Follow the steps outlined below to design, construct, predict performance, and test a balsa or basswood bridge.

1. **Design the bridge.** Your bridge will be tested on a universal testing machine using the loading apparatus shown in Figure 1. The span of your bridge may deviate several inches (+/- 4 inches) from the span shown. The 200 lb load shown is a typical design load for this project—you may use a different design load if you wish. Your design process should consider several different bridge configurations and should include detailed design (e.g. member sizes) of at least two bridge configurations using RISA3D (see the [RISA guide](#) on the class web site). Box-beam bridges are best designed using a spreadsheet and the strength of materials equations for bending and shear stresses. Use assumed material properties for your wood (for example from the internet). Compare your bridge designs for predicted failure load, weight, and constructability and select the best design to construct.

Deliverables should include sketches of considered designs, screen shots of RISA designs, justification of selected design, and sketches showing member sizes and lengths for construction.

2. **Construct the bridge** specified in Step 2. **Do not construct your bridge on tables in classrooms, computer labs, or the study room.** There are no limitations on size of members, lamination, or type of glue. Joint reinforcement using gusset plates, pins or any other method is encouraged so that the bridge members will fail in the members (as predicted by your RISA analysis), rather than in the joints. See the construction tips on Page 3.

Your deliverables are photos of the construction process (the more the better) and your bridge.

3. **Measure the material properties** of critical members from your bridge (see Page 4). Analyze the data to determine the modulus of elasticity (E) and the flexure strength (Fb).

Update the material properties in your RISA model and revise your predicted failure load and bridge weight.

Your deliverables will be photos of the testing, raw data, easy-to-follow analysis, and results (design values for flexure strength Fb, modulus of elasticity E, and unit weight u.w.)

4. **Test your bridge** with the help of the instructor or TA.

Deliverables include the bridge weight and failure load and photos of the testing process. Try to photograph the failed member responsible for bridge collapse and describe the failure mode.

5. **Create a presentation** documenting your bridge project (Steps 1 through 4 above) as described in the class project assignment. Your presentation should serve as a project report, with detailed information at the end of the presentation in an appendix.
The load will be applied to the horizontal members closest to the elevation of the supports. For examples, the bottom chord of a through truss, or the top chord of a deck truss.

Clearance must be provided for a cylindrical loading rod extending from the loading surface at midspan up to the testing machine load head.

**Figure 1. Loading geometry**
Tips for Bridge Construction
The following tips are based on experience observing student-built basswood structures.

Keep in mind as you design that connections are typically the weakest part of your basswood bridge. Strong connections have a lot of surface area for the glued connection. For example, the connection on the left below can use only one gusset plate because the widths of the two members are different; whereas the connection on the right can use two gusset plates because the bottom member is rotated flat-wise. If the bottom member needs to resist bending moment, however, then rotating it flat-wise will dramatically lower it’s bending strength. In some cases, it may be better to make both members the same size.

![Figure 2. Using gusset plates](image)

Another construction recommendation is to arrange members to transfer load via direct bearing (below, right) rather than shear in a glued joint (below, left).

![Figure 3. Transfer load via direct bearing when possible](image)

- Maximize the glued surface area:
  - If the cut end of a member is to be glued, make it as flat as possible by sawing carefully. Some students rub the end of the member on a piece of sandpaper laid on a table.
  - Use gusset plates at connections (see Figure 2) to increase the glued surface area.
- Align connections carefully so that your structure is straight when finished. Some students build a jig to help align connections.
- If building two parallel structures (e.g. two trusses), make the two structures as similar as possible by either using the same jig for both, or by constructing the second structure using the first completed structure as a model. Misaligned structures may cause your bridge to twist when loaded, causing uneven load distribution and premature failure.
- Use diagonal-bracing in every “surface” of your bridge: top, bottom and both ends. Some uneven load distribution is inevitable as loading progresses, and the bracing will prevent your bridge from deforming, which leads to even more uneven load distribution.

**Material Testing**

1. Measure $b$ and $h$ three times with calipers and take average. Measure span.
2. Apply load and measure load and deflection 10 times.
3. Increase load until beam fails. Record failure load.

4. Plot deflection vs. load in Excel (as points, not line) and fit a line to the points.

5. Use equation for deflection of a simply-supported beam due a point load at midspan to calculate the modulus of elasticity, $E$.

6. Use the equation for bending moment due to a point load on a simply-supported beam; and the equation for normal stress due to bending moment to calculate the bending stress at failure, $F_b$.

**Figure 4.** Procedure for measuring $E$ and $F_b$ of a balsa wood piece.