated by mechanical, manual, or other means to raise or lower a load in a vertical or near vertical plane. It also includes lifting tackle. Excludes cranes. (MBIE, 2012).

Point (suspension point): A designated position where a load is to be applied in order to safely impose the forces generated by the load onto the structure of a building (or other supporting structure)

Rigging: Work carried out, or supervised by the various classes of rigger, with the intent of temporary or permanent installation of suspended systems.

Rigger:

A) Ground Rigger – a worker who has been instructed in the proper selection of slings, shackles, top rig, and other rigging equipment as required to support the top riggers to install primary lifting and suspension equipment. A ground rigger is competent in interpreting plans, documentation (including layout and loading documentation) and in evaluating environmental factors to enable him to select and where appropriate pre-set equipment ready for installation. A Ground Rigger may be qualified or working towards an internationally recognised rigging qualification, or the NZQA level 4 or 6 qualifications (see appendix 1)

B) Top Rigger - a worker who has been instructed in the proper process to haul, safely work at height and install rigging equipment to enable the temporary or permanent installation of rigging or suspension systems. A Top Rigger needs to be competent in evaluating environmental factors, loading requirements and safe loading points, and is required to have a thorough understanding of proper and correct installation practices in relation to the task at hand. A Top Rigger may be qualified or working towards an internationally recognised rigging qualification, or the NZQA level 4 or 6 qualifications (see appendix 1)

C) Venue Head Rigger – a rigger with specific and detailed knowledge of the venue in which a production is entering. The Venue Head Rigger is responsible for ensuring all incoming productions meet venue requirements and work within the capacity of the venue.

D) Head or Supervising Rigger – A Head or Supervising Rigger must be onsite and identified for all rigging operations. A Head Rigger or Supervising Rigger would be responsible for:
    a. The planning, implementation, and removal of rigging components for a performance or event;
    b. The creation and/or maintenance of rigging plans for a performance or event;
    c. Ensure the building has the capacity for the staging of a performance or event;
    d. Ensure the performance of event is rigged safely and in accordance to the plans.

Structural Engineer (Engineer): A person with an undergraduate degree in a relevant engineering discipline with sufficient training and experience. Typically a Structural Engineer would be registered with a professional engineering body such as IPENZ.

Safe Working Load (SWL): See Working Load Limit (WLL)

Truss: A framework of slender beams connected at their ends. Trusses typically consist of two to four main chords (to which the loads are attached) supported by diagonal bracing that maintain the spatial relationship of the chords as well as transferring the imposed loads to the supports. The term node is given to the points where the bracing connects to the chords to form a triangular pattern. Heavy loads and truss supports must be applied at the nodes.

Aluminium alloys are most common in the entertainment industry due to its good strength to weight ratio, however steel is also common and other products such as carbon fibre has also been used.

UDL: Uniform Distributed Load

Weight: Mass of a body multiplied by the force of gravity (9.81 $m.s^{-2}$) given in Newtons (N) or kilo Newtons (kN)

Working Load Limit (WLL): The maximum working load as designed by the manufacturer.

Worksafe A crown agent formed in 2013 responsible for the work place health and safety functions previously undertaken by MBIE and prior to that the Department of Labour.

Health and Safety

Notifiable work

Any rigging (construction) work that involves the following is considered notifiable:

- Involves lifting over 500 kg over five metres, and/or
- Involves working where the worker could fall five metres or more.

Hazardous work notifications can be completed online at:
http://www.dol.govt.nz/tools/hazardouswork

Risk Assessment

A job risk assessment is the process of identifying the risks associated with a particular type of work and environment, then assessing them on a likelihood of occurrence verses the severity of consequence matrix. Control measures are stated and the corresponding reduction in the matrix score indicated on the assessment. Risk assessments are covered in detail in *"A guide to Safe Working Practices in the New Zealand Theatre and Entertainment Industry"* which can be found with the following link:
(http://www.etnz.org/files/Guide-Version12.pdf)

Method Statement (Job Safety Assessment)

A Method Statement is a means of documenting the process that will be undertaken to achieve the job. It provides a time line, a hierarchy of responsibility, equipment to be used, and how. A Method Statement is a means of communicating how the risks identified in the Risk Assessment are to be managed for a particular job.

There is a Method Statement template in Appendix 5.0, as provided in the resources section on the ETNZ website (www.etnz.org) under the heading Job Safety Assessment. Job Safety Assessments should comply with the standard AS/NZS 4801:2001

Pre-Start Rigging Task Assessment

1. Have you performed this type of task before or is there a documented procedure?

YES | NO → Do you have suitable experience to complete this task?
or…
Do you have access to suitable advice?

YES | NO

2. Are you experienced with the equipment to be used?

YES | NO → Do you have access to the manufacturer's instructions and specifications?
or…
Is specialist training or advice available?

YES | NO

3. Do you know the maximum point capacity and weight of every load to be rigged?

YES | NO → Can the venue and production provide detailed documentation?
or…
Do you have access to specialist advice?

YES | NO

4. Have all safety issues and hazards been identified and addressed?

YES | NO → Can additional measures be installed to reduce risks?
or…
Can additional equipment be used to manage risks?

YES | NO

5. Do you have suitable access, including necessary personal protection, to work in all areas?

YES | NO → Is access equipment available that you are experienced and qualified in using?
or…
Are you suitably experienced and qualified in advanced access methods?

YES | NO

6. Do you have clear communication channels to other workers in the area?

YES | NO → Are radios or mobile phones available?
or…
Do you have a system of hand signals everyone can understand?

YES | NO

If you can answer YES to all the primary questions, PROCEED WITH THE TASK

If you answered NO to any primary question then YES to a secondary question, check with your immediate supervisor. You may be able to PROCEED WITH CAUTION. The task may need to include experienced supervision.

If you answered NO to any primary question and subsequent secondary questions then STOP. Further specialist input is required.

