The CIV102 Bridge Design and Construction Competition, 2017

Your team is required to design and build segment AC of the model railway bridge shown in Figure 1 using one sheet of mat-board and two tubes of contact cement. The bridge is to span a valley that is 3420 mm wide and must support a 960 mm long train weighing 400 N that will go across the bridge. The structure will then be tested to failure under the action of two equal point loads applied near the middle of span AB and at point C. In order to simplify the calculations and the construction, Detail 1 is to be substituted with Detail 1', where force R is equal and opposite to the support reaction from the simply-supported drop-in span.

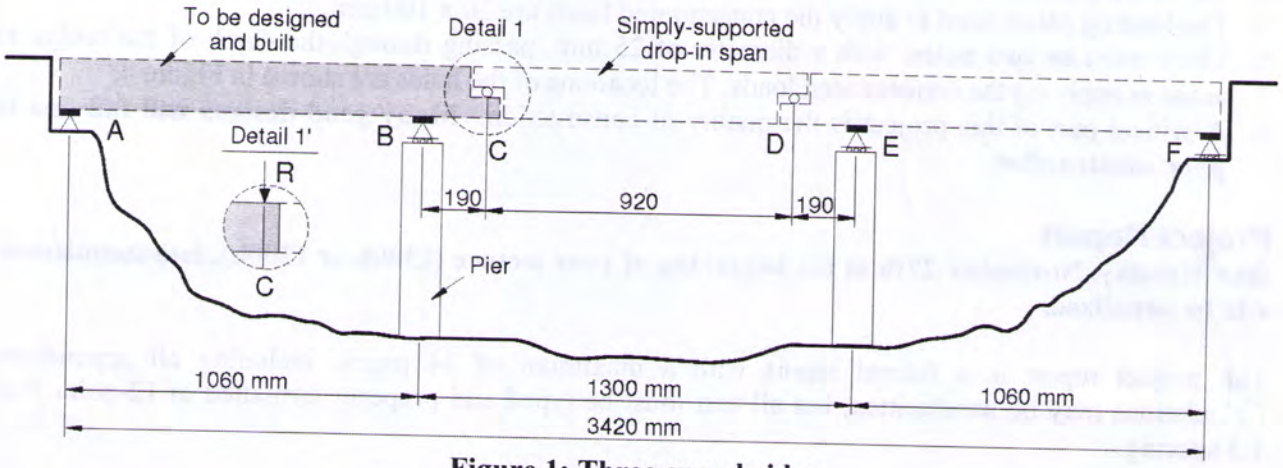

Figure 1: Three-span bridge

Primary Objective:

To design a bridge that will safely support the passage of the 400 N train. Failure means either that the bridge or the train falls down or substantial deformations or instabilities occur. Note that a train in span AB will cause the maximum positive moment at the middle of this span while a train in span BE results in the maximum negative moment at section B.

Secondary Objectives:

To design and construct a strong, aesthetically pleasing bridge with the largest strength-to-weight ratio and the largest stiffness-to-weight ratio, whose behaviour you can predict accurately. A prize will be awarded to each member of the team with the best project entry. Important parameters in the evaluation will be the quality of construction, design calculations, predictions, maximum load carried, and aesthetic appeal. The most important parameter will be the strength-to-weight ratio. An overall mark will be determined from a combination of all design objectives, and will be weighted equivalent to **three times** a regular assignment.

Construction Materials:

One sheet of mat-board 32" x 40" x 0.05", with a total mass of approximately 750 grams will be provided to each team. The estimated mechanical properties include a tensile strength of 30 MPa, a compressive strength of 6 MPa, a shear strength of 4 MPa and a modulus of elasticity of 4000 MPa. Two tubes of contact cement (30 ml each weighing roughly nothing when dry) will be provided. The shear strength of the cement is about 2 MPa if correctly applied. You are allowed to use different values if obtained through testing. The use of any other materials or additional materials is prohibited, your bridge will be disqualified, and may not be tested. Further, any such act will constitute a violation of the academic integrity policy outlined by the University, if discovered will be pursued.

