The Case of the SHATTERED PLANK

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.

Falls from heights are a leading cause of death in many industries (BLS, 2020). Falls often occur when workers step off ledges or through openings, lose their balance, or slip while using ladders and scaffolds. As illustrated in Figure 1, workers may also fall when platforms, beams and other structures collapse from overloading. Overloaded beams can lead to other types of incidents. For example, workers may be injured by falling materials when storage racks or other structures collapse due to excess loading. In this article, we will consider a characteristic of beams known as the section modulus to help determine the weight of a load that may cause a beam to collapse.

Section Modulus Applied to Beams With a Concentrated Load at Center

The section modulus is a measure related to the cross-sectional shape and size of a beam. Larger section modulus values indicate more beam material is present in a favorable shape to resist bending and breaking. The section modulus is a useful measure because, when combined with other information, it can be used to estimate the weight of a load that may cause a beam to break. For the purposes of our calculations, "beam" is defined as a horizontal structure that supports a load. This definition includes planks. We limit our calculations to situations involving simple beams that rest on supports at both ends (with no rigid connections). Finally, the beams involved in our calculations are solid (not hollow), and they are rectangular in cross section.

For solid, rectangular, simple beams, the equation for section modulus is as follows:

$$S = \frac{b \cdot d^2}{6}$$

where:

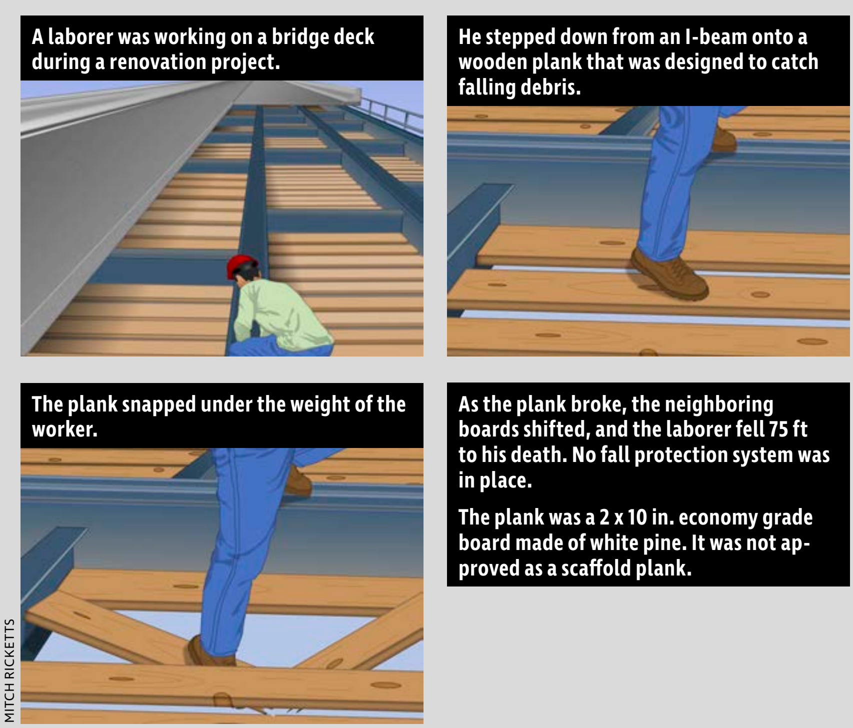
S = section modulus, which is a measure related to the shape and size of a beam's cross section. Values of S are expressed in units of length to the third power. To maintain consistency with later calculations, we will calculate S as cubic inches (in.^{3}).

b = horizontal width of the beam, as illustrated in Figure 2. For consistency, we will calculate b as inches (in.).

d = vertical depth of the beam, as illustrated in Figure 2. Once again, we will use units of in. for consistency.

FIGURE 1

CONSTRUCTION LABORER FALLS THROUGH TEMPORARY PLATFORM, NEW JERSEY, 2007



Note. Adapted from "Construction Laborer Dies After Falling Through Temporary Bridge 'Catch' Platform, 75 Feet to Ground (New Jersey FACE Report No. 07NJ077)," by NIOSH, 2011, www.cdc.gov/niosh/face/stateface/nj/07nj077.html.

Calculating Section Modulus

Let's consider the incident from Figure 1. The plank was a 2 x 10 in. (nominal) economy grade white pine board. In the context of lumber, nominal means dimensions are rounded up to the nearest inch. The exact thickness of the board in this case was reported as 1.875 in., and the exact width was 9.75 in.

We will follow a three-step process to estimate the ultimate (or breaking) load for a plank. First, we will calculate the section modulus in units of in.^{3}. Next, we will look up a value known as allowable fiber stress in bending. Finally, we will calculate the ultimate load based on the section modulus, allowable fiber stress and the span of the beam.