Methodology

Paperwork

Plans

Plans are an easy way to communicate key information to relevant parties. In order to achieve this they need to:

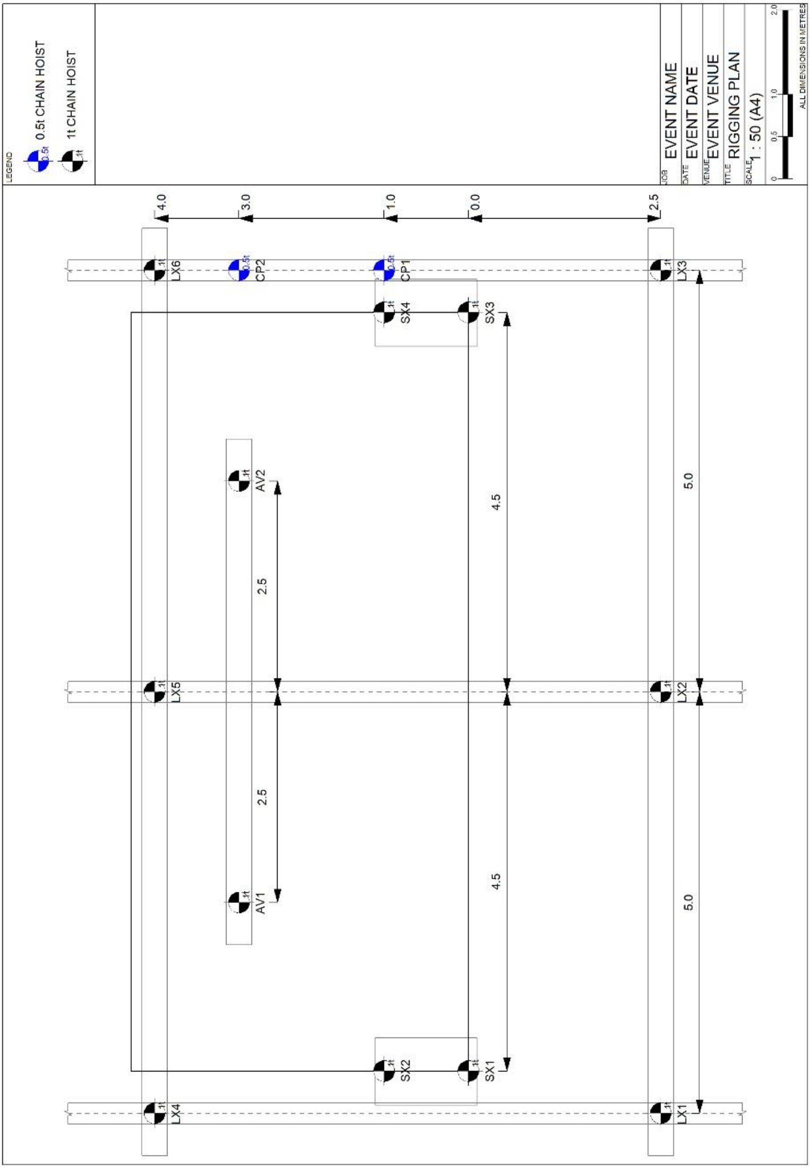
- Be specific to the venue;
- Be of a suitable scale (i.e. readable);
- Be accurate;
- Have a Legend or Key where applicable.

Key measurements should also be stated on a plan and elevations should also be included (especially where venue height could be a limiting factor).

JOB	EVENT NAME	DATE	EVENT DATE
TITLE	RIGGING PLAN	VENUE	EVENT VENUE

POINT	PURPOSE	LOAD	X	Y	Z
AV1	SR Video Wall	350kg	-2.5m	3.0m	7.0m
AV2	SL Video Wall	350kg	2.5m	3.0m	7.0m
CP1	Cable Pick	150kg	5.0m	1.0m	8.0m
CP2	Cable Pick	120kg	5.0m	3.0m	8.0m
LX1	SR Front Truss	170kg	-5.0m	-2.5m	10.0m
LX2	CS Front Truss	550kg	0m	-2.5m	10.0m
LX3	SL Front Truss	190kg	5.0m	-2.5m	10.0m
LX4	SR Rear Truss	230kg	-5.0m	4.0m	8.0m
LX5	CS Rear Truss	750kg	0m	4.0m	8.0m
LX6	SL Rear Truss	250kg	5.0m	4.0m	8.0m
SX1	SR DS PA Hang	450kg	-4.5m	0m	11.0m
SX2	SR US PA Hang	450kg	-4.5m	1.0m	11.0m
SX3	SL DS PA Hang	450kg	4.5m	0m	11.0m
SX4	SL US PA Hang	450kg	4.5m	1.0m	11.0m

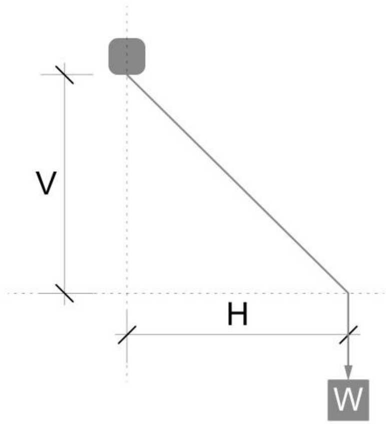
Notes:
1. Load is total head load, including hoist and rigging
2. X,Y measured from downstage centre
3. Z measured to underside of hoist


LEGEND
0.5t CHAIN HOIST
1t CHAIN HOIST
JOB EVENT NAME
DATE EVENT DATE
VENUE EVENT VENUE
TITLE RIGGING PLAN
SCALE 1 : 50 (A4)
0 0.5 1.0 2.0
ALL DIMENSIONS IN METRES
4.0
3.0
1.0
0.0
2.5
LX6
CP2
CP1
LX3
SX4
SX3
AV2
2.5
4.5
5.0
LX5
LX2
2.5
4.5
5.0
AV1
SX2
SX1
LX4
LX1

Load calculations

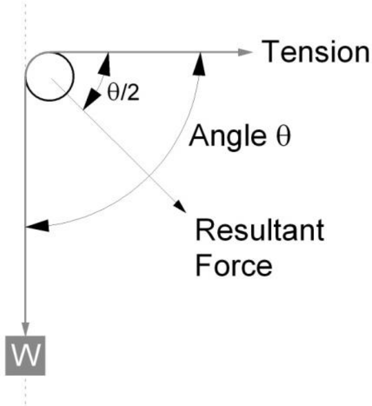
In order to ensure a rigging system can support a show there needs to be an accurate assessment of the loads imposed in the system. Once the loads of the show have been calculated the resultant loads on the rigging and onto the venue can also be calculated.

Resultant loads occur when the load path ceases to be vertical. That is, a horizontal element is added.



