

Balsa Bridge Competition Rules

Sponsored by: The University of Tennessee, Department of Civil and Environmental Engineering and the University of Tennessee American Society of Civil Engineers Student Chapter

Overall Description

The objective of this competition is to design and construct **one or more bridges** to be tested against several performance standards including a Maximum Load (ML) test, Structural Efficiency (SE) test, and a Construction & Traffic (C&T) test. Each school will only be allowed to use **one bridge per test category**. SE and ML tests will be administered in the same testing apparatus and therefore a team's bridge can compete in each of these tests. Teams interested in competing in the C&T test will need to bring at least one other bridge as the testing scenario requires meeting different geometric criteria.

Construction and Traffic (C&T) Test

Objective

The objective of this event is to design and construct a bridge capable of efficiently supporting RC car traffic over a “river.” This test challenges the team to both construct their prefabricated bridge and test for traffic congestion.

Materials

The bridge can be constructed only of **BALSA WOOD, TWINE, AND ELMERS WOOD GLUE**. No other materials will be accepted. The balsa wood must be no larger than 1/4" (6.35 mm) high and 1/4" (6.35 mm) wide. Any dowels **cannot have a diameter greater than 1/4" (6.35 mm)**. Balsa wood comes in various sizes and shapes, such as miniature I-beams, channels, and angles. Twine must be made from natural fiber materials (Jute, Cotton, Hemp, etc.) and **cannot have a diameter greater than 1/8" (1.59 mm)**.

Testing

The C&T Test will require teams to install their prefabricated bridge and perform a traffic test for the bridge. Teams will fabricate their bridges before arriving to our testing site. Stage One of the testing process will require the team to install their bridge at our site's testing scenario. Teams will be timed during this process and need to have the bridge fully installed in less than 5 minutes. Once installed, the judges will do a brief inspection to confirm the bridge is safe for vehicle traffic. In Stage Two, teams are required to send 10 vehicles safely over the bridge, from one side's designated initial parking area to the opposite side's final parking area. Timing for the traffic will be recorded. Totals for both the construction and traffic times will be summed to define the team's performance score; the team with the lowest overall time will be the winner.

Design & Pre-Fabrication Criteria:

Material Specifications

- All bridges must be prefabricated and brought to the event.
- The bridge may not be coated with any material (there is an exception for paint used to mark lanes as described in the “Traffic Requirements” section).
- The bridge must be long enough to exceed the 30" (762mm) wide river and provide a 1" (25.4mm) bearing on the abutments at each riverbank. **THE BRIDGE MUST EXCEED 32" OR IT WILL NOT SPAN THE GAP.** The bridge bearing length **may NOT exceed a length of 34" (863.6mm)**.

Traffic Requirements

- Bridges must be designed to allow for a minimum of one-way traffic so an RC car can be driven onto the bridge and exit the bridge. The RC car will need to be physically in contact with the bridge from the starting abutment to the exiting abutment.
- The bridge must have a width capable of accommodating RC cars that are 3.8" wide, a 3" shoulder to the right of any traffic lanes, and a 2" pedestrian sidewalk to the right of any shoulder.
 - The minimum cross-sectional width must exist throughout the entire length of the bridge.
 - Each traffic lane may not exceed 6".
 - The bridge may not exceed a total width of 60" (1524mm).
- For each additional traffic lane going from the starting side of the bridge to the end of the bridge (not including the original lane) you must add a traffic lane with the same width specifications facing the other direction (Ex. If your bridge has 3 lanes going from the starting side to the ending side. You must have 2 lanes going from the ending side to the starting side.). Bridges with two directional traffic will require a shoulder and a sidewalk on each side of the bridge.
- Lanes and their direction must be clearly marked with paint. All direction markers must be within 20%-80% of the lane width and must be marked at least once in all traffic lanes.
- **Structural Deck** The road surface is defined as the surface that will allow an RC car to pass the length of the bridge. However, the road surface does not need to be solid.
 - Bridges will undergo a compliance check before the transportation test. A judge will drive an RC car from one abutment to the other. To pass, the RC car must be physically touching the bridge for the entire drive test.

River Conditions

- The testing scenario involves placing your bridge on two riverbanks in order to span a river. The river will be built from materials similar to a horse/stock tank and the riverbanks will be wooden boxes placed on each side of the water tank. The boxes will be similar to planter boxes, and a wooden lip will extend over the rim of the tank to provide a bearing surface for your bridge. The tank and wooden boxes will be provided by the competition hosts and do not require any construction efforts from the competing team.

- On either side of the river, the bridge will sit on a riverbank made up of clay with veins of sand and pebble aggregate running through it at various points.
- The riverbank will have 12" (304.8mm) width of space extending perpendicularly away from each side of the river and will run along the entire length of the "river."

