

Vg 100 Introduction to Engineering Project 1
 UM-SJTU Joint Institute Fall 2019

Introduction

Bridges provide passage over obstacles, helping pedestrians and vehicles pass efficiently from one point to another. Bridges typically transmit the loads to piers or abutments through pin or roller connections as shown in Figure 1. The deck provides a continuous support for pedestrians and vehicles to pass, and the deck is supported by floor beams and stringers. Stringers are structural elements that take the majority of the vertically applied loadings of bridges in bending deformation modes, and the floor beams connect the stringers together and help to resist lateral loadings.

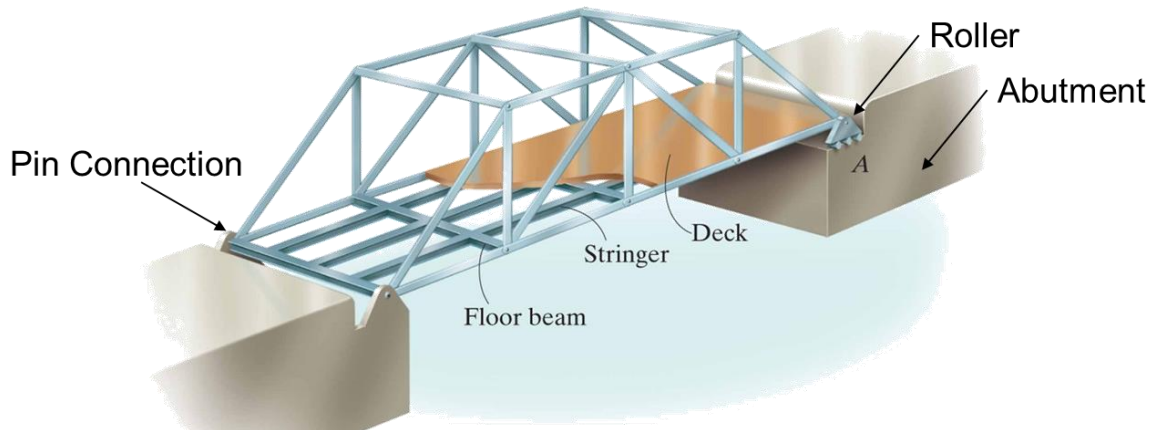


Figure 1: Bridge schematic and terminology

Deployable bridges are implemented when vehicles must temporarily pass over obstacles. Figure 2 shows a few examples of deployable bridges.

(<https://vanoengineering.wordpress.com/2012/08/31/types-of-deployable-bridges-thesis-2011-2012/>). Actuators are required to deploy the structure over the obstacle.

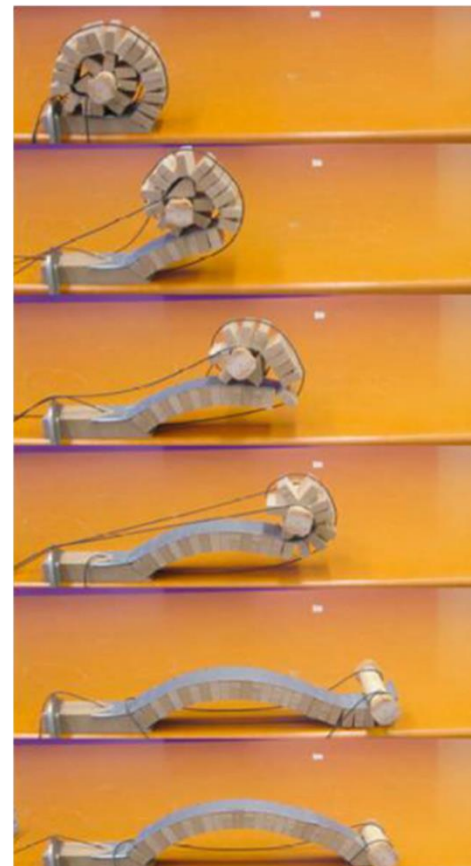
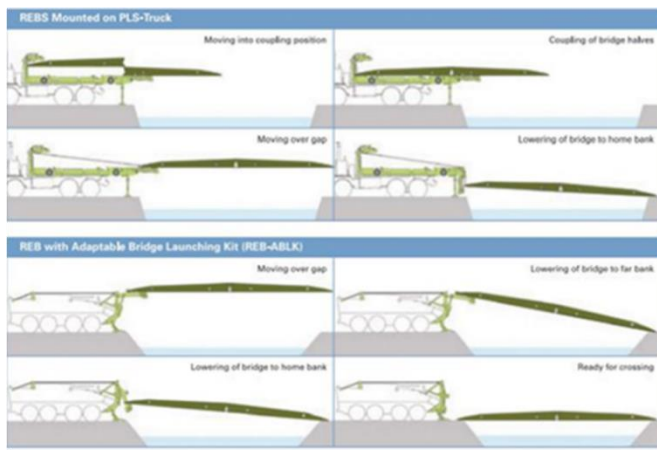
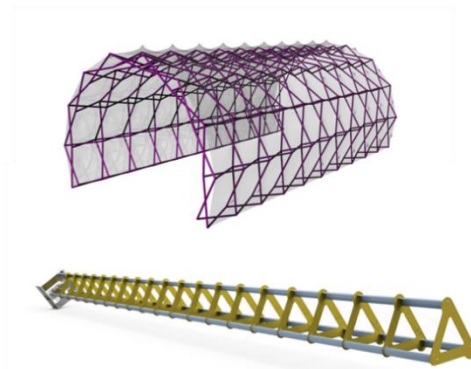