Calculated example. Certain details were not reported by investigators in the case of the shattered plank. Therefore, we will base our calculation on a hypothetical example that mirrors some but not all of the facts of the case.

Step 1: Section modulus (S). The first step in our process is to calculate the value of section modulus based on the actual width and depth of the plank from the case as reported earlier:

•With the plank lying face down, its horizontal width was 9.75 in. This is the value of *b* in the formula.

•The vertical depth of the face-down plank was 1.875 in. This is the value of *d* in the formula.

To calculate the plank's section modulus in cubic inches (in.^{3}), we start with the equation:

$$S = \frac{b \cdot d^2}{6}$$

Next, we insert the known values for the horizontal width (b = 9.75 in.) and vertical depth (d = 1.875 in.). Then we solve for S as in.^{3}:

$$S = \frac{9.75 \cdot 1.875^2}{6} = 5.71\ in.^3$$

(rounded two places past the decimal)

Our calculation indicates that the board had a section modulus of about 5.71 in.^{3} when placed flat, or face down, as a plank. As shown in Table 1, a larger section modulus for vertical loads (meaning more material to resist bending in the vertical plane) can be achieved by placing a board on edge as we do with joists.

Now that we have calculated the section modulus, we will move to the next step in determining the ultimate load for the plank.

Step 2: Fiber stress in bending (F_b). A load imposes stresses on the fibers of a beam, as illustrated in Figure 3 (p. 50). For a horizontal beam subject to a downward vertical load, bending causes the top of the beam to shorten while the bottom of the beam lengthens. Fiber stress in bending is a measure of the compressive and tensile stresses imposed on the most extreme fibers in a beam's cross section—in other words, the fibers located farthest from the beam's neutral axis.

Lumber manufacturers report the allowable fiber stress in bending (F_b) for each grade, dimension and species of lumber that is designed for supporting a load (e.g., see Southern Forests Products Association, 2018). The plank in the opening case was made of economy-grade lumber. Since economy-grade wood is not designed for supporting loads, manufacturers do not report its allowable fiber stress in bending. With this in mind, our calculations from this point will be purely hypothetical.

FIGURE 2

SECTION MODULUS

Section modulus for solid beams with solid rectangular cross sections and vertically imposed loads.

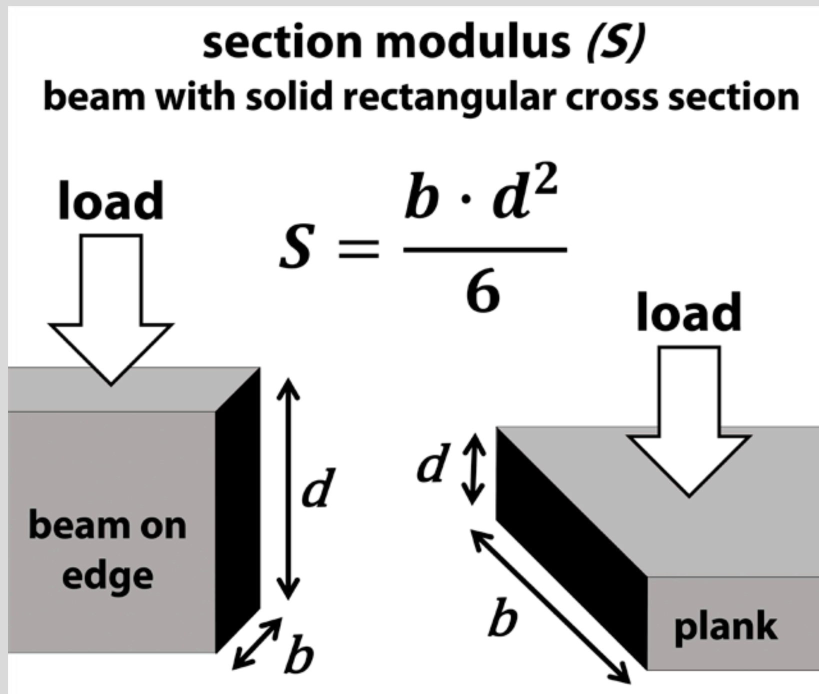


TABLE 1

SECTION MODULUS & ULTIMATE LOAD

Section modulus and ultimate load for beams placed on edge or flat, based on a span of 8 ft and an allowable fiber stress in bending of 1,250 psi. This table ignores the effects of deflection.

