Matboard Bridge Design Project

The Matboard Design Project is the final project in CIV102. This project challenges groups of students to both develop and justify bridge designs to satisfy a series of requirements. This document describes the scope of work of the project and necessary parameters to carry out the design.

Overview

In this project, teams of students are tasked with developing two bridge design concepts to span the valley shown in Fig. 1. One concept shall be a box girder which is supported on its two ends, while the other concept must incorporate an intermediate support which touches the base of the valley. Calculations and drawings must be provided to support each design concept.

The Matboard Bridge Design Project has three main components: a Report, a set of supporting Calculations, and set of Engineering Drawings. The Report describes each concept at a high level, explains the decisions made while designing each design concept, and makes a recommendation for which concept should be built. The Calculations describe the predicted performance of each bridge while subjected to the specified loading conditions. Finally, the Engineering Drawings are intended to showcase both how each bridge concept will be built, as well as the final intended geometry.

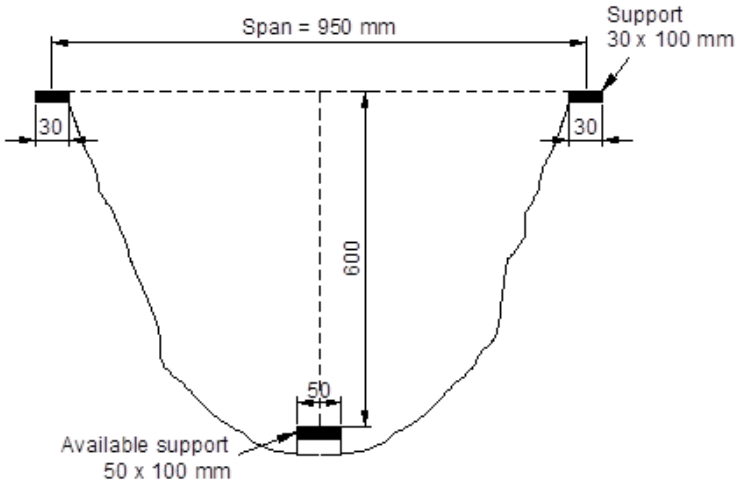

Fig. 1 – Schematic of valley profile which is to be spanned by your team's bridge.
950 mm is the measured distance between the centre of each support.

Objectives

1. Develop two concepts for a bridge which span a distance of 950 mm between supports.
    a. Concept I shall be simply supported with a pin and roller on the two ends
    b. Concept II must include an intermediate support halfway between supports which touches the ground 600 mm below.
2. Use concepts relating to engineering beam theory and thin-plate buckling theory to predict the maximum load the bridge can carry before failure.
3. Articulate design decisions and document construction process in a design report.
4. Demonstrate the ability to communicate a design using engineering drawings.

Project Requirements

Working Constraints

5. Work only in your assigned group of 3 or 4 student engineers.
6. Teams must come up with two concepts, which are described in Objective 1.
7. Each bridge must be made from only one sheet of matboard, which has dimensions of 32" x 40" x 0.05" (813 mm x 1016 mm x 1.27 mm) and a weight of 750 g. Contact cement will be used to glue

components together. The constructability of each bridge concept must be described in the report, as well as in a drawing which explains how the matboard should be cut to obtain the components needed to assemble the bridge.

8. **Both concepts need to be designed to carry a minimum force of P = 1000 N (i.e. the sum of the two point loads must exceed 1 kN).**

Calculation Requirements

9. Calculations must be submitted which demonstrate each bridge's performance under the load case shown in Fig. 3 in the Appendix. Calculate the load causing failure, P, for each design concept. Consider all possible failure mechanisms including all forms of plate buckling.
10. Based on the failure load and the weight of the bridge, calculate the strength/weight ratio of each design concept.
11. Material properties when performing calculations using the matboard and contact cement are given in Table 1.
12. When performing calculations for your second design concept, the strength of the intermediate support must also be considered when checking the load carrying capacity of the bridge. Consider all forms of failure including crushing, global Euler buckling and local plate buckling.
13. To calculate the reaction forces of your second design concept, which is supported at three points and is hence statically indeterminate, use the method described in Question 3 of Assignment 8. **Show calculations demonstrating how the reaction forces are obtained for your design concept.**
14. **Supplementary calculations may be attached at the discretion of your team to qualify for a bonus. Examples of these calculations would be evidence of optimizing cross section dimensions, using multiple cross sections, having a variable-depth bridge or other explaining any other innovations. If included, calculations must be clearly explained to facilitate review by your TA (i.e. do not just attach a raw spreadsheet or output from a computer program).**

Design Report Requirements

15. The report shall include an introduction where each bridge concept is explained in detail. Design features should be discussed, and the predicted failure loads, strength-to-weight ratios, and causes of failure should be mentioned.
16. Include a section in the report containing instructions about how each bridge will be built using the provided materials for each design concept.
17. Based on your calculations and construction plans for each bridge concept, recommend one which should be built. Justify your recommendation by referring to selection criteria, applicable metrics, etc.