Requirements:

1: Your bridge must be constructed using only the materials provided.
2: The total mass of your bridge must not exceed the mass of 1 mat-board.
3: The broken-line contour shown in Figure 2 defines the maximum allowed dimensions of the bridge in elevation.
4: The level of the track should not be higher than 200 mm above the level of the support plates.
5: The deck for the train must be horizontal, be at least 100 mm wide and permit unhindered passage of the train (this includes changes of the number of layers of material which cause a step for the train to climb over). The dimensions of the train are shown in Figure 3.
6: The bearing plates are 30 x 100 mm.
7: The loading plates used to apply the concentrated loads are 30 x 100 mm.
8: There must be two holes, with a diameter of 25 mm, passing through the depth of the bridge to assist in applying the concentrated loads. The locations of the holes are shown in Figure 4.
9: A critical part of this project is the quality of construction. **Many good designs will fail due to poor construction.**

Project Report

Due Monday, November 27th at the beginning of your lecture (1300h or 1500h), late submissions will be penalized.

The project report is a formal report with a maximum of 14 pages, including all appendices. Calculations may be handwritten, but all text must be typed and properly formatted in 12-point font, 1.5 spacing.

The report must contain the following elements:

1. **Short Introduction**: This section frames the remainder of your document by providing the reader with an overview of your design and the key design decisions of your bridge that will be justified in the remainder of the report.
2. **Engineering Design Requirements**: This is **your** summary of the requirements you have regarding engineering design generally, based on your team's definition of "engineering design". Note that all requirements require metrics.
3. **Bridge Design Requirements:** This is your summary of the requirements that guided your bridge design activities, including those given and those your team imposed. This summary is expected to be complete and may replicate some of the content from the assignment handout. Note again that all requirements require metrics.
4. **Statement of Bridge Design Philosophy:** This is the major conceptual claim(s) about the design of your bridge. It should align with your objectives established through your "Bridge Design Requirements" and your "Engineering Design Requirements".
5. **Key Design Decisions:** Building on the Introduction, this section details the key design decisions that have contributed significantly to your final design. This section should be the longest in your report.
6. **Consideration of Design Alternatives:** You should demonstrate having practiced two core skills that are central to almost all codifications of engineering design practice: reflective iteration and the rational consideration of alternative design concepts or design details.
7. **Basis for Key Design Decisions:** While much of the basis for your design decisions will be numerical and contained in the calculations, you should explain how you used both the calculations and any additional evidence and information to support your design decisions.
8. **Design Evaluation:** Assess your final bridge design against both your "Bridge Design Requirements" and your "Engineering Design Requirements."

9. **Appendix A:** All calculations including:
   a. A prediction of the maximum point loads that will cause the bridge to collapse.
   b. A prediction of the deflection at the mid-span location (between A and B) due to point loads of 200N.
10. **Appendix B:** A detailed time log describing each team member's work. All members must sign all time logs to validate approximately equal contributions to the team's efforts.
11. **Appendix C:** An engineering drawing, which completely describes your bridge, on one 11" x 17" piece of paper. Fold the page in half to create an 8.5x11 page as your final page of the report and attach the page such that it does not extend beyond the rest of the report.

Note Items 1 through 8 must comprise no more than 6 pages.

Bridge Markings [!!!]:

1: Clearly print in large font (such that it will be visible in a group photo): **a)** your group number and room (GB117 or GB217) on your bridge. Also print **b)** the predicted deflection under the 200 N loads and **c)** the predicted failure loads.
2: Draw the centrelines of the supports and the loading plates on each side of the bridge as shown in Figure 4.

Failure to adhere to 1 and 2 above will result in disqualification and your bridge will not be tested!

Test days:

During tutorial in location TBA in lecture.