			Ultimate (breaking) load assuming an 8-ft span and allowable fiber stress in bending of 1,250 psi			
	Section modulus (in.^{3})		Load concentrated at center of span (lb)		Load distributed uniformly along span (lb/linear ft)	
Actual size of beam (in.)	On edge	Flat	On edge	Flat	On edge	Flat
1.5 x 7.25	13.14	2.72	684.41	141.60	171.10	35.40
1.5 x 11.25	31.64	4.22	1,647.95	219.73	411.99	54.93
3.5 x 7.25	30.66	14.80	1,596.95	770.94	399.24	192.74
3.5 x 11.25	73.83	22.97	3,845.21	1,196.29	961.30	299.07

Grade no. 3 lumber is the lowest grade for which fiber stress is commonly reported, so we will base our hypothetical case on the strength of this grade of lumber. (Grade no. 3 is much sturdier compared with economy grade, but still not sturdy enough for scaffold planking.) The Southern Forests Products Association (2018) reports the allowable fiber stress in bending (F_b) is 475 pounds per square inch (psi) for 2 x 10-in. (nominal) grade no. 3 southern white pine lumber. In certain circumstances, the American Wood Council (2018) requires the value of allowable fiber stress to be adjusted for conditions of use. To keep our calculations manageable, we will ignore those adjustment factors.

After obtaining the value for allowable fiber stress of 475 psi, we move to the final step in estimating the ultimate load for a 1.875 x 9.75 in. (actual dimensions) grade no. 3 solid sawn southern pine plank.

Step 3: Ultimate load. Ultimate load is the maximum load that may be applied to a beam or other component just prior to failure (ANSI/ASSP A10.8-2019). Knowing the values of allowable section modulus and fiber stress in bending, we can enter the span of the plank and estimate the weight of the ultimate load (Field & Solie, 2007). The following equation assumes that the entire load is concentrated at the center of the plank. For simplicity, we will also assume that the plank's own weight is minimal:

$$W_{center\ load} = \frac{4 \cdot F_b \cdot S}{L}$$

where:

$W_{center\ load}$ = ultimate load for a simple beam with a concentrated load at the center of the span, in pounds (lb)

F_b = allowable fiber stress in bending, in units of psi

S = section modulus, in units of in.^{3}

L = span of the beam, in units of in. For our calculations, the span is the horizontal distance between the faces of the supports, plus half of the required bearing length at each end (American Wood Council, 2018).

The data for the problem can be summarized as follows:

•In the first step of the problem, we calculated the section modulus as 5.71 in.^{3}. This is the value of S in the formula.

•In the second step, we looked up the value of the allowable fiber stress in bending as 475 psi. This is the value of F_b in the formula.

•The length of the plank was reported by investigators as 67.5 in. The report stated each end of the plank was resting on the lips of I-beams, but we do not know the amount of overlap. Let's imagine the actual span was about 65 in. This speculative span of 65 in. is the value we will use for L in the formula.

To solve for ultimate load, we begin with the equation:

$$W_{center\ load} = \frac{4 \cdot F_b \cdot S}{L}$$

Next, we insert the values for section modulus (S = 5.71 in.^{3}), allowable fiber stress in bending (F_b = 475 psi) and span (L = 65 in.). We then solve for $W_{center\ load}$ in lb:

$$W_{center\ load} = \frac{4 \cdot 475 \cdot 5.71}{65} = 166.91\ lb$$

(rounded)

The calculation indicates we may expect a grade no. 3 plank to fail if more than 166.91 lb is applied to the center of the plank's assumed 65-in. span. Again, this value does not include adjustments for conditions of use; it also assumes that the plank's own weight is minimal. Comparing the ultimate load of 166.91 lb with the weight of the average adult American male (about 198 lb, according to Fryar et al., 2018), we can see that it would not be safe to step on the plank. Moreover, the economy grade of lumber in the actual case would be even more likely to break under the weight of a worker. Compounding the issue even further is the fact that scaffold safety standards generally require a plank for a single worker to be rated for an anticipated load of no less than 250 lb (ANSI/ASSP A10.8-2019; 29 CFR Part 1926.451).

Alternate example. For additional practice, let's consider a hypothetical case in which the plank is 2 x 12 in. (actual dimensions). This time, we will imagine that the horizontal distance between the faces of the supports is 64 in. and that the plank overlaps each support by 6 in. (12 in. total for the left end plus the right end). Span is equal to the horizontal distance between the faces of the supports plus half of the required bearing length at each end (American Wood Council, 2018). This means that the span in this case is 70 in. because 64 + (12 ÷ 2) = 70. We will imagine that the plank is composed of solid sawn southern pine with a grade of "dense industrial 72 scaffold plank."

Step 1: Section modulus (S). The section modulus is based on the actual width and depth of the new scaffold grade plank:

•With the plank lying face down, its horizontal width is a full 12 in. This is the value of b in the formula.

•The vertical depth of the face-down plank is a full 2 in. This is the value of d in the formula.

As before, we calculate the section modulus of the plank with the equation:

$$S = \frac{b \cdot d^2}{6}$$

After inserting the known values for horizontal width (b = 12 in.) and vertical depth (d = 2 in.), we solve for S:

$$S = \frac{12 \cdot 2^2}{6} = 8\ in.^3$$

Our calculation indicates the plank has a section modulus of 8 in.^{3}. The section modulus is larger compared to the first example because the new plank has a greater width and depth.

