# SEEING IS BELIEVING

## Helping Workers Understand How Load Angles Affect Sling Tension

By Mitch Ricketts

**Math Toolbox is designed to help readers apply STEM principles to everyday safety issues. Many readers may feel apprehensive about math and science. This series employs various communication strategies to make the learning process easier and more accessible.**

**The July 2020 Math Toolbox** article ("The Case of the Overloaded Sling," *PSJ* July 2020, pp. 48-52) explored the extreme stresses created in sling legs rigged at certain angles. This article will consider an easy-to-build training device to help workers understand how angles affect tension. After examining the training device, the article will discuss two variations of the equation introduced in the previous article to calculate maximum rated loads for rigging angles that differ from those listed in manufacturer's charts and labels.

### Training Device to Help Workers Understand Tension in Sling Legs

As safety professionals, we are often called upon to train workers and explain the reasons we observe standard safety practices. This can be especially challenging for slings and rigging because of the complex nature of the geometry. When difficult concepts are involved, learners often benefit from hands-on experimentation with working models (Bulunuz & Jarrett, 2010). Figure 1 illustrates materials used to build a working model of a bridle sling to help learners visualize the way forces vary when loading angles change. In the model, spring scales serve as sling legs. The spring scales simultaneously display tension as electronic angle finders display the angle of loading. Figures 2 and 3 show the model in use, while Figure 4 shows the insertion of an additional scale to demonstrate how the combined tension in the sling legs may exceed the total weight of the load.

The author began using training models such as this because workers and students sometimes express confusion about the effects of loading angles on stresses in slings and other materials. The first models were rather crude (e.g., with carpenter squares instead of digital angle finders). The models continue to evolve, with a goal to replace the analog tension scales with modern digital versions when funds allow. If readers decide to use a model such as this in their own worker training, the author recommends beginning by showing workers how the sling-leg scales can be moved to vary the angles of loading. Then, ask learners to try each possible configuration of the sling legs to explore how tension is affected by the angles.

Many readers have their own favorite ways of using hands-on models in safety training, and the author welcomes readers to share their experiences. Contact him at **ricketts@nsuok.edu**.

### Review of Sling Tension Calculation

The July 2020 Math Toolbox considered how tension in two-leg bridle slings varies according to the angle of loading. This is important because excessive tension may cause sling legs to break and drop their loads. To review, the internal stresses in a sling leg are affected by the angle of loading (θ, sometimes called the

**FIGURE 1**

**DEMONSTRATION SLING: MATERIALS**

Materials for the training device (not to scale). Top left: two spring scales to be used as sling legs (digital scales will also work). Bottom left: two electronic angle finders and bands for attachment to the spring scales. Top right: free-standing frame, sized appropriately for the sling and weights. The frame used by the author is made of 2- x 4-in. lumber with 1/4-in. plywood scraps for corner braces. Hardware at the top consists of 5/16-in. eye bolts, washers, nuts and S-hooks. The S-hooks are closed around the eye bolts, but the free end of each S-hook remains open to permit easy attachment of spring scales in different configurations. The frame shown is about 41-in. high and 42-in. wide, with two 15-in. stabilizer boards attached perpendicularly at bottom to resist tipping. The entire frame can be made from two 8-ft boards and a bit of scrap plywood. Middle right: lifting beam made of 2- x 2-in. lumber (24-in. long in this example). Lifting-beam hardware consists of 5/16-in. eye bolts, washers, nuts and S-hooks. Bottom right: two weights (a pair of 25-lb dumbbells, in this instance) and synthetic rope for suspending the dumbbells from the lifting beam's S-hooks. Be sure to select materials that match the size and weight of the scales and loads you will use in your training model.

**FIGURE 2**
## DEMONSTRATION SLING CONFIGURED WITH TWO VERTICAL LEGS

**Demonstration of tension in vertical sling legs consisting of spring scales. At a 90° angle of loading, the tension in each sling leg equals half the weight of the load, and the sum of tension in both legs equals the total weight of the load.**