Tuesday	November 28th	1000h – 1200h
Tuesday	November 28th	1500h – 1700h
Friday	December 1nd	1000h – 1200h
Friday	December 1nd	1500h – 1700h

Testing Procedure:

Testing will commence at precisely 10 minutes past the hour. Testing will start with Group 1 from GB117, then move on to Group 2, 3, etc. Then groups from GB217 will be tested. It is the group members' responsibility to report in the proper order to the weighing-in station to commence the testing procedure. Those who do not will forfeit the opportunity to test their bridge.

1: Your bridge will be weighed and judged for aesthetics and quality of construction
2: A picture will be taken of the team with the bridge
3: Your bridge will be placed in the train test apparatus. A 400 N train, as shown below, will be pulled over the bridge.
4: Your bridge will then be placed in another testing apparatus. Two equal point loads will be applied as shown in Figure 4. The deflection at midspan of AB when each load equals 200 N will be determined. The loads will then be increased until the bridge fails. Note that "failure of the bridge" will be declared if the deflections become extreme, which will be defined as span/30. That is a mid-span deflection of 35mm would signify bridge failure. Note: the test operator has the ability to stop the loading if they deem it no longer able to carry the loads in a meaningful way.

The winning group will be announced in the lectures near the end of term.

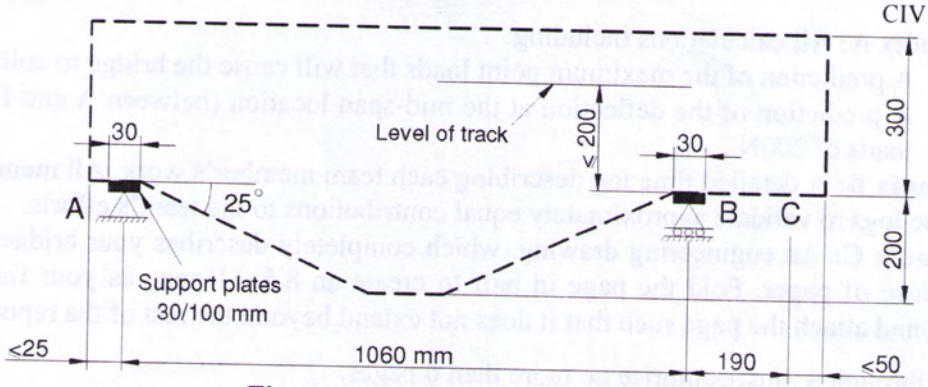

Figure 2: Important Dimensions

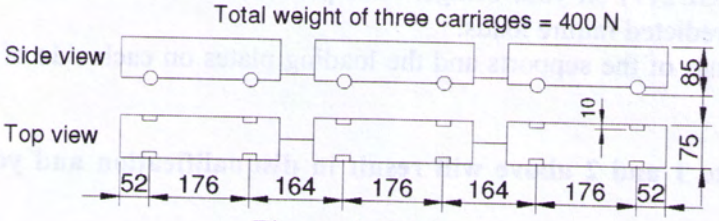

Figure 3: Train

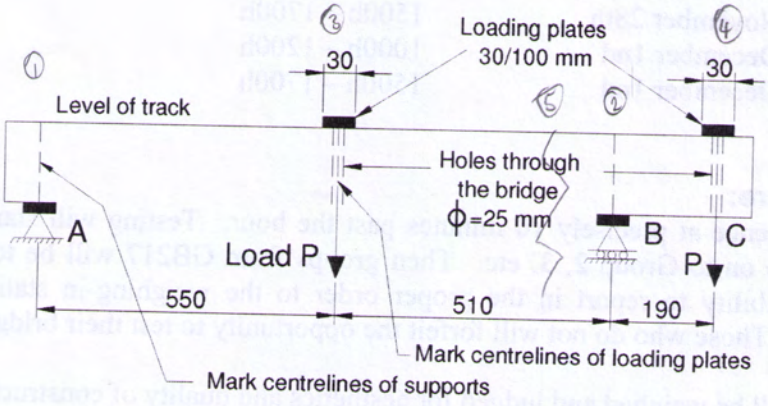

Figure 4: Concentrated Load Schematic