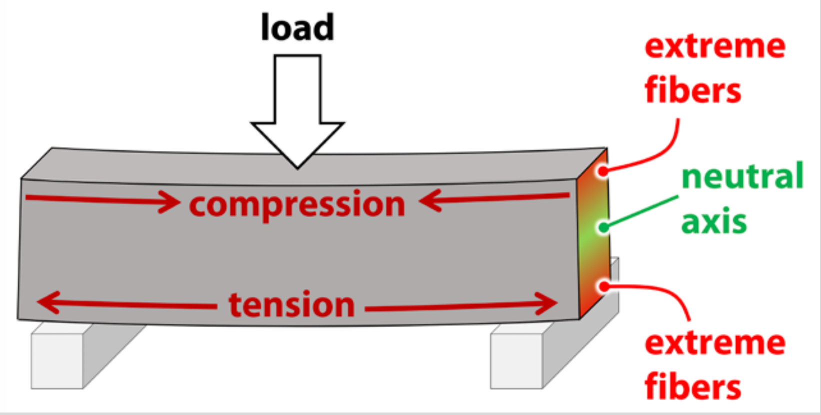
We now move to the next step.

Step 2: Fiber stress in bending (F_b). The allowable fiber stress in bending is 2,400 psi for a 2-in. thick dense industrial 72 scaffold grade plank (Southern Forests Products Association, 2018). This higher value indicates that the higher grade of lumber is much more resistant to the stresses of bending compared to the first example.

FIGURE 3

FIBER STRESS IN BENDING

Extreme fibers (those farther from the neutral axis) are subject to maximum compressive or tensile stress during bending.



Step 3: Ultimate load. We are now ready to calculate the ultimate load for the scaffold plank, based on the following data:

•In the first step of the problem, we calculated the section modulus as 8 in.³. This is the value of S in the formula.

•In the second step, we looked up the value of allowable fiber stress in bending as 2,400 psi. This is the value of F_b in the formula.

•As stated earlier, the span of the plank is 70 in. This is the value of L in the formula.

We begin with the equation:

$$W_{center\ load} = \frac{4 \cdot F_b \cdot S}{L}$$

Next, we insert the known values for allowable fiber stress in bending (F_b = 2,400 psi), section modulus (S = 8 in.³) and span (L = 70 in.). Finally, we solve for $W_{center\ load}$ in lb:

$$W_{center\ load} = \frac{4 \cdot 2{,}400 \cdot 8}{70} = 1{,}097.14\ lb$$

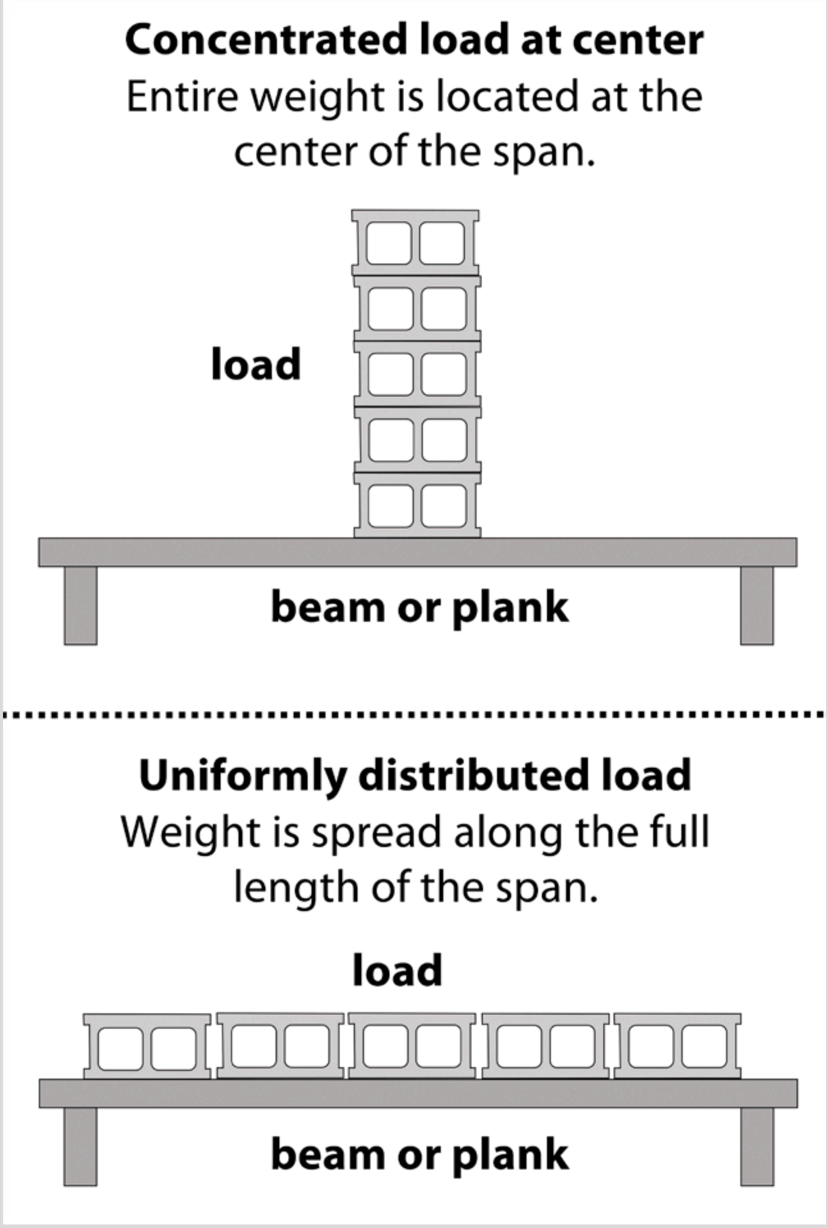
(rounded)