Figure 2: Examples of Deployable Bridges

Objective

The objective of Project 1 is to build a deployable bridge to allow cars to pass over the river and boats to pass under the bridge. The learning objective is to:

- apply knowledge learned from statics, mechanics, and structures to build a bridge
- apply knowledge of physics and motors to deploy/move the bridge

One way bridges transmit loads to the ground is through abutments. An abutment is a substructure at the end of the bridge span where the main structure connects or contacts with the ground. The abutments provided in this project are shown in Figure 3 and Figure 4 (one with baffle while another not). Assume that between these abutments is a river or other waterway, and the bridge will help cars to pass over while allowing tall boats to pass underneath. The abutments define the span of the bridge, and the settings are shown in Figure 5. On the other hand, a roller will also be provided in the project (Figure 6), the tip of the roller is of the same height with the abutment (minor error may exist).

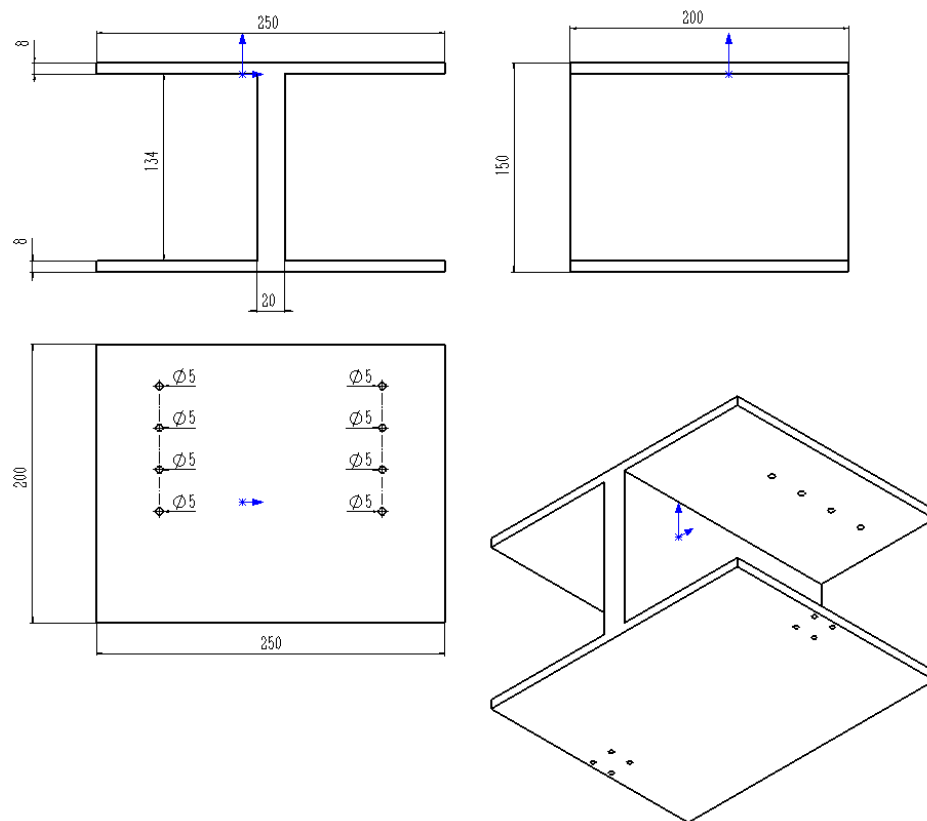


Figure 3: Bridge abutment (without baffle) (unit in mm)

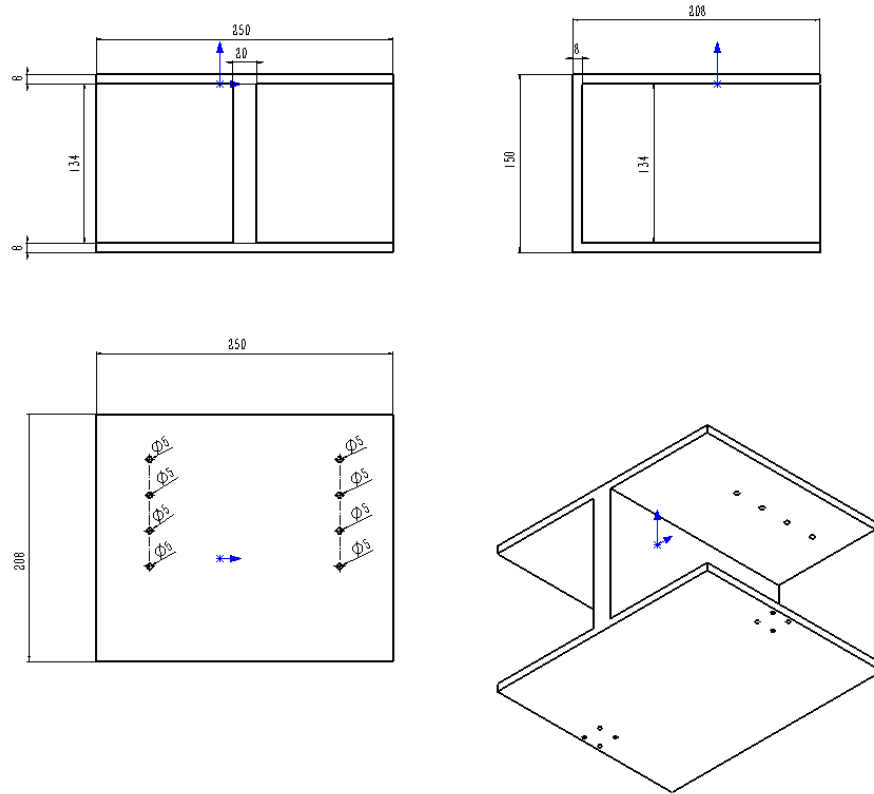


Figure 4: Bridge abutment (with baffle) (unit in mm)

