



Crane Rigging

The Angle of Sling Loading and its Effect on Capacity

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Improper rigging, not knowing the full weight of the load, and load movement during lifting are all common causes of crane incidents. Being aware of the sling configuration and its impact on capacity will go a long way to ensure a lift is performed safely.

When it comes to rigging safety, there are numerous scenarios and considerations necessary to plan then execute each lift. Crane operators, riggers, and engineers must know the capability and limitations of all components being used for the lift. The weight of the load, center of gravity (CG), the primary lifting device (e.g., mobile, fixed overhead, or gantry) and rigging hardware are equally critical to ensure a safe lift. This topic is focused on the most basic sling configurations and simple checks which can be used during the planning phase then actual lift execution in the field to ensure rigging is adequate in terms of sling angle impacts on the load.

BACKGROUND

Mobile crane incidents can cause massive production delays, devastating property damage and loss of life. From 2011 to 2017, the Census of Fatal Occupational Injuries (CFOI) reported 297 total crane-related deaths, an average of 42 per year over this 7-year period (U.S. Bureau of Labor Statistics, 2019). Many fatalities could likely have been avoided with proper mobile crane lift planning (Spear, 2004).

One of the critical elements to lift-planning is the understanding of rigging used and how the configuration of the rigging (slings) can impact the weight of the load being lifted. OSHA describes the angle of loading as the inclination of a leg or branch of a sling measured from the horizontal or vertical plane (OSHA, 2019). The lower the angle (from horizontal), more tension (force) exerted onto the sling. Typical lifting angles used for rigging are 90° (considered vertical), 60°, and 45° angles (measured from horizontal).

Riggers assigned to a load-handling activity shall, at a minimum, be responsible for ensuring the weight of the load and its approximate center of gravity have been obtained, provided, or calculated. A rigger must also select the proper rigging equipment, inspect it, and comply with the applicable operating practices according to the criteria of the applicable American Society of Mechanical Engineers (ASME) B30 volumes (i.e., B30.9, B30.10, B30.20, B30.23, B30.26) ensuring the rated load of the rigging equipment as selected and configured is sufficient for the load to be handled, based on the number of legs, hitch configuration, and effects of angles (ASME, 2018). A single-leg lift configuration is common but makes keeping the load stable more difficult, thus the need for a two-leg bridle configuration for many lifts.



“OSHA estimates that 89 crane-related fatalities occur each year in construction work.”

SLING LOADING WITH A TWO-LEG BRIDLE

In many load-handling activities there may be only a single point of attachment to the load handling equipment (LHE) e.g., a crane (mobile, overhead or gantry crane). In this configuration, the use of a two-leg bridle helps to control the load when it clears the ground by minimizing the load's tendency to tip to one end or the other if the load attachment points are equidistance from the load center of gravity (CG).

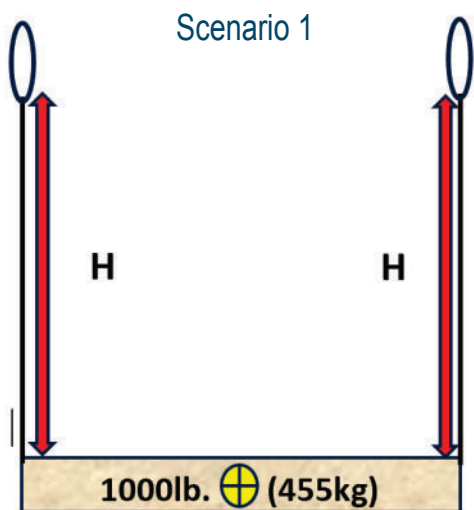
When using a two-leg bridle configuration, the slings will work harder due to the angle the sling takes to the load.


When a lift is made with this configuration, the slings are trying to lift and crush the load at the same time. This causes the sling to see tension at a magnitude greater than half the load. The assumption that each sling carries half the load weight is incorrect and may result in the overloading of the slings and attachment hardware e.g., shackles.

ESTIMATING THE LOAD ON A SINGLE SLING IN A TWO-LEG BRIDLE

How can you estimate sling leg loading to a degree that ensures you do not overload the rigging?

This simple calculation uses basic trigonometry functions. Trigonometry is the branch of mathematics that deals with the relationship between a triangle's sides (length and height) and the angles. A crane operator, rigger, and lift planner can complete these calculations in the field simply using a tape measure and calculator. Simple methods are also available to verify the sling angle.



NOTE:  The center of gravity (CG) for each load must be known to ensure the rigging configuration is balanced in relation to the CG. The CG is not covered in detail in this topic, but the CG is normally available on the load engineering or shipping details

Scenario 1: A simple two-leg lift using vertical hitches (90° angle) to the load. This scenario requires two upper attachment points that can be accomplished by the use of a spreader bar, or two hoists.