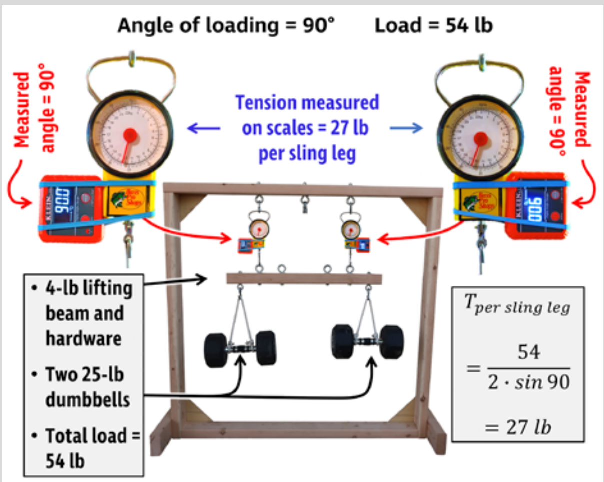
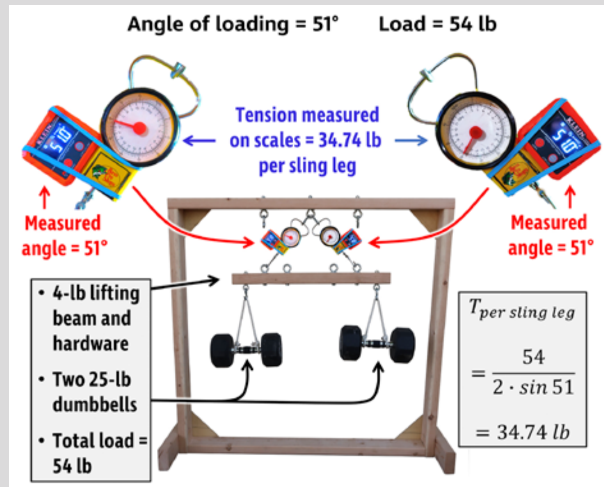



**FIGURE 3**
## DEMONSTRATION SLING WITH TWO INCLINED LEGS (BRIDLE HITCH)

**Demonstration of tension in sling legs (spring scales) rigged at acute angles in a bridle hitch. When the loading angle is less than 90°, the tension in each sling leg is greater than half the weight of the load, and the sum of tension in both legs exceeds the total weight. Note: The two unused eyebolts in the lifting beam allow trainees to experiment with a third configuration having a different angle of loading.**




horizontal angle). For loads being lifted upward, the angle of loading is the acute angle between the sling leg and the horizontal plane (Figure 5, p. 44). The sling's rated load is the maximum allowable load printed on the manufacturer's label attached to the sling. Never exceed the rated load, as this may cause the sling to fail. (The rated load is also known as the rated capacity or working load limit, WLL). The rated load varies depending on rigging method and angle of loading, because these factors affect tension within the sling. Tension is a pulling force within a material. Extreme tension can stretch a sling or rip it apart. For vertical- or bridle-hitch slings with one or two evenly loaded legs, tension in each leg is calculated as follows:

$$T_{per\ sling\ leg} = \frac{W}{N \cdot sin\, \theta}$$

where:

T = tension (pull) in each sling leg due to the force of the load at a particular angle

W = weight of the load (including the weight of any hardware added between the sling and the load)

N = number of sling legs

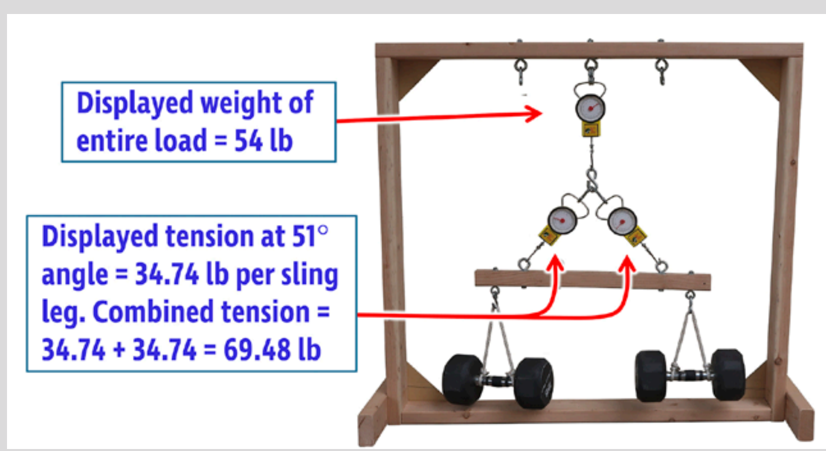
θ = angle of loading (angle from horizontal)

sin = sine of the angle

Figure 5 (p. 44) illustrates the components of the equation.