Engineering Drawing Requirements

18. Drawings showing the following views of each bridge concept must be developed:
    a. All views of the bridge (Concepts I and II) and support (for Concept II only), including views from above, below, and from the side.
    b. Include a cross section view which is cut along the length of the bridge to show components which are inside the bridge, such as diaphragms, connections, etc.
    c. Draw as many cross-section views as necessary to sufficiently to describe your bridge and indicate where along the length of the bridge they correspond to.
    d. Include construction drawings which describes how the sheet of matboard shall be cut to create your bridge, and indicate the purpose of each piece.
19. Drawings must include annotations, dimensions, a border and a completed title block. Research typical engineering drawing conventions when preparing your drawings.
20. Drawings may be prepared by hand or digitally. Straight lines must be drawn with a ruler if done by hand.

Other Misc. Bridge Requirements

21. The bridge must fit within the envelope shown in Fig. 2 in the Appendix.
22. The deck of the bridge must be horizontal, be at least 100 mm wide, and permit unhindered passage of a vehicle over it.
23. The bearing plates used to support the bridge on the two ends are 30 mm x 100 mm. The bearing plate to seat the intermediate support for Concept II is 50 mm x 100 mm. The loading plates used to apply the concentrated point loads to the bridge are also 30 mm x 100 mm.
24. Diaphragms, which are inserts that "fill in" the bridge so that the cross section becomes "solid" , must be provided at each location of the bridge where there is a concentrated load due to the applied forces or a support reaction. At least two must be provided at each point.

Table 1 – Specified Material Properties

Material	Material Property	Specified Value
Matboard	Specified Dimensions	32" x 40" x 0.05" (813 mm x 1016 mm x 1.27 mm)
	Weight	750 g
	Tensile Strength, σ'_t	30 MPa
	Compressive Strength, σ'_c	6 MPa
	Shear Strength, τ'_m	4 MPa
	Young's Modulus, E_m	4000 MPa
	Poisson's Ratio, υ_m	0.2
Contact Cement	Shear Strength, τ'_g	2 MPa.
	Weight	Negligible

Deliverables and Deadlines

Due date: Tuesday December 8 at 11:59pm Toronto time

a. Submit the project Design Report which describes the bridge design concept, various design features and the construction process. The total length of this report including both text and images must not exceed 5 pages. Text shall be written in 11-point font and single spaced.
b. Submit the Calculations as an appendix to the Design Report. The total length of the calculations which satisfy requirements 9-13 must not exceed 15 pages in length. **If supplemental calculations are included to qualify for a bonus, an additional 5 pages may be included.**
c. Submit a set of Engineering Drawings which completely describe your bridge and include all of the components described in the Engineering Drawing Requirements section. Three pages of drawings shall be submitted for each bridge concept (total 6), and be organized as follows:
    i. Views of top, bottom, side and cross section along length
    ii. Cross-section views
    iii. Construction drawing showing matboard cuts
d. Submit a detailed time log for all work done on the project. The tasks and time spent on these tasks should be clearly recorded for each group member. Indicate the date and times that each task was performed. This time log is not included in the page limit for calculations. Each group member is to sign this time log. Use quarter hour precision.
e. Submissions shall be uploaded to Quercus in the form of four pdf files. Only one submission is required for each group, and all of the files must be submitted by one member of each team. These files must have the following naming convention, where xx is your group number.
    a. Report: CIV102-Project-Report-Group-xx.pdf
    b. Calculations: CIV102-Project-Calculations-Group-xx.pdf
    c. Drawings: CIV102-Project-Drawings-Group-xx.pdf
    d. Time log: CIV102-Project-Timelog-Group-xx.pdf
f. Each file must contain the names of each group member and your classroom TA on the first page.

Grading Scheme and Project Weight

Approximate Grading Scheme

The overall project grade will consist of the report (20%), drawings (30%), and calculations (50%).