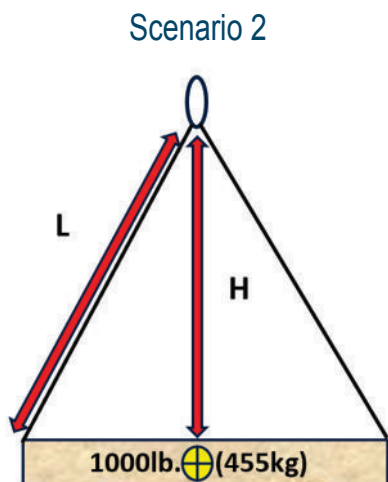
In this scenario, we can determine sling and attachment hardware loading by taking the overall load and dividing by the number of slings (two) since this scenario is a straight vertical lift (90° lift angle).

(Load / # of legs) = The load on one sling in the bridle.

1. Dividing the load weight by two (2) determines the vertical force applied to each sling.

$$(1000/2) = \text{Single sling load in a vertical Two-Leg}$$

Each sling will have a tension of 500 lbs applied to it.



Scenario 2: We can determine sling and attachment hardware loading by taking a few measurements and doing simple calculations to ensure the sling configuration can handle the load.

(Load / # of legs) x (L/H) = Load on one sling in the bridle
In this scenario L= 10 feet (3.05 m) / H= 8 feet (2.5 m)

1. Dividing the load weight by two (2) determines the vertical force applied to each sling.
2. L= Length of the bridle leg
3. H= Height of the bridle or hitch
 - a. This is measured from the horizontal plane between the two attachment points to the attachment point at the LHE.

$$(1000/2) \times (10/8) = \text{Single sling load in an angle Two-Leg Bridle}$$

Each sling will have a tension of 625 lbs. applied to it rather than 500 lbs.

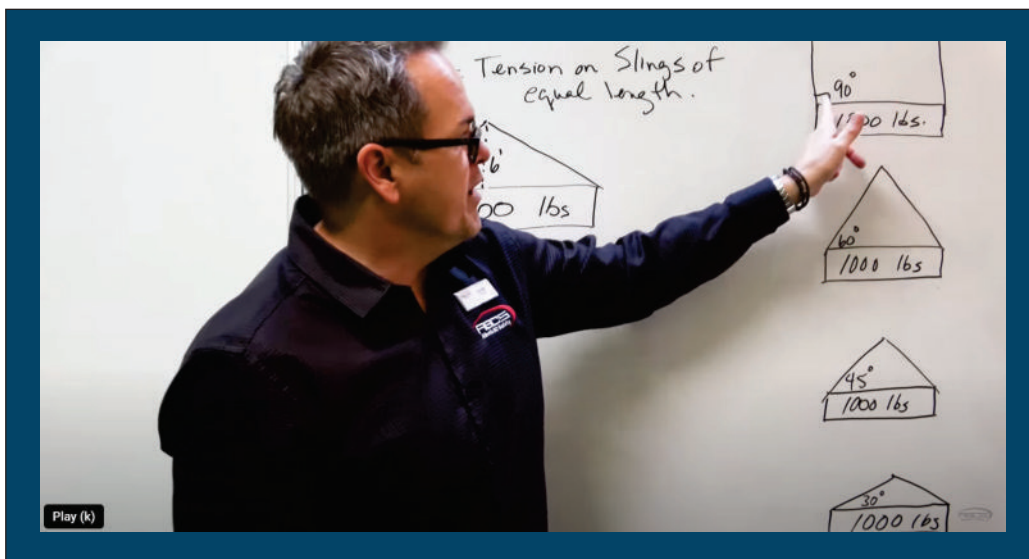
CONCLUSION

Do not forget, when using a two-leg bridle configuration, the slings will work harder due to the angle the sling takes to the load. When a lift is made with this configuration, the slings are trying to lift and crush the load at the same time.

Simple rigging configuration and field checks (calculations) will go a long way to ensure sling loading is understood and correct. When using multiple slings, ensure the angle of loading is known. **The lower (smaller) the sling angle, the greater the tension is on the slings and attachment hardware.**

Bring out a tape measure and calculator and verify the overall changes to the sling load before making the lift. Also be sure all rigging equipment (everything below the hook) is taken into consideration when determining the overall weight of the load!

There are several video resources available which also cover this topic and are easy to use during training and safety meetings. The link below is a short video on YouTube by ABCS Safety training on how the sling angle impacts on safe working loads.



[2 Minute Tool Box Talk on the Effect of Sling Angles on SWL - YouTube](#)

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