Foundation & Anchoring

- Bridges will need to rest on each riverbank on a 1" wooden abutment located in between the river and "riverbank."
- Spiral anchors and stakes will be provided for teams to anchor their bridge into the riverbank. Using the provided eye bolts, teams need to anchor their bridges using twine components built into their prefabricated structure.
 - Eye bolts provided will meet these specifications ([LINK](#)).
 - Teams are required to anchor their bridge, but there is no requirement to the load transfer between the bridge's bearing or anchoring.
 - Twine can be connected to the bolts using simple knots. The knots can be assembled using additional twine not part of the initial prefabricated structure.
 - Teams cannot use additional metal fasteners such as rings, hooks, or other connectors.
- Up to 8 spiral anchors and/or stakes may be used (4 anchors/stakes per side) and placed anywhere in the "riverbank."
- Teams may use manual tools (any tool that isn't powered) to assist in the construction of their prefabricated bridges. These tools must be provided by the team.

Construction Time Score

- Teams will be required to construct their pre-fabricated bridge. The team will be provided a staging area to place their bridge. Construction will require moving the bridge from the staging area to the river, ensuring required bearing criteria is met, and anchoring the bridge to the abutment soils.
 - Up to 2 team members may construct the bridge as a base construction team.
 - Any extra team members assisting in constructing the bridge will incur a 30 second time penalty added to the construction time.
 - Extra team members must be involved from the beginning of the build effort and cannot join mid-way through bridge construction.
- If the bridge or any of its components fall in the river during construction, the team will receive a 60 second time penalty to construction time.

Traffic Test Time Score

- After construction inspection, the traffic congestion test will begin. The team will be responsible for navigating (10) RC cars across the bridge and into a final parking area.
- Time will start when the first team member picks up a remote control and will end once the team puts down all remote controls.
- Each school will be allowed a maximum of 3 drivers to control the RC cars.
- All RC cars must be stopped in the final parking area for a team's transportation time to stop.
RC cars may not be stacked or otherwise connected to each other. Each car must independently cross the bridge.

Additional Rules & Details

- All bridges need to be submitted prior to testing. Tickle 211 will be open at 9:00 am for drop off. The bridges will be evaluated to determine if they meet the specifications.
 - Bridges will be weighed before testing and the weight of any provided anchors/stakes used will not be included.
- Testing Order will be determined by a virtual sign up that will be sent out prior to Engineers Day. **TEAMS MUST SIGN UP FOR A TIME SLOT PRIOR TO THE EVENT TO ENSURE THEY ARE ABLE TO PARTICIPATE.**
- Teams get overall results on the day of the event via the University of Tennessee Engineers Day communication system. Individual testing certificates will be sent to team advisors the following week.
- The event supervisors will provide all equipment/materials for testing.
- Viewing priority will be given to teams that are testing their own bridges, but observation by other teams will be permitted.
- The event supervisor will provide the RC cars.

Penalties

- RC cars driving in a lane designated for the opposite direction of traffic will be pulled over by the "University of Tennessee Police Department (UTPD)" and incur a 30 second time penalty while they are ticketed before continuing. If the car does not then immediately move to the correct lane it will be pulled over again and incur additional 30 second penalties until it moves back to the correct lane.
- Any car that collides with another car or the bridge infrastructure will result in a 5 second time penalty being added to the score.

- Any car that falls off the bridge or testing setup will receive a 60 second time penalty for “UTPD” to arrive and rescue the car. The car will then be removed from the scenario and the team will continue.
- After testing is begun, team members moving an RC car with their hands or externally propelling the vehicle in any other form will incur a 30 second transportation time penalty.
- Judges will place the vehicles in the designated starting parking area, but teams can stage the vehicles fully in the designated initial parking area according to their preferences. A 10 second penalty will be applied for all cars parked outside of the designated area after time starts (after a team member picks up a remote control). A bearing of at least 1” must be accomplished at both abutments; the judges will measure the bearing; if a bearing is less than 1”, the team will have the option to take a 30 second penalty to resume construction; the additional construction time will also be added to the total construction time.

Scoring:

Construction Test

The construction winner will be determined by fastest total construction time. Total construction time will be defined as the time from when the team is allowed to start construction to when their bridge is ready for testing plus any penalties incurred.

Transportation Test

The transportation winner will be determined by fastest total transportation time. Total transportation time will be defined as the time from when the team is allowed to start with all cars in the initial parking zone to when 10 RC cars are stopped in the final parking zone plus any penalties incurred.