Minor adjustments to a rigging system can have a significant impact to the forces acting on the rigging. For example making a bridle shallower or taking an extra wrap on a sling around a truss to gain a slightly higher trim height. The use of pulleys in a rigging system will also have an effect on the resultant loads. The following table shows typical load factors:

Resultant Force = Tension x Angle Factor



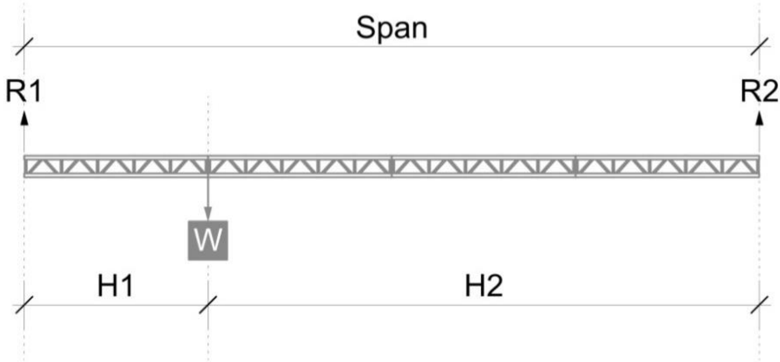
Angle	Angle Factor
180°	0.00
150°	0.52
120°	1.00
90°	1.41
60°	1.73
30°	1.93
0°	2.00

Where there is a complex load distribution calculations should be checked by a suitably qualified structural engineer.

Most rigging texts including Donovan (2002), Higgs (2002), and PLASA (2010) have a number of useful formulas for determining resultant loads. Please see the reference sections for more details on the sources. Some common calculations are described along with additional methods and equation proofs in appendix 3.

Samples of simple load calculations

Calculating the resultant reactions from a point load and a series of point loads on a truss

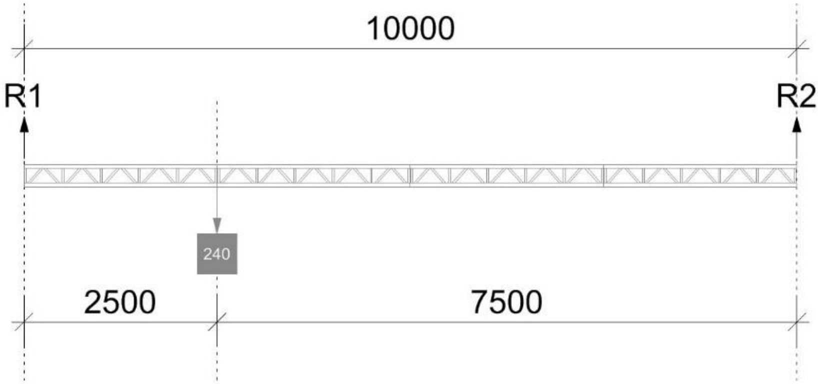


The resultants for a single point load can be calculated as follows:

$$R_1 = \frac{WH_2}{\text{Span}}$$

$$R_2 = \frac{WH_1}{\text{Span}}$$

Example:



$$R_1 = \frac{240 * 7.5}{10.0}$$

$$R_1 = 180\ kg$$

$$R_2 = \frac{240 * 2.5}{10.0}$$

$$R_2 = 60\ kg$$

For more than one point, the above formula can be used for each point load and the values for R_1 and R_2 can be summed to give the total resultants.

This method can be extended further by setting R1 to zero and referencing all the other distances from R1. R2 is determined by calculating the sum of vertical forces multiplied by their distance from R_1 then dividing by span. R_2 is effectively the amount required to stop the structure from rotating.

This is displayed mathematically as:

$$R_{2=} \frac{\sum_{i=1}^{n}(W_i\, H_i)}{span}$$

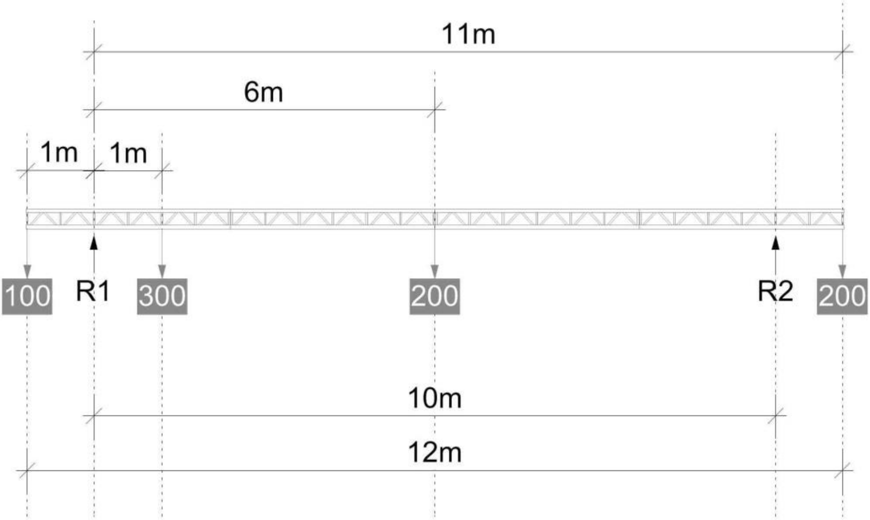
Or in long form as:

$$R_2 \; = \; \frac{(W_1 H_1) + (W_2 H_2) + (W_3 H_3) + (W_4 H_4) \dots}{span}$$

R_1 can subsequently be calculated by subtracting the value for R_2 from the total load.

Example:

(Excluding the weight of the truss and motors):



$$R_2 = \frac{100 \times (-1) + 300 \times 1 + 200 \times 6 + 200 \times 11}{10}$$

$R_2 = 360\ kg$

$R_1 = total\ load - R_2$

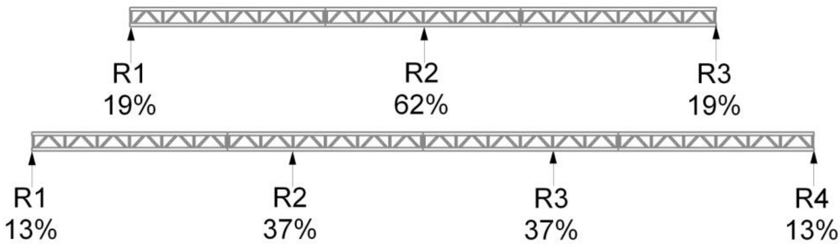
$R_1 = 440\ kg$

Resultants from distributed and linearly increasing loads can be obtained by applying the total load as a point load through the centre of gravity of the element.

Approximating the resultant reactions from a load applied to a multi-point truss

When a load is supported by more than two points it becomes statically indeterminate. This means that should one point become unloaded then the entire structure may not necessarily undergo catastrophic failure.