The calculation indicates that we may expect this plank to fail if a concentrated load exceeding 1,097.14 lb is applied to the center of plank's 70-in. span. This value assumes that the plank's own weight is insignificant. We will consider additional loading considerations for scaffold planking in the "Concluding Comments" section. For now, keep in mind that the scaffold plank must be capable of supporting at least four times its intended load, and we must also ensure that the plank has adequate stiffness so it does not deflect (bend) excessively under the load.

FIGURE 4

LOAD DISTRIBUTION

Concentrated versus uniformly distributed load.



You Do the Math

Apply your knowledge to the following questions. Answers are on p. 59.

1. Imagine a face-down plank with an actual horizontal width of 8 in., a vertical depth of 2 in. and a span of 54 in. Also, imagine that the plank is solid sawn southern pine with a grade of "dense industrial 65 scaffold plank" and a fiber stress in bending of 2,200 psi. (You can confirm the value of fiber stress in bending by referring to Southern Forests Products Association, 2018.) Calculate the section modulus and ultimate center load as follows:

a. What is the section modulus for the plank, based on the actual dimensions of the plank as given above? Use the equation for the section modulus and solve for the value of S in units of in.³.

b. Keeping in mind that the allowable fiber stress in bending is 2,200 psi and the span is 54 in., calculate the ultimate center load ($W_{center\ load}$) in lb.

2. Imagine a board is placed face down to be used as a shelf. The shelf has an actual horizontal width of 5.25 in., a vertical depth of 1.5 in. and a span of 76 in. Also, imagine that the shelf is solid sawn grade no. 2 southern pine with a fiber stress in bending of 1,000 psi. Calculate the section modulus and ultimate center load as follows:

a. What is the section modulus for the shelf? Refer to the dimensions above, use the equation for section modulus and solve for the value of S in units of in.³.

b. Keeping in mind that the allowable fiber stress in bending is 1,000 psi and the span is 76 in., calculate the ultimate center load ($W_{center\ load}$) in lb.

Maximum Intended Loads for Uniformly Loaded Planks or Beams

The previous calculations assumed that the entire load was concentrated at the center of the plank. Sometimes, we expect the load to be spread uniformly all along the beam's span. Figure 4 (p. 51) illustrates how uniformly distributed loads differ from concentrated center loads. With this distinction in mind, we will change our assumptions and calculate the ultimate uniformly distributed load for solid sawn wood beams and planks. The first two steps of the process remain the same (calculating section modulus and looking up maximum fiber stress in bending); however, we will use a new formula for estimating ultimate load in step three.

Calculated example. Imagine a plank that is 2 x 9 in. (actual dimensions) with a span of 60 in. The new plank is composed of solid sawn southern pine with a grade of "dense industrial 72 scaffold plank." The first step is to calculate the section modulus using the same formula as before.

Step 1: Section modulus (S). We calculate the section modulus based on the actual width and depth of the plank:

•With the plank lying face down, its horizontal width is a full 9 in. This is the value of b in the formula.

•The vertical depth of the face-down plank is a full 2 in. This is the value of d in the formula.

Again, the equation is:

$$S = \frac{b \cdot d^2}{6}$$

After inserting the known values for the horizontal width (b = 9 in.) and vertical depth (d = 2 in.), the formula becomes:

$$S = \frac{9 \cdot 2^2}{6} = 6\ in.^3$$

Our calculation indicates that the plank has a section modulus of 6 in.^{3}. We now move to the next step.

Step 2: Fiber stress in bending (F_b). The fiber stress in bending is 2,400 psi for a 2-in. thick dense industrial 72 scaffold grade plank (Southern Forests Products Association, 2018). As before, we will simplify by ignoring any adjustment factors and we will assume that the plank's own weight is insignificant. We are now ready to estimate the ultimate load.