**FIGURE 4**
## DEMONSTRATION SLING: COMBINED TENSION IN SLING LEGS MAY EXCEED WEIGHT OF LOAD

**By inserting a third spring scale at top, trainees can see that the weight of the suspended load remains the same, even as tension varies. This demonstrates that tension does not always equal weight, and tensile forces in sling legs may differ from tension in crane hooks, lifting beams and other components.**




*Note:* All calculations in this article apply to evenly loaded vertical and bridle slings having no more than two legs, with no shock loading. Additional factors must be considered to determine sling tension for other types of hitches (e.g., choker and basket hitches) and for slings with more than two legs. Finally, slings must be used in accordance with guidance published by manufacturers, American Society of Mechanical Engineers (ASME, 2018) and OSHA (n.d.).

Figure 2 provides a "seeing is believing" example of tension in the legs of a vertical sling. In Figure 2 (p. 43), the weight of the load (W) is the sum of the 4-lb lifting beam plus the two 25-lb dumbbells (W = 4 + 25 + 25 = 54 lb). Since Figure 2 depicts a two-leg sling, the number of legs is N = 2. Finally, both sling legs are vertical, so the angle of loading is θ = 90°. Inserting these numbers into the equation, we calculate the tension ($T_{\text{per sling leg}}$) as follows:

$$T_{per\ sling\ leg} = \frac{W}{N \cdot sin\,\theta} = \frac{54}{2 \cdot sin\,90} = 27\ lb$$

Our calculated value of 27 lb per leg indeed matches the tension displayed for each spring scale in Figure 2.

*Note:* Most calculators have a *SIN* button that will provide the correct answer with keystrokes similar to the following in this case: *54÷(2XSIN90)=*. If your calculation results in 30.20 lb, it is likely that your calculator is set to interpret angles in units of radians instead of degrees. The calculator manual will explain how to select the degree function (for example, many calculators have a dedicated button that toggles between *DEG*, for degrees, and *RAD*, for radians). The procedure is different in an Excel spreadsheet because the program requires converting the angle to radians before applying the sine function. You can calculate the answer in Excel for this example with the following cell formula: *=54/(2*SIN(RADIANS(90)))*.

Figure 3 (p. 43) illustrates a second example, as follows:

•The load still weighs 54 lb. This is the value of W in the formula.

•The sling still has two legs. This is the value of N in the formula.

•This time, the angle of loading is 51°. This is the value of θ in the formula.

Based on these data, we calculate the tension per sling leg ($T_{\text{per sling leg}}$):

$$T_{per\ sling\ leg} = \frac{W}{N \cdot sin\,\theta} = \frac{54}{2 \cdot sin\,51} = 34.74\ lb$$

In Figure 3, the tension displayed for each spring scale is approximately 34.74 lb, as calculated. Thus, for both examples, the calculated values match the tensions displayed by the spring scales in the training model. *Note:* If your calculation resulted in 40.28 lb, see the note about degrees versus radians in the first example.

### Calculating Maximum Acceptable Load When Angle of Loading Differs From Manufacturers' Charts & Labels

We can use our equation to solve many practical on-the-job rigging problems. By rearranging the formula, for example, we can calculate the rated load for angles that differ from those provided by the manufacturer. To begin, look up the weight (W) of the manufacturer's rated load for a single-leg, vertical-hitch sling. Use this value as maximum tension (T) for the rated load, because W = T for single-leg vertical slings (as demonstrated in Math Toolbox, *PSJ* July 2020). We then rearrange the formula and solve for W to find the maximum weight (i.e., rated load) at the new angle of interest.

Since we are solving for the maximum weight based on the manufacturer's rated load per sling leg, we rearrange the equation and adjust the subscripts for W and T, as follows:

$$W_{maximum} = T_{90°\ rated\ load\ per\ sling\ leg} \cdot (N \cdot sin\,\theta)$$

where:

$W_{\text{maximum}}$ = maximum weight that will not exceed the rated load at the angle of interest, θ (maximum weight includes any hardware added between the sling and the load)

$T_{\text{90° rated load per sling leg}}$ = manufacturer's rated load (WLL) for the single-leg, vertical-hitch sling (this is the tension that must never be exceeded)

N = number of sling legs

θ = angle of loading (angle from horizontal)

sin = sine of the angle

To illustrate this use of the modified equation, imagine a sling for which the manufacturer's chart or label indicates a rated load of 4,400 lb per leg when used in a single-leg vertical hitch (Figure 6). The chart in Figure 6 includes additional rated loads for other configurations, which we will ignore for now. Let's imagine we will make a lift using two of these same sling legs in a bridle hitch at a load angle of 50°. What is the maximum load for the two-leg bridle sling at this unlisted 50° angle of loading?