Overall C&T

The overall C&T winner will be determined by fastest total combined construction and transportation times

RC cars will be similar to this model

https://www.amazon.com/KULARIWORLD-2-4Ghz-Rechargeable-Remote-Control/dp/B0D7ML8C2T?ref_=ast_bl_cpl_dp



Figure 1: RC Car Example

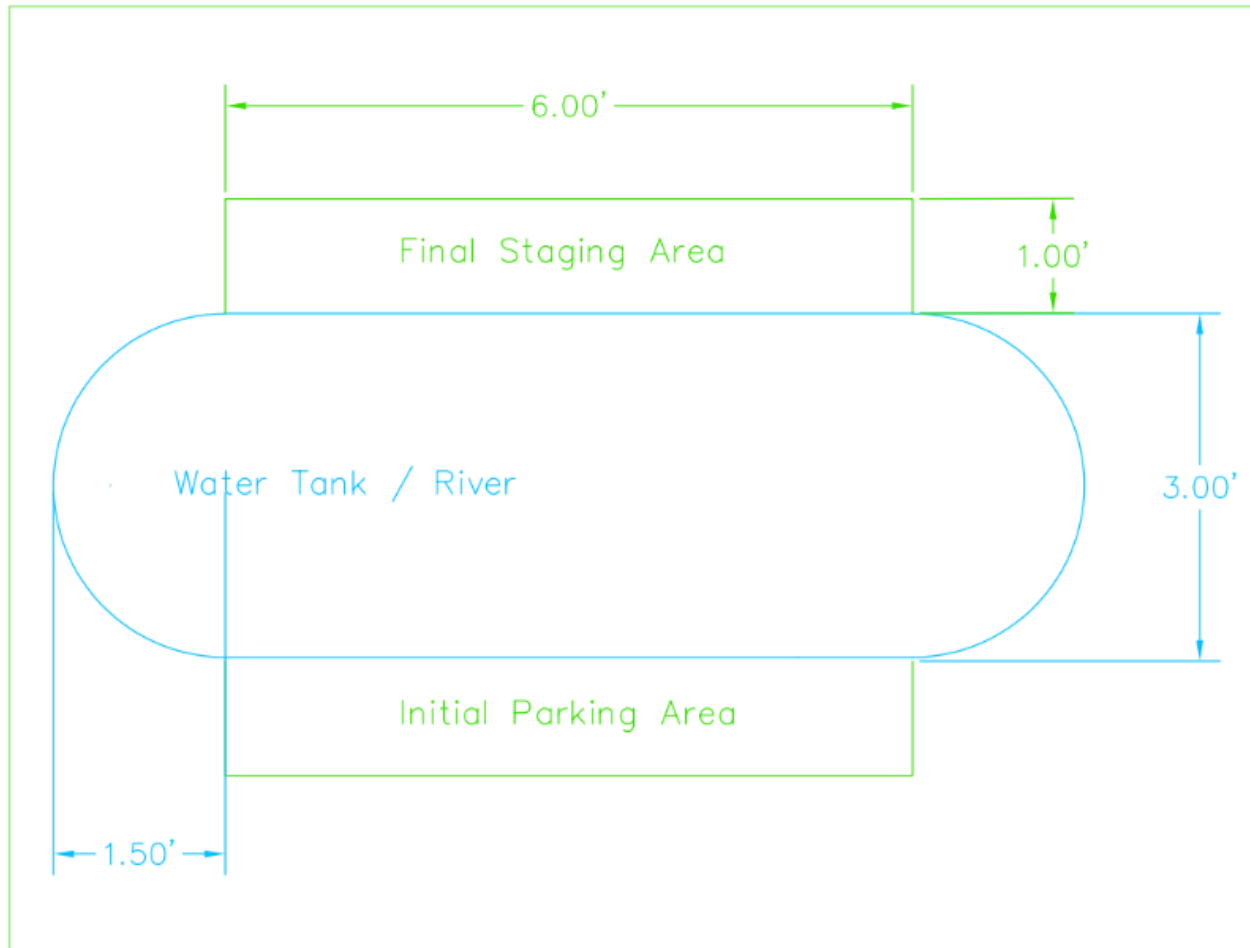


Figure 2: C&T Testing Apparatus

Strength

Objective

The objective of this event is to design and construct the lightest bridge capable of supporting a given load over a given span. The bridge must allow the passage of one Hot Wheel's Car of any variety along the entire length

Materials

The bridge can be constructed only of **BALSA WOOD, TWINE, AND ELMERS WOOD GLUE**. No other materials will be accepted. The balsa wood must be no larger than 1/4" (6.35 mm) high and 1/4" (6.35 mm) wide. Any dowels **cannot have a diameter greater than 1/4" (6.35 mm)**. Balsa wood comes in various sizes and shapes, such as miniature I-beams, channels, and angles. Twine must be made from natural fiber materials (Jute, Cotton, Hemp, etc.) and **cannot have a diameter greater than 1/8" (1.59 mm)**.

