UNIVERSITY
OF WOLLONGONG
IN DUBAI

Laboratory Session 3:
Project 1 Attempt A - Balsa Beam Design and Test

Family Name:				
First Name:				
Student Number:				
Student Submitting				
Group number	1			

Subject number and name:	ENGG102 - Fundamentals of Engineering Mechanics
Subject coordinator:	Dr. Umar Asghar
Title of Assignment:	Project 1 Attempt A - Balsa Beam Design and Test
Date and time due:	24-01-2024, due 30-01-2024
Lab Number:	1.53
Tutor Name:	Mr. Ahmed Mohamed
Total number of pages:	9

ENGG102 Project 1A Beam Design and Reflection Report: Assessment sheet

Lab session number: 3 Instructor's name: Mr. Ahmed Mohamed

Team Number: 1 Date and time of exercise: 24.01.2024 10:30

Names and ID Numbers: [redacted]

Aspect	Comment	Mark
Appendix A: Minutes of Team Meetings (evidence of teamwork)	**Minus 2 marks if Minutes of Team Meetings (more than one!) are not included with this Report**	-1
Appendix B: A completed copy of your Team Ground Rules Contract Form	**Minus 2 marks if a copy of your Team Ground Rules Contract Form is not included with this Report**	-1
Structure of report, team information etc (as per "what report should contain")	0.5 mark for each item 3-12 (see Report structure provided above)	5 /5
Overall Presentation	Neatness Spelling Grammar Diagrams Professionalism	10 /10
Brainstorming and rationale: List 2 distinct proposals Reasons for selection of prototype	Must show evidence of developing at least two distinct design ideas and variations/improvements to one.	5 /5
Description of beam Drawing/sketches with dimensions	Describe the principle behind the design. Accurate line drawings or neat and clear sketches with all important dimensions (should enable tutor to build the same structure)	15 /20
Results including comparison with other team(s) WHAT happened!	Comparison table of all results. Discussion of results with commentary on table and main factual findings. Describe the main failure mechanisms.	9 /10
Reflections – identify some reasons for the performance of your beam and other teams. WHY it happened! Consider the various aspects of the task (fabrication, material use). Discuss how it might be improved, what knowledge might be needed, & design criteria considered.	To achieve top marks (35-40/40) in this section your report must demonstrate clear and insightful reflection considering own solution and others in the class. Demonstrates further reading and critical analysis. To achieve 25-35/40 your report must describe the performances of your solution and some others. Itemisation of knowledge gaps and some critique of designs. To achieve 0-25/40: Describes own solution with limited reference to other beams.	35 /40
Mapping of learning outcomes	Identifies all the relevant outcomes from subject outline and discusses how well each is addressed.	5 /5
Conclusion	1 or 2 paragraphs that draw appropriate conclusions from evidence presented in report. Include the main results, both numerical and qualitative.	3 /5
Total		85 /100

Content Table

Statement of Purpose

Be careful of typos (Force applied is "24.5N". Not "245N")

The primary goal of this report is to design a balsa wood beam that can support the equivalent of a central mass of 2.5 kg (245 N) over a 400mm span. Moving on, the beam needs to deflect within the specified range, that is, 1.0mm to 6.5mm. The beam's height should be not more than 75 mm, and its width is restricted to 50 mm. The goal of this report was to create a beam that adhered to the material restrictions imposed.

To achieve a perfect design, certain skills must be applied during the beam's construction. Teamwork, design, communication, and fabrication skills are some examples of skills that are required. The project required team members to better understand one another. This also helped to identify each member's strengths and weaknesses. The lab work required the team to work hand in hand to fabricate the beam.

Eventually, this task required what many qualified engineers do daily: designing structures, communicating, designing, and creating something useful and relevant using fundamental physical laws.

Brainstorming

Design 1: I beam

An I beam looks like a beam shaped like the letter “I” with two parallel horizontal supports on the top and bottom called “flanges” and one horizontal support in the middle called the “web”. I The flat flanges at the top and bottom of the beam prevent bending and the web resists blunt force. These components are designed to withstand a maximum bending load with the least material possible and make up the basis of support for high bearing loads.