To review, here are the data for our problem:

•The manufacturer's chart indicates a vertical rated load per sling leg of 4,400 lb. This is the value of $T_{\text{90° rated load per sling leg}}$, representing the maximum tension that must never be exceeded.

•The sling has two legs. This is the value of N in the formula.

•The angle of loading is 50°. This is the value of θ in the formula.

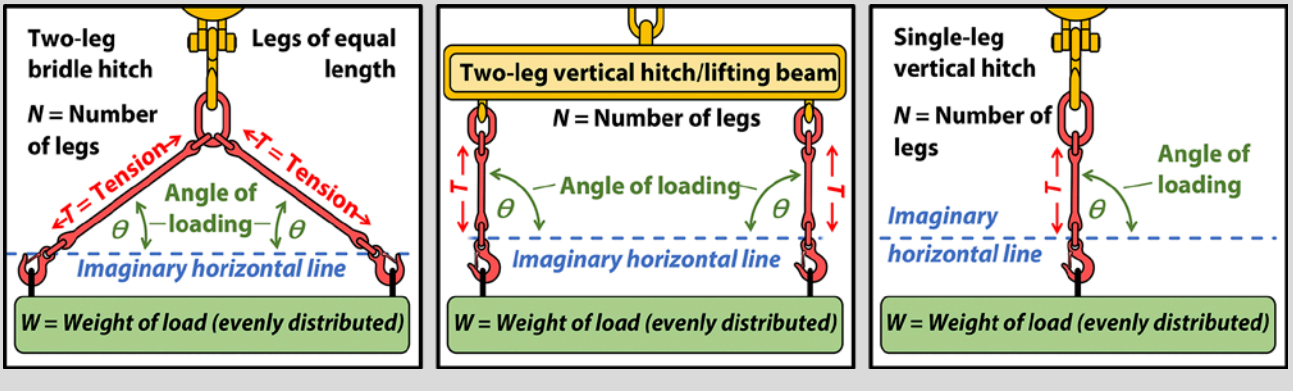
**Step 1:** Start with the sling tension equation, modified to solve for $W_{\text{maximum}}$:

$$W_{maximum} = T_{90°\ rated\ load\ per\ sling\ leg} \cdot (N \cdot sin\,\theta)$$

**FIGURE 5**

## EQUATION COMPONENTS

**Bridle hitches (left) are rigged at acute angles, with legs attached to a single fitting at top. Vertical hitches (middle and right) are rigged perpendicularly to the load.**



**Step 2:** Insert the known values for the vertical rated load ($T_{90^\circ \text{ rated load per sling leg}}$ = 4,400 lb), number of sling legs (N = 2), and angle of loading (θ = 50°). Then solve for $W_{maximum}$:

$$W_{maximum} = 4{,}400 \cdot (2 \cdot sin\, 50) = 6{,}741.19\ lb$$

*Note:* Most calculators will provide the correct answer with keystrokes similar to the following in this case: *4400X(2XSIN50)=*. If your calculation resulted in -2,308.9 lb, see the note about degrees versus radians in the first example. In an Excel spreadsheet, the proper formula is: *=4400*(2*SIN(RADIANS(50)))*.

**Step 3:** Our calculation indicates that 6,741.19 lb is the maximum weight we can handle with a two-leg bridle sling at a load angle of 50° when each sling leg has a vertical rated load of 4,400 lb.

*Important:* Besides ensuring that we do not overload the sling legs, we must also avoid overloading any connectors, lifting devices or other hardware involved in the lift. This means we can handle 6,741.19 lb only if all components of the rigging are rated for this load. Furthermore, our calculations apply only for vertical- and bridle-hitch slings with one or two legs. Finally, the value we use as $T_{90^\circ \text{ rated load per sling leg}}$ must be the manufacturer's rated load (or WLL) for a single-leg vertical hitch.