Construction:

- All construction must be completed prior to the event.
- The bridge may not be coated with any material.
- The bridge must be long enough to span the 350 mm (13.78") opening. There is no maximum length. **THE BRIDGE MUST EXCEED 350 mm OR IT WILL NOT SPAN THE GAP.**
- The bridge must have a width of at least 100 mm (3.94") throughout the entire cross section of the bridge
- The road surface is defined as the surface that will allow a Hot Wheel Car to pass the length of the bridge. However, the road surface does not need to be solid.

Loading

- The load point will be at the center of the bridge.
- The bridge must accommodate a **25 mm (.98") long X 80 mm (3.15") wide X 25 mm (.98") high loading block, which will be lowered down from above**. This means there needs to be an opening in the top of the bridge that will allow for the mechanical loading block and device to be dropped down to the loading base of the bridge. The loading base does not have to be on the road surface.

Testing

Structural Performance Tests will require teams to install their prefabricated bridge and perform a load test for the bridge. Teams will fabricate their bridges before arriving to our testing site. Before testing, the bridge will be reviewed to confirm the Hot Wheels car can

safely move across the bridge and other measurement compliance checks will be performed. The testing process will require the team to install their bridge in the testing apparatus. The bridge will be loaded until structural failure as defined by the hosting judges. Measurements will record the weight of the bridge and the maximum load held by the bridge before the determined failure moment.

Rules

- All bridges must be submitted prior to the testing. Tickle 211 will be open at 9:00 am for drop off. The bridges will be evaluated to determine if they meet the specifications.
- **Testing Order will be decided prior to Arrival/Drop-off** to facilitate faster testing. Participants will sign up for a time slot for testing. If your school has to leave prior to the awards ceremony please let us know.
- Teams get overall results on the day of the event via the University of Tennessee Engineers Day communication system. Individual testing certificates will be sent to team advisors the following week.
- The event supervisors will provide all equipment/materials for testing.
- Viewing priority will be given to teams that are testing their own bridges, but observation by other teams will be permitted.
- The bridge will be inclined by placing one end on a **50 mm (1.97")** wooden block. The Hot Wheel's car will be placed on the elevated portion of the bridge and will be allowed to roll down its entire length. If the car gets stuck, the students are allowed two restarts. If the car still does not pass after two restarts, a penalty of **2 kgs (4.41 lbs.)** will be deducted from the sustained load until the car passes through (for example, if the bridge holds **20 kgs (44.09lbs.)** and it takes the car 3 tries to get down the bridge, the bridge will be treated as if it only holds **18 kgs (39.68 lbs.).**)
- The event supervisor will provide the Hot Wheel's cars
- The bridge will be centered on the testing apparatus, containing a **350 mm (13.78") opening** between the bridge supports.
- The loading block will be lowered to the load point of the bridge
- The laboratory supervisor will gradually add force to the mechanical loading device until the bridge fails or **deflects more than 20 mm (.787")**. **Hint:** It is no advantage to build a bridge that will hold more than **70 kgs (154.3 lbs.)**.
- The bridge must support a **5 kg (11.02 lbs.) load for a minimum of 5 seconds** to qualify for scoring.
- Students will be able to see where and how quickly their bridge failed on a graph produced by the mechanical loading device.

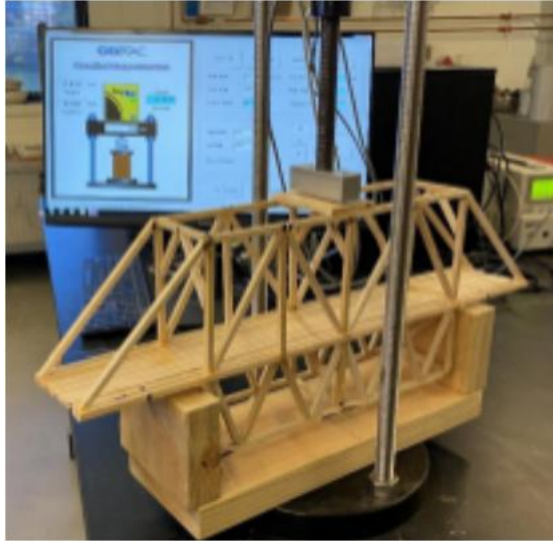


Figure 3: Loading Configuration

Scoring:

Structural Efficiency Test (Strength to Weight Ratio)

The winner will be determined by the largest load/mass ratio with **70 kgs (154.3 lbs.)** as the maximum load.

Maximum Load Test

The winner will be determined by the largest maximum load before failure or a maximum load of **2000 lbs (907.2 kgs)**. In the case of a tie, the winner will be the bridge with a lower weight.