Care needs to be taken when approximating the loads at each point. The following diagram shows the loads at each point for a three and four point truss that is uniformly loaded.

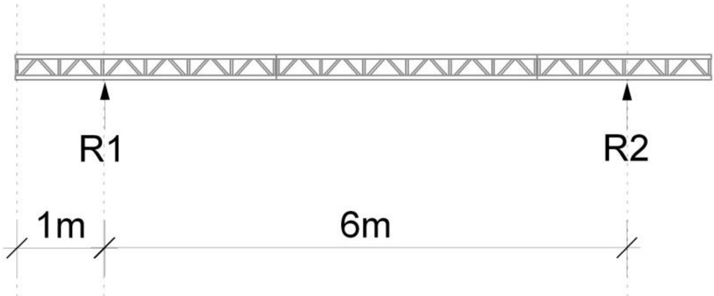


To approximate point loads on these systems the point load can be divided between the two adjacent points as per the equation on page 13. When using the addition of points to provide redundancy then the system has to be tested to the following criteria:

- That in the event of a point becoming unloaded then no part of the system subsequently becomes overloaded and;
- In the event that a point becomes unloaded then the system remains stable.

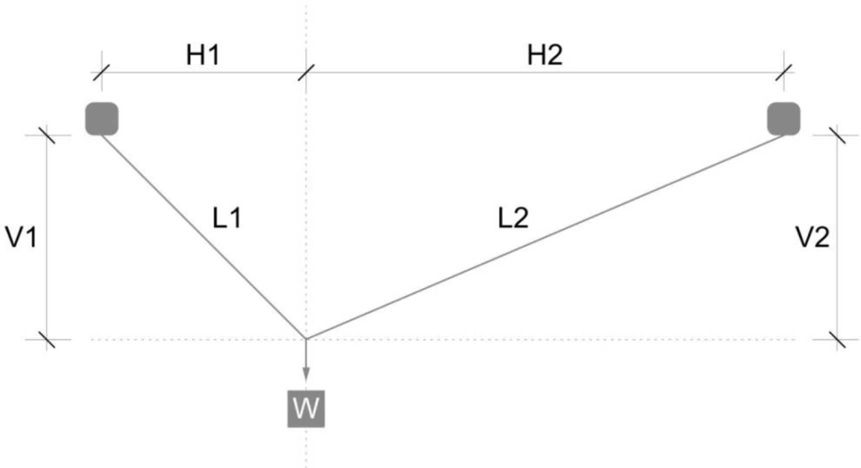
Cantilevered Truss Loads

It is widely accepted as “rule of thumb” and recommended by many truss manufacturers that a truss may cantilever past the nearest support point by a distance of 1/6th of the length of the adjoining free span. In the instance of a significantly heavy load, this distance may be too far, or likewise could be extended for a very light load. Manufacturer’s recommendations for loading are always the best reference when deciding on acceptable cantilever distances.



The distribution of load from the cantilever to the hoists on a 2 point pickup can be assessed as per the calculation on page 15 of this guide. In the case of a multi-point pickup, the load would generally all be applied as load to the nearest hoist.

Calculating leg length and tension in two legged bridles



Calculating the length of a bridle leg is performed using Pythagoras' theorem:

For bridle leg one: $L_1 = \sqrt{V_1^2 + H_1^2}$

For bridle leg two: $L_2 = \sqrt{V_2^2 + H_2^2}$

Calculating bridle leg tension on a standard two-legged bridle

For the first bridle leg[1]: $T_1 = \frac{WH_2L_1}{(V_1H_2)+(V_2H_1)}$

For the second bridle leg: $T_2 = \frac{WH_1L_2}{(V_1H_2)+(V_2H_1)}$

[1] See appendix 3 for the proof of this equation

Contractor / Client to supply to the venue

- Provide a load plan of the proposed rig in the venue at least ten working days prior to arrival;
- Provide a method statement as outlined above;
- Provide a risk assessment for particularly hazardous situations;
- Provide, if requested, proof that equipment complies with current standards and is serviceable (proof of load test, PAT test, and service record);
- Inform venue of any late changes (e.g. needing to move points elsewhere or a significant change in load distribution);
- Ensure all points are designed with suitable redundancy so that the failure or one component will not result in catastrophic failure. This can be achieved by the use of a secondary suspension at each point where the secondary point is appropriately installed to handle the transfer of load onto it. (Where a venue stipulates a secondary suspension point (safety) must be provided, it is the responsibility of the Contractor/Client to prove that there is sufficient redundancy in their rigging to omit the safeties and obtain a written exemption from the venue management);
- Ensure that where it is not possible or practicable to install secondary points, a detailed and job specific risk assessment and method statement must be produced which will stand up to peer review or be approved by an industry based engineer.

Venue to supply to the contractor/client

- Publish and make available a service load manual to users and sub-contractors upon request;
- Publish additional requirements that the venue has – e.g. all riggers to have completed a safety at height course;
- All allowable rigging points to have the load capacity (and load distribution if applicable) permanently marked on the points with the date the assessment was made;
- Check proposed loads from production companies against venue service load manual (seek additional advice e.g. peer review / engineer as required);
- Provide a competent person knowledgeable of both the venue and current rigging practices during all major rigging and de-rigging procedures;
- Working at Heights / Rigging work permit. If venue has in place a work permit system, full details and compliance requirements must be supplied in advance, and work permits issued prior to production access;
- NOTE: Venues should be pro-active in seeking and providing information in advance of incoming production to ensure that they are efficiently and safely installed, used, and removed from the venue. This includes timely and accurate provision of information, and review and response to incoming production documentation.

Factors of Safety

The factor of safety is the ratio between the designated working load limit (WLL) (or safe working load (SWL)) and the load the equipment is expected to fail at. The following are the minimum factors of safety are extracted from the Approved Code of Practice for Load-Lifting Rigging (ACPLLR) (MBIE, 2012);

Equipment	Factor of Safety
Flat web and round slings	6:1
Steel rope	5:1
Chain and accessories	4:1

- In high risk situations (i.e. when suspended over people) the above safety factors must be doubled or be at least 8:1;
- Proprietary trusses are deemed as engineered structures and typically have a factor of safety lower than rigging accessories. The allowable loads are usually published in a table of common spans and loading situations. In high risk situations the allowable applied loads within the load tables must be halved to double the safety factor.
- It is illegal to exceed the WLL on any rigging equipment.