**Alternate example:** To confirm that our calculations are consistent with the values shown in the manufacturer's chart or label, let's calculate the rated load for one of the angles shown in the chart. Once again, the manufacturer's chart indicates a vertical rated load per sling leg of 4,400 lb as shown in Figure 6. To confirm our procedures, let's calculate the maximum rated load using two of these sling legs in a bridle hitch, this time at a load angle of 60°, which we can verify from the chart. Does our calculated maximum load match that shown in the manufacturer's chart (i.e., 7,621 lb for the two-leg bridle sling at a 60° angle)? Here is a summary of our data:

•The manufacturer's chart indicates a vertical rated load per sling leg of 4,400 lb. This is the value of $T_{90^\circ \text{ rated load per sling leg}}$.

•The sling has two legs. This is the value of N.

•The angle of loading is 60°. This is the value of θ.

To calculate the maximum load for the two-leg bridle hitch at the angle of 60°, we use the sling tension equation arranged to solve for $W_{maximum}$:

FIGURE 6

## SAMPLE CHART OR LABEL A

Sample load chart or label (A) for rated sling loads.

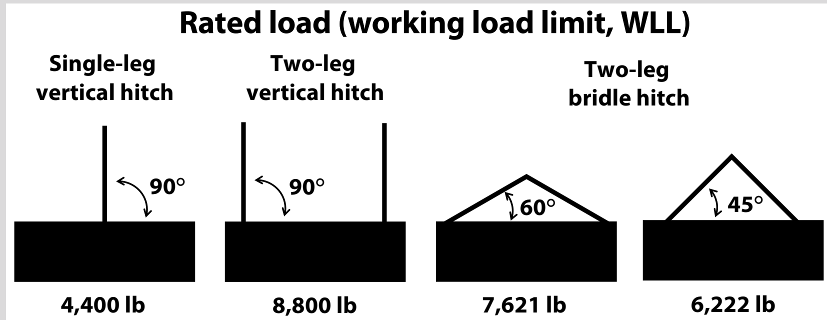



FIGURE 7

## SAMPLE CHART OR LABEL B

Sample load chart or label (B) for rated sling loads.

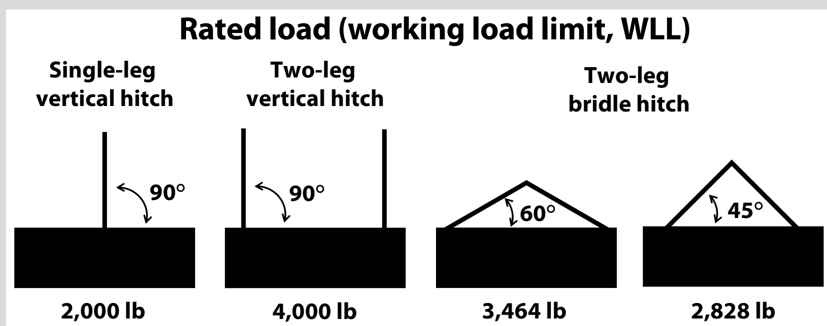
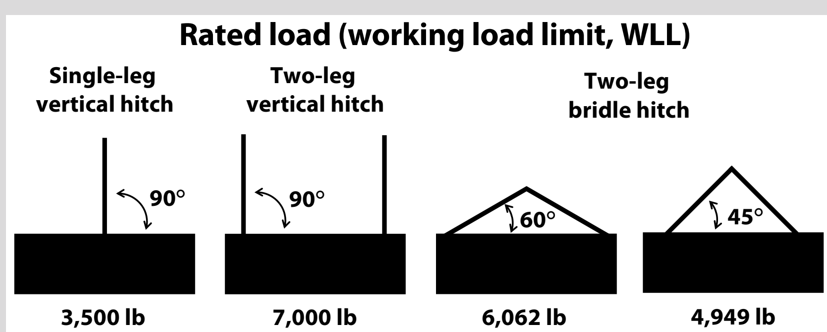



FIGURE 8

## SAMPLE CHART OR LABEL C

Sample load chart or label (C) for rated sling loads.




$$W_{maximum} = T_{90^\circ \text{ rated load per sling leg}} \cdot (N \cdot sin\,\theta)$$

Insert the current values for vertical rated load per sling leg ($T_{90^\circ \text{ rated load per sling leg}}$ = 4,400 lb), number of sling legs (N = 2), and angle of loading (θ = 60°) to obtain the following result:

$$W_{maximum} = 4{,}400 \cdot (2 \cdot sin\, 60) = 7{,}621.02\ lb$$

Our calculated result can be rounded to 7,621 lb, matching the rated load for the 60°, two-leg bridle sling in Figure 6.