Project Weight

This project is worth 10% of your final grade. The same grade will be assigned to all members of each team except in the condition of a serious dispute. If your team is experiencing serious challenges, please email your classroom TA and cc Allan Kuan.

Bonus

To encourage innovative designs, a bonus of up to 15% will be awarded to teams which are able to design bridges which demonstrate both creativity and judicious application of the course concepts. To qualify for a bonus, teams must satisfy the following:

a. **At least one of your two concepts must be designed to go above and beyond the basic reference designs presented in the lectures and tutorials,**
b. **This bridge concept should carry at least P = 1200 N,**
c. **Your team must clearly indicate in your report that you would like to be considered for a bonus,**
d. **Supplementary calculations must be included, and your report must argue how your extra work improved the overall performance of your design(s).**

Appendix – Loading Configuration

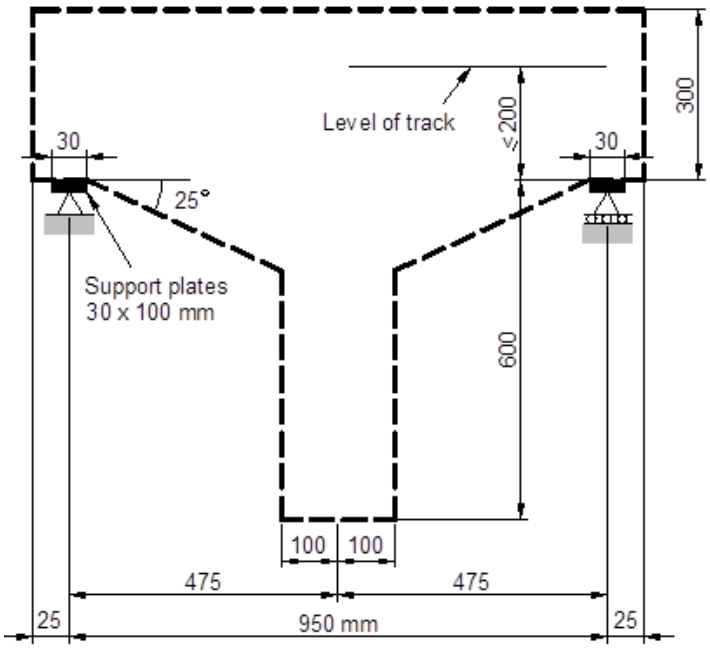

Figure 2: Important Dimensions. The broken-line contour defines the maximum allowed dimensions of the bridge in elevation. All dimensions in mm.

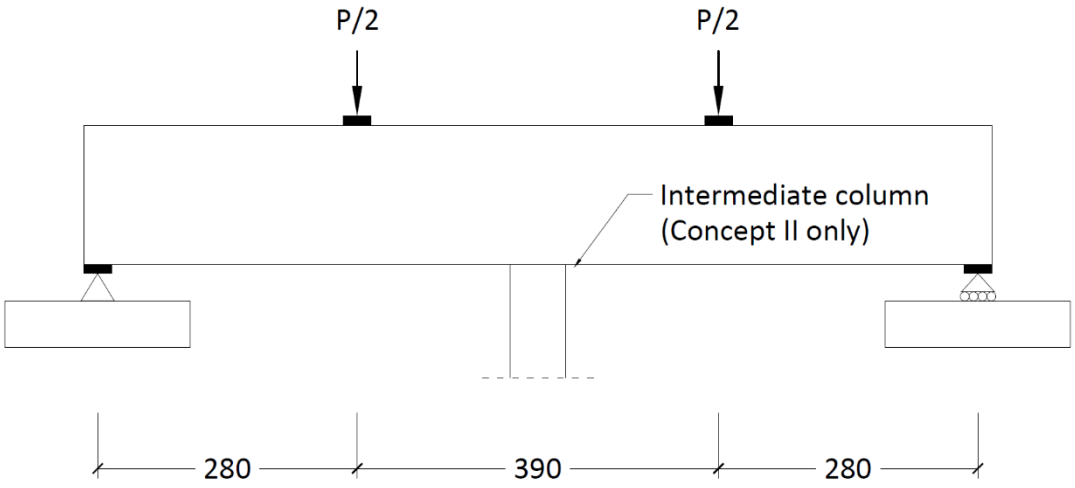

Figure 3: Concentrated Load Schematic (all dimensions in mm). Each plate is 30 mm x 100 mm.