How the rigging equipment is to be used may affect the WLL of the equipment (MBIE, 2012).

Treatment	Multiplication factor
Straight pull	1.0
Basket hitch	2.0
Choke hitch	0.8

When choking slings they must never be ‘hammered down’ as this risks damaging or overloading the sling.

Chains from lifting devices must never be choked or prevented from twisting freely in the hook as the twist could damage the chain and / or lifting device, and cause jamming.

Equipment

Truss

Aluminium (and to a lesser extent, steel) truss is a standard product used for suspending lighting, audio visual and scenic equipment in the events industry. There are numerous shapes and sizes of truss available to meet the job requirements.

When selecting truss take into account the following considerations:

- Know the potential loads and distribution of loads along the truss;
- Know the span lengths (distance between support points) you require;
- Truss must have a label stating:
    - Manufacturer;
    - Type of truss;
    - Serial/batch number.
- The supplier of the truss must be able to provide:
    - The materials used to manufacture the truss;
    - The dimensions and engineering properties of the truss;
    - The standards the truss was manufactured to (e.g. AS/NZS 1664:1997, EN 13814);
    - Discard criteria for the truss;
    - A load table that has some standard spans and standard load configurations[2].
- When renting truss the supplier must be able to present a maintenance policy and service log for the equipment.

[2] As there is an infinite number of load configurations it would be impossible to tabulate them all, however, a structural engineer would be able to calculate the suitability of design based on the dimensional and engineering properties supplied.

Lifting Appliances

The electric-chain hoist is another staple piece of equipment in the entertainment industry. Other equipment commonly used for lifting including manual chain blocks, and wire rope winches (often mounted to stands).

Like truss, there are a range of sizes, configurations, and manufactures of chain hoists and the type required depends on the proposed use. The following considerations need to be taken:

- What loads are to be lifted;
- What speed do the loads need to be lifted at (it is important to consider the dynamic loads imposed on the supporting structure;
- How many points the structure is to be lifted by and the load distribution through these points;
- The following information must be stated on the lifting equipment:
    - Manufacturer;
    - Type of hoist, WLL;
    - Serial number; and
    - If applicable, electrical requirements (voltage, number of phases required, amperage draw);
- Electrical equipment needs to have a current PAT test tag or log as per AS/NZS 3760:2010;
- When renting lifting equipment the supplier must be able to present a maintenance policy and service log for the equipment;
- When using more than one hoist to lift a load (e.g. a truss line suspended on two hoists) the WLL of the hoist must be reduced by a factor of 0.75 to allow for discrepancies such as the truss not being perfectly level (Ref: NPR 2080-10);
- Ground support towers often use a combination of truss and a lifting device. These towers need to have an accompanying engineering report stating the allowable height of the tower, allowable loads that can be suspended, and any bracing required to ensure structural stability;
- When using ground supported structures the load carrying capacity of the ground needs to be factored into load calculations.

Rigging Accessories

Rigging accessories are considered to be items that are required to connect the truss to the lifting device and the lifting device to the venue. This includes:

- Steel hardware such as shackles, Masterlinks, and Quicklinks;
- Steel cable such as slings, stingers, and drifts (tracers);
- Synthetic slings such as web slings and polyester round (endless) slings (e.g. Spansets);
- Chain slings and clutch chains;
- Lifting brackets, spreader and equalizing beams`.

Rigging accessories need to display:

- Working load limit;
- Manufacturer;
- Batch / serial number.
- For synthetic materials date of manufacture or date of removal from service

As with other rigging devices the supplier must be able to provide documentation as to the standards the equipment complies with (e.g. Federal Specifications RR-C-271 for shackles) and an inspection and discard criteria as well as, in a rental situation, a maintenance and service log.

Rope Rigging

As ropes are used in numerous applications in event rigging it is important to consider the following when selecting the appropriate rope:

- The purpose of the rope rigging (e.g. a haul line for points / cable picks, to hang banners, or as part of a working at height system);
- The loads imposed on the rope;
- The temperature properties of the rope;
- And the abrasion resistance properties of the rope.

A minimum rope diameter of 16 mm should be used for hauling lines to allow for a safe grip.

The properties of ropes can be provided by the supplier and further information on appropriate use can be found in the "A*pproved Code of Practice for Load-Lifting and Rigging" (MBIE, 2012).*

Ropes need to be inspected for damage from temperature, chemicals (including rot), and abrasion prior to use. A risk assessment must be completed prior to selecting and using a rope or cord for a given purpose. See AS/NZS 1380

Inspection and Maintenance

All equipment must be visually inspected prior to each use. In addition to this all equipment must be periodically inspected by a competent person and documented.

- The inspection chart must state the asset number or serial number of the piece of equipment, the date put into service, the condition and outcome, and the name of the inspector;
- The length of period will be defined by the manufacturer or governing legislation and is adjusted according to amount of use and/or the environmental conditions. In any case the minimum requirement is twelve months. (MBIE, 2012);
- An example of an inspection chart can be found in Appendix 4.

Attaching a lifting appliance to a truss

As with the types and sizes of truss there are numerous safe and adequate ways to sling / attaching a lifting appliance to a truss. A lifting appliance must be attached at or as close as practical to a truss node (panel point). When slinging a truss the following considerations should be made:

- The effect the slinging method or rigging accessory (e.g. lifting bracket) has on the stability of the truss;
- The internal forces generated in the truss due to the method of slinging / attachment of the rigging accessory to the truss;

The following images show some typical slinging methods for attaching a lifting appliance to a truss:

Glossary

There are a number of online resources for the definitions of theatrical terms including:

http://www.theatrecrafts.com/glossary/results.php?searchtype=4&wordsearch=RIG&submit3=Search ; and

http://www.jrclancy.com/reference%20terms.html

Arena: A Large entertainment venue with no specific set layout, often with a movable / customizable stage. Audience can be seated on up to three sides of the stage. Venue would often contain large capacity high steel suitable for temporary entertainment rigging.

Batten: The horizontal metal (steel or alloy) tube or box section hung from flying lines or forming part of a grid from which lighting equipment and scenery etc. may be suspended.

Base Plate: A metal plate which prevents damage to floors and provides stability when using scaffolding or trussing.

Beam: A steel member to which rigging or other equipment may be connected to allow the suspension of fixtures or products

Burlap / Bagging: Sackcloth hessian, used as softening under steel wire rope slings. It's used because it's flexible and easy to use, and will not cause injury when dropped

Chain Block: A hand drawn mechanical hoist for the purposes of lifting trusses or other equipment. Chain blocks usually comprise of a load chain and an endless hand chain.