This confirms that our procedure is correct. *Note:* If your calculation resulted in -2,682.33 lb, see the note about degrees versus radians in the first example.

As always, we must check the specifications for our lifting devices and other hardware to ensure that all components of the rigging are rated to handle the 7,621 lb maximum load.

### You Do the Math

Apply your knowledge to the following questions. Answers are on p. 55.

1. As shown in Figure 7 (p. 45), a manufacturer's chart or label indicates a 2,000-lb vertical rated load per sling leg. We need to make a lift using two of these sling legs in a bridle hitch at a load angle of 72°, which is not shown in the chart. What is the rated load for the two-leg bridle sling at the 72° angle of loading? Use the rated load for a single-leg vertical-hitch sling as the value of $T_{90°\text{ rated load per sling leg}}$. Then use the sling tension equation arranged to solve for $W_{maximum}$ at 72°. The result is rated load for the 72°, two-leg bridle sling.

2. To confirm our procedures, calculate the rated load for the 45° angle of loading as shown for the two-leg bridle sling in Figure 7. Once again, use the 2,000-lb vertical rated load per sling leg as the value of $T_{90°\text{ rated load per sling leg}}$. Then use the sling tension equation arranged to solve for Wmaximum at 45°. The result should match the rated load for the 45°, two-leg bridle sling, as shown in Figure 7.

### Calculating the Minimum Angle of Loading When Weight of Load Differs From Manufacturers' Charts & Labels

As a final use of our formula, we can calculate the minimum angle of loading for weights that differ from those provided by the manufacturer. For example, imagine a sling with a manufacturer's chart indicating a vertical rated load per sling leg of 3,500 lb, as shown in Figure 8 (p. 45). Now imagine that we need to lift a load of 5,500 lb using two of these sling legs in a bridle hitch. What is the minimum angle of loading for the two-leg bridle sling when handling this 5,500-lb load?

Again, we use the manufacturer's vertical rated load per sling leg as $T_{90°\text{ rated load per sling leg}}$. This time, however, we adjust the subscripts and rearrange the formula to solve for minimum angle of loading ($\theta_{minimum}$):

$$\theta_{minimum} = \sin^{-1}\frac{W}{T_{90°\ rated\ load\ per\ sling\ leg} \cdot N}$$

where:

$\theta_{minimum}$ = minimum angle of loading that will not exceed the rated load

$\sin^{-1}$ = inverse sine (arcsine) of the angle

W = weight of the load (including the weight of any hardware added between the sling and the load)

$T_{90°\text{ rated load per sling leg}}$ = manufacturer's rated load (WLL) for the single-leg, vertical-hitch sling (this is the tension that must never be exceeded)

N = number of sling legs

Recall the data from our example based on Figure 8:

•The manufacturer's chart indicates a vertical rated load per sling leg of 3,500 lb. This is the value of $T_{90°\text{ rated load per sling leg}}$.

•The sling has two legs. This is the value of N.

•We will lift a load of 5,500 lb. This is the value of W.

**Step 1:** Start with the sling tension equation, modified to solve for $\theta_{minimum}$:

$$\theta_{minimum} = \sin^{-1}\frac{W}{T_{90°\ rated\ load\ per\ sling\ leg} \cdot N}$$

**Step 2:** Insert the known values for weight of the load (W = 5,500 lb), vertical rated load per sling leg ($T_{90°\text{ rated load per sling leg}}$ = 3,500 lb) and number of sling legs (N = 2). Then solve for $\theta_{minimum}$:

$$\theta_{minimum} = \sin^{-1}\frac{5{,}500}{3{,}500 \cdot 2} = 51.79°$$

*Note:* If your calculator has a $SIN^{-1}$ or ASIN button, your keystrokes will be similar to the following in this case: *$SIN^{-1}$X(5500÷(3500X2))=*, or alternatively: *ASINX(5500÷(3500X2))=*. If your calculation results in 0.90°, make sure your calculator is set to the degree function, as noted. In an Excel spreadsheet, the proper formula for this example is: *=DEGREES(ASIN(5500/(3500*2)))*.

**Step 3:** Our calculation indicates that we must rig the two-leg bridle sling with a load angle of no less than 51.79° to safely lift the load of 5,500 lb using the two sling legs with rated vertical-hitch capacities of 3,500 lb each. Since the angle of loading must be no less than 51.79°, it would be acceptable to use larger angles (e.g., 55°, 60°, 85°). On the other hand, it is not acceptable to use smaller angles (e.g., 30°, 45°, 50°). Once again, we must check the specifications for our lifting devices and other hardware to ensure that all components of the rigging are rated to handle this 5,500-lb load.