Step 3: Ultimate load. This time, we will base our calculation on the assumption that the weight is spread evenly along the entire 60-in. span of the plank. We use a different formula to account for the uniformly distributed load. As before, we will assume that the plank's own weight is insignificant.

$$w_{uniform\ load} = \frac{8 \cdot F_b \cdot S}{L} \div \frac{L}{12}$$

where:

$w_{uniform\ load}$ = ultimate load for a simple beam with the load distributed uniformly along on the beam's span. Important: the lowercase "w" indicates the result is stated in units of pounds per linear foot (lb/linear ft).

F_b = allowable fiber stress in the beam in units of psi

S = section modulus in units of in.^{3}

L = span of beam in units of in.

12 = conversion from in. to ft

The data are as follows:

•In the first step, we calculated the section modulus as 6 in.^{3}. This is the value of S in the formula.

•In the second step of the problem, we looked up the value of the fiber stress in bending as 2,400 psi. This is the value of F_b in the formula.

•The span of the plank is 60 in. This is the value of L in the formula.

To solve for ultimate load, we begin with the equation:

$$w_{uniform\ load} = \frac{8 \cdot F_b \cdot S}{L} \div \frac{L}{12}$$

Next, we insert the known values for fiber stress in bending (F_b = 2,400 psi), section modulus (S = 6 in.^{3}) and span (L = 60 in.). Finally, we solve for $w_{uniform\ load}$ in lb/linear ft:

$$w_{uniform\ load} = \frac{8 \cdot 2{,}400 \cdot 6}{60} \div \frac{60}{12} = 384\ lb/linear\ ft$$

The calculation indicates we may expect the dense industrial 72 scaffold grade plank to fail if a uniformly distributed load exceeding 384 lb/linear ft is applied all along plank's 60-in. span. This value does not include adjustments for conditions of use.

Alternate example. This time, imagine a board placed *on edge* for use as a joist to support a uniform load. On edge, the joist has a horizontal width of 1.5 in., a vertical depth of 11.25 in. and a span of 96 in. (actual dimensions). The joist is composed of grade no. 1 solid sawn southern pine. First, we calculate the section modulus.

Step 1: Section modulus (S). As noted, the horizontal width (b) and vertical depth (d) are b = 1.5 in. and d = 11.25 in.

The equation for section modulus is:

$$S = \frac{b \cdot d^2}{6}$$

Inserting these values of b and d in the equation, we find the section modulus is about 31.64 in.^{3} for the joist placed on edge:

$$S = \frac{1.5 \cdot 11.25^2}{6} = 31.64\ in.^3$$

(rounded)

We now move to the next step.

Step 2: Fiber stress in bending (F_b). The allowable fiber stress in bending is 1,000 psi for a 1.5 x 11.25-in. grade no. 1 southern pine board (Southern Forests Products Association, 2018). We will continue to ignore any adjustment factors and assume that the board's own weight is insignificant.

Step 3: Ultimate load. The data for the joist can be summarized as follows:

•The allowable fiber stress in bending is 1,000 psi. This is the value of F_b.

•The section modulus is about 31.64 in.^{3}. This is the value of S.

•The span of the joist is 96 in. This is the value of L.

To solve for ultimate load, we begin with the equation:

$$w_{uniform\ load} = \frac{8 \cdot F_b \cdot S}{L} \div \frac{L}{12}$$

Next, we insert the known values for allowable fiber stress in bending (F_b = 1,000 psi), section modulus (S = 31.64 in.^{3}) and span (L = 96 in.). Then we solve for $w_{uniform\ load}$ as lb/linear ft:

$$w_{uniform\ load} = \frac{8 \cdot 1{,}000 \cdot 31.64}{96} \div \frac{96}{12} = 329.58\ lb/linear\ ft$$

(rounded)

The calculation indicates that we may expect the grade no. 1 solid sawn southern pine joist to fail if a uniformly distributed load exceeding about 329.58 lb/linear ft is applied along the joist's 96-in. span. As before, this value does not include adjustments for conditions of use.

You Do the Math

Apply your knowledge to the following questions. Answers are on p. 59.

3. Imagine a plank laid *face down* with an actual horizontal width of 10 in., a vertical depth of 2 in. and a span of 48 in. Also, imagine that the plank is solid sawn southern pine with a grade of "dense industrial 65 scaffold plank" and an allowable fiber stress in bending of 2,200 psi. Calcu-

late the section modulus and ultimate uniform loading as follows:

a. What is the section modulus for the plank based on the actual dimensions given above? Use the equation for the section modulus and solve for the value of S in units of in.^{3}.

b. Keeping in mind that the allowable fiber stress in bending for this plank is 2,200 psi and the span is 48 in., calculate the ultimate uniform load ($w_{uniform\ load}$) in lb/linear ft.