Chord: The main horizontal member(s) in a truss/lattice structure.

Coupler: A device for joining two or more items together
Conical Coupler
Conical couplers are commonly used to join trusses or structures together; used in conjunction with pins and clips to secure the connection.
Scaffold Coupler
A scaffold coupler may join two pieces of scaffold pipe in a linear or angled configuration.

Dead: A pre-plotted height for a piece of scenery or lighting bar - 'that bar's on its dead'. The positional indicators on the rope (either PVC tape, or more traditionally cotton tape passed through the strands of the rope) are called DEADS. Sometimes flying pieces are given a number of extra dead's, that may be colour coded, in addition to the 'in dead' (lower) and 'out dead' (higher - out of view). In the US, TRIM has the same meaning.

Dead Hang: A rigging point hung directly from the grid / beams above the stage, not to a flying bar, spreader bar, or bridle rigging.

Dog / Wire Rope grip: A U-shaped clip and saddle used for terminating wire rope. Wire rope grips must not be used on dynamic rigging.

Dynamic: The term associated to force when associated with motion.
Dynamic Load
A Dynamic Load magnifies the loading on the supporting equipment and structure due to the need to overcome the force of gravity, and has potential additional forces due to motion factors.

Engineer: A person who designs, builds, or maintains engines, machines, or structures. An engineer in relation to a rigging environment would be a chartered structural engineer, with sufficient training and experience to review, design and recommend load distribution and structural supports.

Ferrule: The metal sleeve used to form an eye termination in steel wire rope which is pressed onto the rope under pressure from a hydraulic tool. Ferrules are usually made from aluminum alloy, copper or steel.

Hand Line: A rope or lifting line principally managed by hand.

Hoist / Motor: Electrically driven hoist for lifting scenery and lighting equipment. The chain hoists are rigged to fixed points in the venue. Hoists are commonly used to lift lighting truss into position for touring shows or concerts.

JSA: Acronym for Job Safety Analysis. A documented review of the risks and hazards involved with a work task. This review would include pre control risk analysis, control methods for these risks, and a post control re-analysis. A detailed JSA may encompass a method statement also.

Knots: An interlacing, twining or looping, of cord or rope, drawn tight into a knob or lump, for fastening, binding, or connecting two cords together or a cord to another item.
Bowline
Most riggers' knot of choice as it is fairly secure and easy to undo after heavy loading.

Leg: Each sling used as part of a multiple sling, e.g. a 'two leg sling' has two slings used as the 'legs' of the sling. A bridle 'leg' is therefore one half of a two 'leg' bridle, or one third of a three way bridle, etc.

Line: A rope or cord length from a coil once cut to length or installed for a specific function.

Long Link Chain / Deck Chain: A rated chain with long links, where the pitch diameter exceeds the nominal diameter by a factor of three or more; used for creating a variable length adjustment in a rigging situation. Long link chain must only be used for a straight load path. Generally long-linked chain is not to be used in lifting applications however PLASA has developed a code of practice for the use of long link chain in lifting applications – "Code of practice for the safe use of long link chain as a means of adjusting rigging in the entertainment industry." A link is included in the Reference list.

Method Statement: A documented description of a planned work task. This document would usually include detailed step by step work process, often addressing task based risks and controls. A detailed Method Statement may encompass a Job Safety Analysis also.

Node: The connection between structural members in a construction

Pickle: Small handheld motor controller that plugs into a cable connected to a winch or other motorized system.

Point: The rigging point or hanging point to which the lifting machine or suspension component is rigged. Can be temporary ('rigging the points'), or permanent, 'The house points' for example.

PPE: Abbreviation for Personal Protective Equipment. The equipment utilized to minimize risk or reduce harm in a hazard managed environment. For example – a fall arrest harness may reduce exposure to risk when working at height. A hardhat may reduce the harm in the event of an item being dropped from above.

Redundancy: Planning and providing for additional capacity, equipment or systems to ensure a safe margin of capacity exists to allow for unexpected changes, failures or faults to avoid damage or systemic failure. Often associated with "safety wires" or additional load capacity planning

Roof: The rigging structure or existing structure used for rigging from.

Safety Factor: The ratio of Working Load Limit to the minimum breaking load of the equipment.

Scaffold Clamps: A variety of different clamps designed to join or attach pipes to a structure or each other
Cheeseboro, Scaffies' Clamp, Clip
Scaffold clamps have a rounded clamp face which surrounds the pipe and holds fast the pipe by friction due to a tightened bolt and nut system.
Scaffold tube and clips must comply with AS/NZS 1576.3
Clamps can be in many configurations including
Girder Clamp (Gravlock)
Girder clamps are used to attach scaffold tube to other structural steel members such as I beams. Girder clamps must be used in pairs to form a secure connection.

Scaffold Pipe / Barrel / Bar / Boom: A metal (steel or alloy) tube usually 48mm outside diameter, hung from flying lines (or forming part of a grid) from which lighting equipment and scenery etc. may be suspended. Also known as a BARREL, and when used vertically, it is known as a BOOM.

Secondary: An additional rigging set in parallel to the main rigging system to provide redundancy to the primary suspension point. A Secondary is often colloquially referred to as a safety.

Sling: An endless sling made of a coil of (manmade) fibers or steel wires, sheathed in a protective man-made cover, flexible, soft, light weight and cheap

Slinging Methods:
Basket Hitch (Basket)
A method of slinging that employs a sling wrapped around an object and both ends or eyes being connected by a component at the load support point.
Bridle
An assembly arranged to create a lifting point where required between two or more structural points.
Choke
A slinging pattern made by passing one end of a sling through the opposite end's eye or by making a 'lark's head' loop with an endless sling. Useful, but reduces the SWL/WLL of the sling by 30%

Shackle: A metal connecting device comprising two parts. An open link connects the items to be joined and a pin is fitted to make the link complete. Many sizes and designs exist, the most common to the entertainment world being the screw pin 'bow' shackle. The pin should always be loaded in shear, not in tension.

SOP: Acronym for Standard Operating Procedure which is a document which clearly outlines the standard process to be followed in relation to a work task. This document may also reference relevant legislation or work standards.

Steel Sling: A slang term for a round sling, or very flexible sling made of steel wire or a series of steel wires. Also referred to as Gak or soft steel.

Steel: A Generic term used for a plain wire rope sling. Also used when referring to roof structural steel and individual steel beams or scaffold materials and so on.

