So this is the model I'm going to use for a simply supported beam. So Owl built a truss bridge that was spanned between the 2 trees, which was 9 meters. So we're going to look at if we had used a beam instead of a truss, how would we design it. So this is the model I'm going to use.

Looking at this, we could solve for these reactions. That's my first step. I'm going to solve for the reactions. I could use rotational and vertical and horizontal equilibrium.

But looking at the load, I have a total load acting downward in the middle and everything is symmetric. The total downward load is going to be 5 kilonewtons per meter times that 9 meters, or 45 kilonewtons.

Because everything is symmetric and it's evenly distributed it really just gets half of it to each side. So I'll have 22.5 and 22.5. And there's nothing acting horizontally so my horizontal reaction will be 0. And that'll tell me my reactions.

So that's my starting point but I need to know internally what's happening. And we're going to draw diagrams here eventually. But let's look at one point in here.

So I'm going to make a free body diagram. I'm going to cut this beam. Let's cut it at 2 meters over. And I can draw a diagram to represent that. So we can do the equilibrium.

This is 2 meters long. I still have the applied load on it. Just 5 kilonewtons per meter. And I have my reaction force. It's 22.5 kilonewtons. And what I'm looking for is when I made this cut, I exposed the beam inside the beam. I need to calculate the shear force, V, and the bending moment, M.

Now I'm back to just doing equilibrium on this little piece. So let's do the shear force first. Summing forces in the y direction. So I have upward 22.5 kilonewtons. I have acting downward a total of 10 kilonewtons since it's 5 kilonewtons per meter, but I'm acting over 2 meters. So that will be a downward 10 kilonewtons. And a downward V. And that all equals 0. So I can solve for that V, which is shear force. And that should be 12.5 kilonewtons.

So I know what the shear force across this face is. And that's what I would use to design at that location. But I'd also want to calculate this bending moment. Bending moment tends to be more critical in beams.

So let's go and look at the moments. Sum the moment. Let's sum the moment about this cut again. So that is at my 2 meters. So I'm looking at this point. This is my point of rotation over here.

So I'll have positive 22.5 kilonewtons. That's at a distance of 2 meters from my point. I could use this distributed load, but I can also just use the resultant load when I do the moments. So I have 10 total kilonewtons pushing me the opposite direction. So that is 10 kilonewtons. And it's acting at a distance of 1 meter.

And I always have the moment still acting in there. Minus M all equals 0. I should be able to solve for this M. That's the other side. And I get the moment is 35 kilonewton meters. So that is what I get for M.

That's at one point. So if for some reason I was designing right at that point, these would be the values I would use. But for this beam, I want to find the maximum values, the maximum of shear and moment. So I'm going to go and draw the diagrams, which is something you can get from the beam simulator.

Let's look at what's happening along the whole length. So this will be my shear diagram. It will represent the shear at any location along the length. We know we have at the support 22.5 kilonewtons. That's half of the load. So we get to the middle of this beam, we'll have another half of the load acting downward. We're going to cross the 0 point right at the middle.

And my shear-- I'll try to make a straight line-- so that's what my shear is going to look like. It'll come down to 22.5 here. My reaction support will bring it back up to 0. So this tells me the shear along the length. So if I'm worried about shear in my beam, which I would be for a very short, wide beam, I'd be worried about the supports as the failure points in shear. And this would be my maximum value for that shear value.

Now let's look also at the moment. For this beam, I expect the moment to be more critical, if I were to look at both. Let's look at the moment along the length. Moment again always starts at 0. It turns out that the slope of the moment diagram equals the shear value. And the area under here equals the moment value. Again, you don't have to know how to do that, but that's what's going to help me draw this diagram.

The diagram's going to start at 0. I have a certain slope. It's going come up to a maximum in the middle and then go back down to 0. It should be symmetric. It'll be even on both sides. But that tells me what's happening to the moment over the whole length. The maximum is right here at the middle is 50.6 kilonewton meters.

When we're designing beams, we look at many things. We look at the supports. We look at the moment. We look at the shear. And we often look at the deflection as well.

I'm just going to look at the moment today, which tends to be the most critical for most long slender beams. So we know the maximum moment in the beam. And we need to design the size for that maximum moment.

When we design trusses and columns, we looked at stresses. So we're going to do a similar thing here. We're going to look at the stress in this beam. We're going to look at bending stress. So axial stress, which is tension or compression-- you just took the force and divided by area. When we have bending, we use something called the flexure formula. We take the moment, we multiply by c divide by I. We'll talk about these values.

But the moment is just this maximum moment value that I'll put in. c is half the height of the cross section, since bending happens about the center of the cross section. And moment of inertia is a quantity. We can look up the formula for it, but it is the resistance to bending.

So that's my flexure formula. That will tell me the stress in this beam-- at least the maximum stress. And I want to keep that less than my allowable.

We're going to assume that Owl's going to use wood again. And the allowable stress for the wood he's using is 30,000 kilonewtons per meter squared. So this gives me a starting point. My goal is to design the cross section of the beam. So I need to make some assumptions. Or I need to start playing with variables.

We've already assumed it's wood. I'm going to also assume that we're going to use a rectangular cross section. I'm going to assume actually that this width, as well, is 200 millimeters, to give me a starting point. So that's the width of my wood. And then I'm going to determine what height I need. So that's my goal. It's to figure out that height.

Looking at this equation, if I want to calculate the c value, c always goes from the middle to the outside edge. So it'll just be h over 2. Moment of inertia, I can look up the value for a rectangular cross section.

It is base times height cubed over 12.

Again resistance to bending, but we can calculate it using that equation. So these values will get plugged into this equation. And that'll leave me with just one variable each. So I'll have 50.6 kilonewton meters times h over 2 over b h cubed. B is-- I'm going to change to meters-- 0.2 meters times h cubed over 12. And that has to be less than 30,000 kilonewtons per meter squared.

The only unknown is h. So this will allow me to calculate the required height to make this being work for this loading. And if we calculate it, we find that h is 225 millimeters. So if OWL wants to use a beam instead of a truss, she needs a cross section that is 200 millimeters wide by 225 millimeters high, if She wants to use a rectangular cross section. We could also look at hollow sections eventually or I-beams. And that's something an engineer would play with-- different dimensions, different shapes. But this is how you design a beam.