4. Imagine a board placed *on edge* for use as a joist to support a uniform load. On edge, the board has a horizontal width of 1.5 in., a vertical depth of 7.25 in. and a span of 72 in. (actual dimensions). Also, imagine that the joist is solid sawn grade no. 2 southern pine with a fiber stress in bending of 925 psi. Calculate the section modulus and ultimate uniform loading as follows:

a. What is the section modulus for the joist based on the actual dimensions above? Use the equation for the section modulus and solve for the value of S in units of in.^{3}.

b. Keeping in mind that the allowable fiber stress in bending is 925 psi and the span is 72 in., calculate the ultimate uniform load ($w_{uniform\ load}$) in lb/linear ft.

Concluding Comments

A basic understanding of beam and plank loading concepts is helpful when discussing design issues with engineers and competent persons during construction projects. The calculations discussed here are relevant for simple beams with solid rectangular cross sections, with a uniform load or a concentrated load at center. The calculations have assumed that the beam's own weight is negligible, no adjustment-for-use factors are necessary and the beam has adequate stiffness to prevent excess deflection in the direction of the load.

In practice, calculations may require numerous modifications. For example, it may be necessary to include the beam's own weight as a uniformly distributed load. Furthermore, a variety of adjustment factors may be necessary to account for conditions of use. For instance, the American Wood Council (2018) requires the use of adjustment factors for conditions such as extreme temperatures, moisture content, use of repetitive structural members and beams that are incised, oversized and other variables.

It is also important to note that scaffold planks and supporting members of scaffolds must be capable of supporting four times the maximum intended load (ANSI/ASSP A10.8-2019; 29 CFR Part 1926.451). This requirement has given rise to a "scaffold-use factor" that is applied to the allowable fiber stress in bending. For example, with solid-sawn lumber, the scaffold-use factor requires the manufacturer's value of F_b to be multiplied by 0.8 (Gromala, 1993).

Finally, a separate calculation may be needed to ensure that the stiffness of the beam's material is adequate to prevent excessive bending or deflection in the direction of the load. As an example, scaffold planks must be designed to limit downward deflection to no more than 1/60th the span of the plank. This means a plank with a span of 120 in. must not deflect more than 2 in. because 120 ÷ 60 = 2. Maximum deflection of a plank is based on the weight and distribution of the load, the beam's dimensions and the modulus of elasticity (E), which is a property that reflects the stiffness of the material comprising the beam. Values for the modulus of elasticity are routinely reported in the same tables that list the allowable fiber stress in bending.

How Much Have I Learned?

Try these problems on your own. Answers are on p. 59.

5. Imagine a board placed *on edge* for use as a beam to support a *concentrated center load*. On edge, the beam has a horizontal width of 1.5 in., a vertical depth of 5.25 in. and a span of 50 in. (actual dimensions). Also, imagine that the beam is solid sawn grade no. 1 southern pine with a fiber stress in bending of 1,350 psi. Calculate the section modulus and ultimate concentrated center load as follows:

a. What is the section modulus for the beam based on the actual dimensions given above? Use the equation for section modulus and solve for the value of S in units of in.^{3}.

b. Keeping in mind that the allowable fiber stress in bending is 1,350 psi and the span is 50 in., calculate the ultimate concentrated center load ($W_{center\ load}$) in lb.

6. Imagine that a board is laid *face down* to be used as a shelf. The shelf has an actual horizontal width of 7.25 in., a vertical depth of 1.5 in. and a span of 84 in. Also, imagine that the shelf is grade no. 3 solid sawn southern pine with a fiber stress in bending of 525 psi. Calculate the section modulus and ultimate *uniformly distributed load* as follows:

a. What is the section modulus based on the dimensions as given above? Use the equation for the section modulus and solve for the value of S in units of in.^{3}.

b. Keeping in mind that the allowable fiber stress in bending is 525 psi and the span is 84 in., calculate the ultimate uniformly distributed load ($w_{uniform\ load}$) in lb/linear ft. **PSJ**

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Mitch Ricketts, Ph.D., CSP, is an associate professor of safety management at Northeastern State University (NSU) in Tahlequah, OK. He has worked in OSH since 1992, with experience in diverse settings such as agriculture, manufacturing, chemical/biological laboratories and school safety. Ricketts holds a Ph.D. in Cognitive and Human Factors Psychology from Kansas State University, an M.S. in Occupational Safety Management from University of Central Missouri, and a B.S. in Education from Pittsburg State University. He is a professional member and officer of ASSP's Tulsa Chapter, and faculty advisor for the Society's NSU Broken Arrow Student Section.