Stinger: Steel wire rope sling used to extend the length or reach of a hoist chain or to allow a hoist to reach the ground from the point, (a 'down leg').

SWL: An acronym for Safe Working Load. The rated maximum allowable applied load to a rigging item. This rating is calculated by the items manufacturer. Now superseded by WLL – Working Load Limit

Theatre: For the purposes of this document; a permanently constructed and set performance hall, usually with a proscenium and stage flying system

Thimble: Protective metal or plastic loop used to reinforce and protect the eye at the end of a wire rope. Specifications vary according to use, but all conform to basic rules of proportion in forming the correct size loop for the rope diameter/type.

Tirfor: The brand name of a wire rope hoist that utilizes twin sets of jaws to grip on the rope. Commonly used as the slang name for all brands of clamping wire hand winches.

References

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ETNZ, 2011, *A Guide for Safe Working Practices in the New Zealand Theatre and Entertainment Industry,* version 12, ETNZ, downloaded from www.etnz.org;

Higgs, C., 2008, *An Introduction to Rigging in the Entertainment Industry* 2nd Edition, Entertainment Technology Press;

MBIE (Ministry of Business and Employment), 2012, *Approved Code of Practice for Load Lifting*, downloaded from: http://www.business.govt.nz/healthandsafetygroup/information-guidance/all-guidance-items/acop-load-lifting-rigging;

PLASA, 2010, *PLASA National Rigging Certificate Handbook* 2nd edition, Professional Lighting and Sound Association;

PLASA, nd, *Code of practice for the safe use of long link chain as a means of adjusting rigging in the entertainment industry*, Professional Lighting and Sound Association, downloaded from: http://www.plasa.org/technical/Long_Link_Chain_Code_of_Practice.asp;

http://www.theatrecrafts.com/ and contributors

Other References

Glerum, J.O.; 1987; *Stage Rigging Handbook;* 3rd Ed.; Southern Illinois University Press

Appendices

1.0 Qualifications

Currently there are no New Zealand based rigging qualifications specific to the event and entertainment sector. However the New Zealand Qualification Authority (NZQA) has given permission for the development of a certificate in entertainment and event technology at level three and four and a New Zealand diploma in entertainment and event technology at level six. It is viewed that for a person to be deemed competent in entertainment and event rigging that they will hold at least the level four certificate with the specialisation in rigging. It is anticipated this qualification will be online and available for achievement by the end of 2015

2.0 Governing legislation and standards

Legislation can be found through the following website:
http://www.legislation.govt.nz/

Standards can be found at the following website:
http://www.standards.co.nz

Health and Safety in Employment Act 1992 (reprinted December 2013)
*Note – New health and Safety Legislation will come into effect in 2015.

AS 1418.5-2013 (Parts 1-10); *Cranes, hoists and winches - Mobile cranes* (EN 13000:2010, MOD)

Dept. of Labour; *Approved Code of Practise for Cranes*, 2009; 3rd Edition

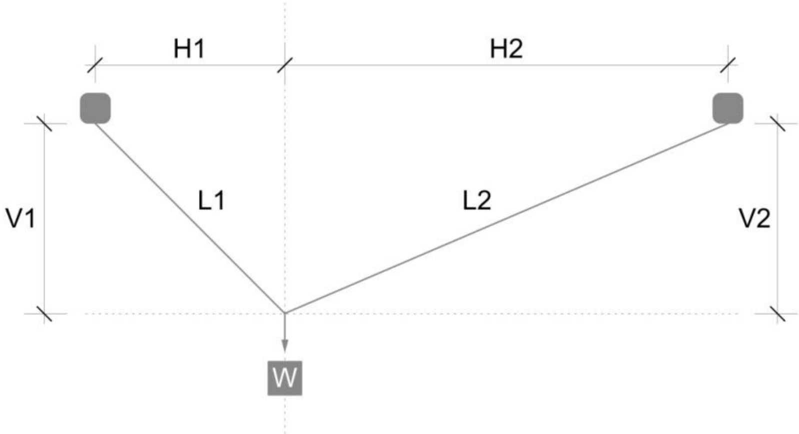
MBIE (Ministry of Business and Employment); 2012; *Approved Code of Practice for Load Lifting*, downloaded from: http://www.business.govt.nz/healthandsafetygroup/information-guidance/all-guidance-items/acop-load-lifting-rigging;

Worksafe; 2013; *Best Practice Guidelines for scaffolding;* New Zealand

NPR 2080-10 NEN NPR 8020-10:2006; *Entertainment - Rigging - Design Factors for Safety for Lifting Equipment*

3.0 Alternative bridle leg calculation methods and equation proofs.

Proof of bridle load calculation



From fundamental statics:

1. Sum of forces in vertical (F_V) direction equal zero: $T_1 \frac{V_1}{L_1} + T_2 \frac{V_2}{L_2} - W = 0$
2. Sum of forces in the horizontal (F_H) direction equal zero: $T_1 \frac{H_1}{L_1} + T_2 \frac{H_2}{L_2} = 0$

Rearranging 2:

3. $T_2 = -T_1 \frac{H_1 L_2}{L_1 H_2}$

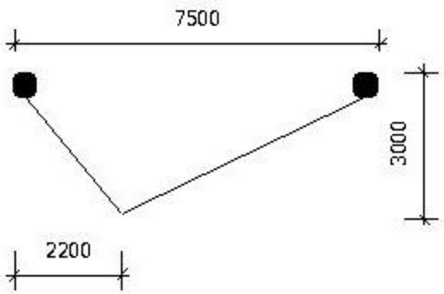
Substituting equation 3 into 1

4. $T_1 \frac{V_1}{L_1} - T_1 \frac{H_1 L_2}{L_1 H_2} . \frac{V_2}{L_2} - W = 0$

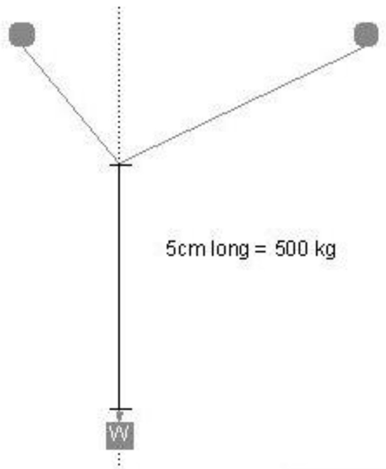
5. $T_1 \left(\frac{V_1}{L_1} - \frac{H_1 V_2}{L_1 H_2}\right) = W$
6. $T_1 \left(\frac{H_1 V_2 - H_1 V_2}{L_1 H_2}\right) = W$
7. $T_1 = \frac{W L_1 H_2}{H_1 V_2 + H_1 V_2}$

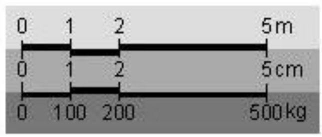
This equation can also be proven using trigonometric or Unit Vector based methods.