**Alternate example:** To confirm that our calculations are consistent with the values shown in the manufacturer's chart or label, let's calculate the minimum load angle for the two-leg bridle sling in Figure 8 when handling a load of 6,062 lb. Does our calculated minimum angle of loading match that shown in the manufacturer's chart (i.e., 60° for the two-leg bridle sling with a load of 6,062 lb)? Here is a summary of the data:

•The manufacturer's chart in Figure 8 (p. 45) indicates a vertical rated load per sling leg of 3,500 lb. This is the value of $T_{90°\text{ rated load per sling leg}}$ in the formula.

•The sling has two legs. This is the value of N in the formula.

•We will lift a load of 6,062 lb. This is the value of W in the formula.

To calculate the minimum angle of loading, we use the sling tension equation arranged to solve for $\theta_{minimum}$:

$$\theta_{minimum} = \sin^{-1}\frac{W}{T_{90°\ rated\ load\ per\ sling\ leg} \cdot N}$$

Insert the current values for weight of the load (W = 6,062 lb), vertical rated load per sling leg ($T_{90°\text{ rated load per sling leg}}$ = 3,500 lb) and number of sling legs (N = 2). Then solve for $\theta_{minimum}$:

$$\theta_{minimum} = \sin^{-1}\frac{6{,}062}{3{,}500 \cdot 2} = 59.997°$$

Our calculated result can be rounded to 60°, matching the angle shown for the 6,062-lb rated load in Figure 8. This confirms that our procedure is correct. Since the angle must be no less than 60°, it would be acceptable to use larger sling angles (e.g., 65°, 70°). On the other hand, it is not acceptable to use smaller angles (e.g., 50°, 55°). Finally, we must ensure that all components of the rigging are rated to handle the 6,062-lb load. If your calculation resulted in 1.05°, make sure your calculator is set to the degree function.

### You Do the Math

Apply your knowledge to the following questions. Answers are on p. 55.

3. A sling manufacturer's chart indicates a vertical rated load per sling leg of 3,500 lb, as shown in Figure 8. We need to lift a load of 6,300 lb using two of these sling legs in a bridle hitch. What is the minimum angle of loading for the two-leg bridle sling when handling this 6,300-lb load? Use the rated load for a single-leg vertical-hitch sling as the value of $T_{90°\text{ rated load per sling leg}}$. Then use the sling tension equation arranged to solve for $\theta_{minimum}$ with a load of 6,300 lb.

4. A sling manufacturer's chart indicates a vertical rated load per sling leg of 2,000 lb, as shown in Figure 7 (p. 45). We need to lift a load of 3,700 lb using two of these sling legs in a bridle hitch. What is the minimum angle of loading for the two-leg bridle sling when handling this 3,700-lb load? Use the rated load for a single-leg vertical-hitch sling as the value of $T_{90°\text{ rated load per sling leg}}$. Then use the sling tension equation arranged to solve for $\theta_{minimum}$ with a load of 3,700 lb.

## Final Comments

Our two-article exploration of tension has focused on vertical and bridle hitches having no more than two evenly loaded sling legs. Keep in mind that tension is calculated differently for other types of hitches and for additional rigging components such as crane hooks and lifting beams. Also, remember that slings may fail because of harsh work conditions and improper load-handling practices. Refer to recognized standards for guidance on these broader issues (e.g., ASME, 2018; OSHA, n.d.).

### How Much Have I Learned?

Try these problems on your own. Answers are on p. 55.

5. As shown in Figure 8 (p. 45), a manufacturer's chart indicates a vertical rated load per sling leg of 3,500 lb. We need to make a lift using two of these sling legs in a bridle hitch, at a load angle of 53°. What is the maximum load for the two-leg bridle sling at the unlisted angle of 53°? Use the vertical rated load per sling leg as the value of $T_{90° \text{ rated load per sling leg}}$. Then use the sling tension equation arranged to solve for Wmaximum at 53°. The result is the rated load for the two-leg bridle sling at a loading angle of 53°.