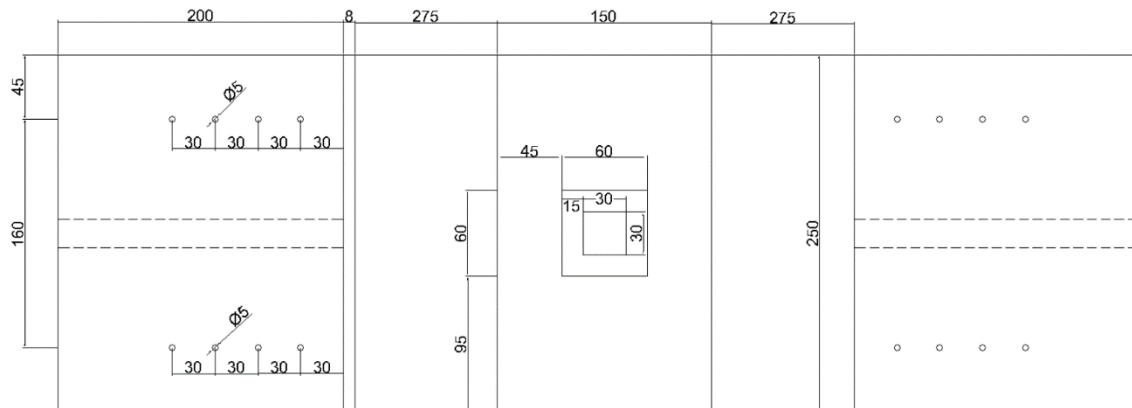


Figure 5: Abutments and Span

Bridge Tests in the Game

A. Weight Test

The mass of the bridge (battery only excluded) will be tested in Weight Test. An electronic scale will be used in the test.

B. Deployment Test

Automated deployment function of the bridge will be tested in Function Test.

C. Retraction Test

Automated retraction function of the bridge will be tested in Function Test.

D. Load Test

A small weighted plate will be placed at 0.25 and 0.75 length of the span as shown in Figure , and a dial gauge measures the vertical deflection. Maximum load that the bridge is able to hold without exceeding the maximum vertical deflection (2mm) will be recorded. (We choose the smaller load of the two position to record.)

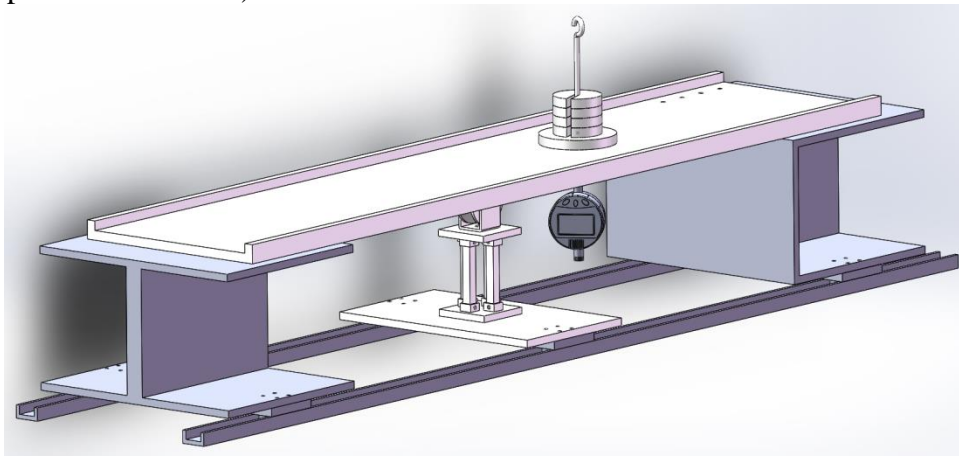


Figure 6: Deployable Bridge Vertical Loading Schematic, Perspective View

E. Size Test

The bridge should be able to fixed in a proposed volume right before and after Function Test. A cuboid box with the size 350mm * 350mm * 250 mm will be provided for the test.

Rules for the Game

Restrictions

1. The material used for the construction of structural part of the bridge must be balsa wood, wood glue (wood glue will be available in lab, if you are willing to purchase yourself, the brand must be Elmer's) for all structural components. Cables of any material are allowed, but they must be loosen in Load Test part (or we will cut them

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off). Other materials (especially metal) can only be used in the construction electrical devices, and some special structural connections between members of the structure with TA/instructor written permission.

2. The bridge should be at least 700mm long, which is defined as the distance between abutments on the two sides. The actual distance between two abutments can be adjusted to fit your bridges (if the span of your bridge is longer than 700mm).