Online
6/4 • Workplace Violence Prevention: A Case Study and Dissertation Research in Action. This presentation reviews the results of a study on whether workplace violence prevention programs significantly impact the number of assaults to registered nurses, and discusses recommendations for safety professionals when working in healthcare and social assistance sectors. ASSP Healthcare and Public Sector practice specialties; https://bit.ly/32M9wO2.

Online
6/7-6/8 • Essential Risk Assessment Tools. ASSP; (847) 699-2929; www.assp.org.

Online
6/7-6/8 • System Safety for Everyone. ASSP; (847) 699-2929; www.assp.org.

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Online
6/10 • Bow-Tie Analysis. ASSP; (847) 699-2929; www.assp.org.

Online
6/10 • Machine Safety Risk Assessment. ASSP; (847) 699-2929; www.assp.org.

Online
6/11 • Manage Risk, Not Safety. ASSP; (847) 699-2929; www.assp.org.

Online
6/13-7/11 • Enterprise Risk Management for Safety Professionals. ASSP; (847) 699-2929; www.assp.org.

Online
6/14 • ANSI/ASSP Z16: Metrics and Measurements for the Modern Safety Professional. ASSP; (847) 699-2929; www.assp.org.

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6/14 • Business Strategies for the Safety Professional. ASSP; (847) 699-2929; www.assp.org.

Online
6/15 • Selling Safety to the Front Line. ASSP; (847) 699-2929; www.assp.org.

Online
6/16 • Becoming a Competent Trainer: Increasing Skills and Boosting Relevance. ASSP; (847) 699-2929; www.assp.org.

Online
6/16-6/25 • Math Review, CSP and ASP Exam Preparation. ASSP; (847) 699-2929; www.assp.org.

Online
6/17-6/18 • Employment Law for Safety Professionals 2.0. ASSP; (847) 699-2929; www.assp.org.

Online
6/25 • Emergency Management in Healthcare: Understanding the Framework and the Safety Officer Role. Addressing safety in a healthcare environment sometimes requires a complete emergency management construct for a comprehensive response to major incidents and natural disasters. Todd De Voe provides insight to help attendees understand this framework and the safety officer role within it. ASSP Healthcare Practice Specialty; https://bit.ly/3dQyYYY.

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Online
7/6- 8/6 • Safety Management I. ASSP; (847) 699-2929; www.assp.org.

Online
7/16 • Workplace Violence Prevention in Healthcare: Best Practices and Unified Standards for Hardwired Culture Change. Identifying and sharing best practices is critical to addressing workplace violence in healthcare. Hardwiring these best practices is key to long-term, consistent, reliable prevention. Linda Enos discusses best practices and the importance of standardization through credible organizations. ASSP Healthcare Practice Specialty; https://bit.ly/32Q2fwM.

Online
7/27-7/30 • Math Review, CSP and ASP Exam Preparation. ASSP; (847) 699-2929; www.assp.org.

Online
7/29 • Risk Assessment. ASSP; (847) 699-2929; www.assp.org.

Math Toolbox, continued from pp. 48-53

Answers: The Case of the Shattered Plank

You Do the Math

Your answers may vary slightly due to rounding.

1.a. $S = \frac{8 \cdot 2^2}{6} = 5.33\ in.^3$ (rounded)

1.b. $W_{center\ load} = \frac{4 \cdot 2{,}200 \cdot 5.33}{54} = 868.59\ lb$ (rounded)

2.a. $S = \frac{5.25 \cdot 1.5^2}{6} = 1.97\ in.^3$ (rounded)

2.b. $W_{center\ load} = \frac{4 \cdot 1{,}000 \cdot 1.97}{76} = 103.68\ lb$ (rounded)

3.a. $S = \frac{10 \cdot 2^2}{6} = 6.67\ in.^3$ (rounded)

3.b.
$W_{uniform\ load} = \frac{8 \cdot 2{,}200 \cdot 6.67}{48} \div \frac{48}{12} = 611.42\ lb/linear\ ft$ (rounded)

4.a. $S = \frac{1.5 \cdot 7.25^2}{6} = 13.14\ in.^3$ (rounded)

4.b.
$W_{uniform\ load} = \frac{8 \cdot 925 \cdot 13.14}{72} \div \frac{72}{12} = 225.08\ lb/linear\ ft$ (rounded)

How Much Have I Learned?

5.a. $S = \frac{1.5 \cdot 5.25^2}{6} = 6.89\ in.^3$ (rounded)

5.b. $W_{center\ load} = \frac{4 \cdot 1{,}350 \cdot 6.89}{50} = 744.12\ lb$

6.a. $S = \frac{7.25 \cdot 1.5^2}{6} = 2.72\ in.^3$ (rounded)

6.b.
$W_{uniform\ load} = \frac{8 \cdot 525 \cdot 2.72}{84} \div \frac{84}{12} = 19.43\ lb/linear\ ft$ (rounded)