In his text *An Introduction into Rigging in the Entertainment Industry*, Higgs, details a graphical method for calculating bridle leg tensions reproduced below with permission (Derived from the Cremona-Maxwell Diagrammatic Method)

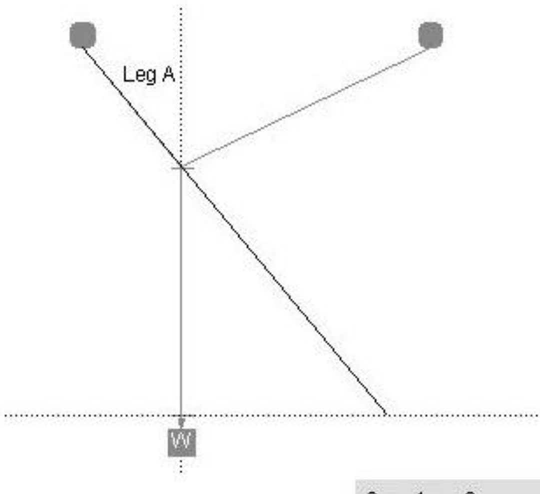


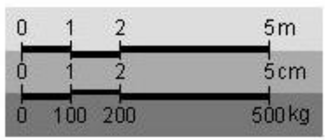
STEP ONE:
Draw to scale, an elevation of the rigging beams or points. Draw the bridle required to the same scale (be as accurate as possible)
In this instance, we have shown the scale as 1:100 (1cm = 1m)
Quick tip - Use grid paper to make drawing these pictures easier.



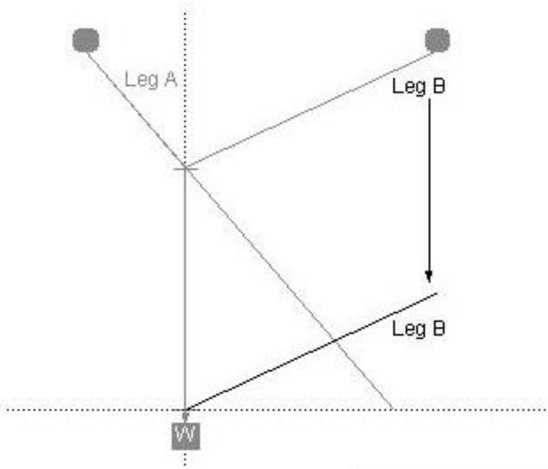


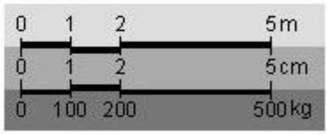
STEP TWO:
Draw a verical line from the root of the bridle down, scaling the length of the line to the value of the load (e.g. a scale of 1cm = 100kg, would mean a 5cm vertical line).



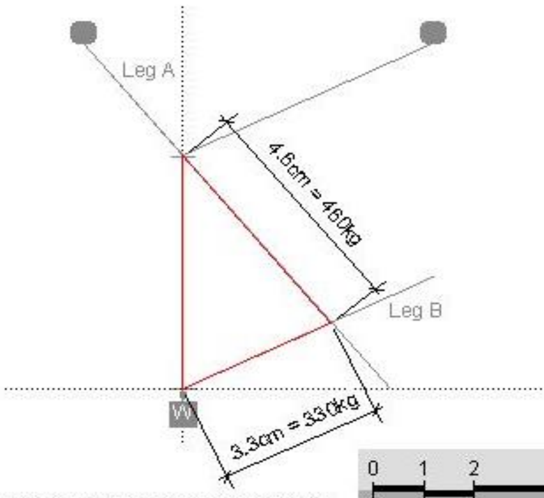


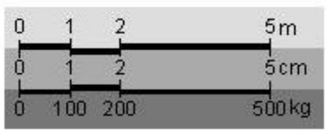
STEP THREE:
Extend one bridle leg 'line' from the bridles root to approximately intersect with the base of the "weight" line. Ensure the line you extend maintains the origional straight line of the bridle leg. You can extend either leg - in this instance we have extended leg A.





STEP FOUR:
Now draw a line parallel with the other bridle leg line (Leg B) from the base of the "weight" line to intersect with the extended bridle leg - again ensure you are as close to accurate with your parallel as possible.





STEP FIVE:
The lines below the bridle root should now create a small triangle. Measure the two angled lines from where they intersect the "weight" line to their respective ends and reference the measurements to the origional scale
In this case, 4.6m = 460kg.
The higher load is the total leg tension imposed onto the shortest bridle leg.

4.0 Example of Equipment Inspection Log sheet

Rigging Equipment Record

Round Steel Slings

Asset Tag ID:
Purchase Date (if known): / /
Primary location:
Load Rating:
Length:

Check Date: / /	Condition:	Checked by:
Check Date: / /	Condition:	Checked by:
Check Date: / /	Condition:	Checked by:
Check Date: / /	Condition:	Checked by:
Check Date: / /	Condition:	Checked by:
Check Date: / /	Condition:	Checked by:

Written off / out of service Date: / / Reason: Authorized by:

Asset Tag ID:
Purchase Date (if known): / /
Primary location:
Load Rating:
Length:

Check Date: / /	Condition:	Checked by:
Check Date: / /	Condition:	Checked by:
Check Date: / /	Condition:	Checked by:
Check Date: / /	Condition:	Checked by:
Check Date: / /	Condition:	Checked by:
Check Date: / /	Condition:	Checked by:

Written off / out of service Date: / / Reason: Authorized by:

5.0 Example of Job Safety Analysis Work Sheet

Job Safety Analysis Work Sheet

Date:		Dept:		Approved by:	
Job Location and details:					

These are mandatory fields and must be filled in on all jobs. Consider hazards and controls for people, plant, process, property and environment.

Team Members	PPE Requirements	Plant, Equipment, Tools	Isolation, Permits Tags, Barricades

General Considerations

Step No.	Job Step	Hazard Identified	Controls	Action