Grading Rules

A. Size Test (50pts)

- a. The span of the bridge is in the range from 700mm to 750mm. (10pts)
 If the span exceeds 750mm or is smaller than 700mm, 5pts will be deducted for each 10mm out of the span limit.
 If the span exceeds 800mm, the group will receive 0 pts for Size Test.
- b. The width of the bridge is in the range from 160mm to 200mm, 5pts will be deducted for each 10mm out of the span limit.
- c. Any part of the bridge is able to let a car with a width of 90mm and a height of 20mm fully stand on (two front wheels or two back wheels can touch the bridge at the same time), 20pts will be deducted otherwise.
- d. The bridge can be fixed in the box right before Deployment Test (after the bridge fixed on the abutment). (20pts)
- e. The bridge can be fixed in the box right after Retraction Test. (20pts)

B. Deployment Test (60pts)

- a. The bridge can be fixed on the larger abutment (the bridge is not allowed to be fixed on the smaller abutment). (if not, the group receive 0pts for Deployment Test and Load Test)
- b. The bridge can be deployed automatically within 1 minute. (60pts)
 If deployment time exceeds 1 minute, 2 pts will be deducted for each 5 seconds out of the time limit (maximum deduction of 24pts).
- c. The bridge cannot be deployed automatically. (0pts)

C. Retraction Test (50pts)

- a. If the deployed bridge can be retracted automatically within 1 minute. (40pts)
 If retraction time exceeds 1minute, 2 pts will be deducted for each 5 seconds out of the time limit (maximum deduction of 16pts).
- b. The bridge cannot be retracted automatically. (0pts)

D. Load Test (40pts)

- a. If materials used do not follow the restriction, the final pts earned in Size and Load Tests will be halved.
- b. The bridge can hold more than 1000g load or more than 3.33 times of its own weight (e.g. 1000g load / 300g weight). (16pts)
 Rank the groups according to the ratio, groups with larger ratio rank higher.

$$\text{Ratio} = \frac{\text{Weight of Maximum Load}}{\text{Weight of the Bridge}}$$

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1. The first 1/4 groups will receive 24pts.
 2. The second 1/4 groups will receive 16pts.
 3. The third 1/4 groups will receive 8pts.
 4. The last 1/4 groups will receive 0pts.
- c. The maximum load of a bridge is 3000g (load more than 3000g will also be treated as 3000g).
 Groups whose bridge can hold 1000g load will rank better than those whose bridge cannot.
 If the ratios of two groups are the same, the group whose bridge is lighter ranks better
- E. Bonus (20pts)
- a. Aesthetics.
 - b. Uniqueness and originality. (e.g. Bridge deploys like a telescope.)
 - c. The greatest ratio of load weight/bridge weight.
 - d. Other aspects that deserve bonus (you are welcome to contact instructors and TAs).

Game Procedure

1. The whole bridge will be put on an electronic scale. (Weight Test)
2. The group will use Setup Time (3 minutes) to fix their bridge on one of the two abutments.
3. The bridge will be fix in a box (Size Test Part 1).
4. Deployment Test
5. Retraction Test
 (The program should be uploaded to the board before the game and the deployment part and retraction part should be included in a single program).
6. The bridge will be fix in a box (Size Test Part 2).
7. The group manually deploy the bridge and take Load Test.

Term Explanation

1. Setup Time and Fix Time:
 Each group will be given 3 minutes to fix their bridge on the abutment and 1 minute for reparation. If Setup part exceeds 3 minutes, fix time will be used. If not, the spare time for setup time will be wasted. When fix time is expired, the group will be forbidden from touching the bridge (except for rebooting) or receive 0pts for Deployment and Retraction Test.
2. Reboot:
 Outside Fix time, each group has 3 times to reboot their board. If times are expired, the group will be forbidden from touching the bridge or receive 0pts for Deployment and Retraction Test.
3. Span:
 The span of the bridge is defined by the distance between the two abutments on the two side. The length of the roller in the middle is also included.
4. Width:



The width of the bridge is defined by the width between the two abutments. Any part of the width should not be out of the proposed range.

5. Fix in the Box

The box is one end open (350mm×250mm) and can only be put down vertically to cover the whole bridge. On the other hand, the lower end of the box will not go below the upper surface of the abutment, so any volume below the upper surface of the abutment during Size Test will be considered as failure to fix the bridge in the box.

Reference:

[1] 2017 USF SE balsa bridge competition rules and guidelines

[2] <http://www.balsabridge.com/bb-rules.html>