6. As shown in Figure 6 (p. 45), a manufacturer's chart indicates a vertical rated load per sling leg of 4,400 lb for a single sling leg when used in a vertical hitch. We need to lift a load of 7,250 lb using two of these sling legs in a bridle hitch. What is the minimum load angle for the two-leg bridle sling when handling this 7,250 lb load? Use the vertical rated load per sling leg as the value of $T_{90° \text{ rated load per sling leg}}$. Then use the sling tension equation arranged to solve for $\theta_{minimum}$ with a load of 7,250 lb.

## For Further Study

Learn more from the following source: *ASSP's ASP Examination Prep: Program Review and Exam Preparation*, edited by Joel M. Haight, 2016. **PSJ**

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# PROJECT ACCELERATION

## Juggling the Dichotomy of Safety vs. Production

By Cory J. Grimmer

**Accelerating project schedule can pay dividends in meeting production schedule. Negative consequences may follow, however, if safety and quality are sacrificed for the sake of pushing production or trying to remain ahead of schedule.**

**In such cases,** any benefit that may have been received by driving schedule is often offset by losses due to injury, rework and lower production from workers.

Nepal et al. (2006) performed an empirical investigation that collected survey data from 102 construction practitioners working on 38 construction sites. They found that negative effects of schedule pressure arose primarily by working out of sequence, generating work defects requiring rework, cutting corners and even from workers losing motivation to work. To minimize these adverse effects, the researchers recommend scheduling construction activities realistically through proactive planning, motivating workers and establishing an effective mechanism for project coordination and communication.

While this study does not directly correlate schedule pressure with safety, it touches on the negative effects on quality that can result from pushing schedules. When schedules are applied to meet production goals, safety is often the first casualty, quickly followed by a downturn in quality.

Mike Rowe (2009) of *Dirty Jobs* says:

> Of all the platitudes automatically embraced in the workplace . . . there is none more pervasive, erroneous, overused and dangerous, than "Safety First!" in my opinion.
>
> Is it important? Of course. But is it more important than getting the job done? No. Not even close. Making money is more important than safety—always—and it's very dangerous in my opinion to ignore that.

Whether there is some measure of truth to this statement, the slogan of "safety first" tends to be popular for many companies; however, while worker safety is important to most managers, meeting production drives future business. As a direct result, a production-first mentality often will be the driving force behind most business decisions.

Rather than look at this problem as one induced by schedule pressure, a deeper dive must be initiated. Often a pronounced dichotomy exists between safety and production. While the safety of workers is important to the majority of companies, when acceleration of production goals comes around, the best safety cultures can place safety on the back burner in an effort to meet production demands.

Perhaps a fresh view of this issue should be considered. While some think of safety and quality as antithetical to production, in reality, safety + quality + production = successful business (profit). A company that prioritizes the safety and quality of work being performed in conjunction with production during project acceleration will find meeting production goals easier to achieve. In turn, the negative effects identified by Nepal et al. (2006) will diminish.

Prioritization of safety and quality in union with production is necessary. Prioritizing safety in particular prioritizes the workforce. The true measure of success is a company's ability to juggle all three components of the safety, quality and production triangle and manage it efficiently at every level.

Success of this strategy is contingent upon buy-in from ownersship. A fundamental shift in both thinking and behavior, in addition to an organization-wide commitment is not easy but can be achieved through consistent reinforcement of these values from top tier leadership. As this paradigm shift in company values occurs, safety and quality will be at the forefront of leadership's goals, even in the midst of chaos. PSJ

## References


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### Vantage Point



### Math Toolbox, continued from pp. 42-47

### Answers: Seeing Is Believing: Helping Workers Understand How Load Angles Affect Sling Tension

You Do the Math

Your answers may vary slightly due to rounding.

1. $W_{maximum} = 2{,}000 \cdot (2 \cdot sin\,72) = 3{,}804.23\ lb$

2. $W_{maximum} = 2{,}000 \cdot (2 \cdot sin\,45) = 2{,}828.43\ lb$, which approximates the value of 2,828 lb in the chart

3. $\theta_{minimum} = \sin^{-1}\frac{6{,}300}{3{,}500 \cdot 2} = 64.16°$

4. $\theta_{minimum} = \sin^{-1}\frac{3{,}700}{2{,}000 \cdot 2} = 67.67°$

How Much Have I Learned?

5. $W_{maximum} = 3{,}500 \cdot (2 \cdot sin\,53) = 5{,}590.45\ lb$

6. $\theta_{minimum} = \sin^{-1}\frac{7{,}250}{4{,}400 \cdot 2} = 55.47°$