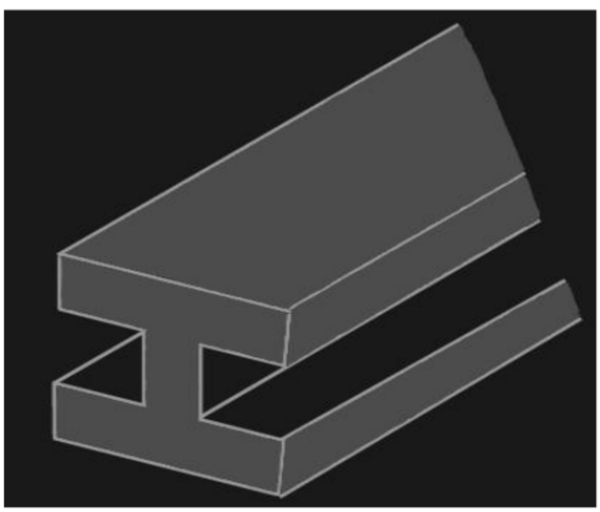


Figure 1: Cross-sectional view of an I - beam

Design 2: Hollow beam

Hollow beams are beams that have a hollow cross-section. They can come in various shapes, including but not limited to circular, square and rectangular. Hollow beams are easy to manufacture and hence have a lower cost of manufacturing [1]. Hollow beams are also among the lightest while having comparable strength to other types of beams such as I beams.
In terms of torsion, the hollow beam is better suited to resist deformation. [2]

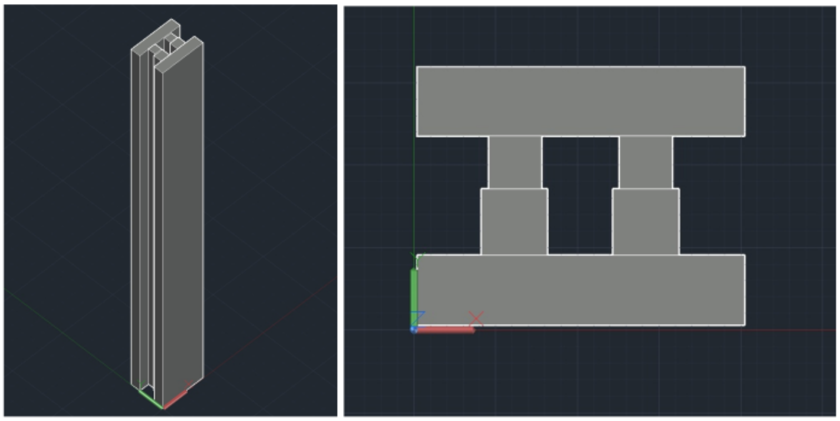


Figure 2.1 & 2.2: Different views of a hollow beam

Chosen Concept

The concept of the beam is based on the **Hollow Tube** beam type. This design was chosen in hopes of achieving a Balsa Beam capable of withstanding a mass of 2.5kg hanging from its center which induces a weight force that aims to result in a deflection ranging from 1.0mm to 6.5mm.[3]

Why is there a reference when you are talking about the project requirements?

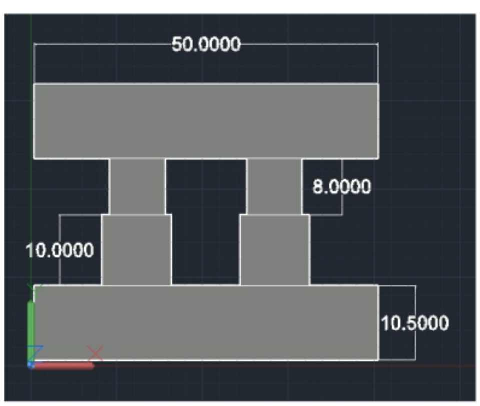
Rationale

The reason behind this choice is due to its ability to withstand loads in different directions with the help of its cross-sectional axes which aids in withstanding perpendicular force to the beam. Moreover, this design also makes it resistant to torsion as most of the material is located at the edge boundary of the beam [2]. To add to this, the fabrication effort required would be less compared to constructing an I beam as it is easier to balance the roof due to the double supports.

Description

You didnt mention the distance between the 2 supports

A **Hollow Tube beam** is fabricated by creating two supports at the edges of the bottom and top of a wide flat piece. This is done by using pieces made of **Balsa Wood** with the following dimensions using hot glue:



- **Base and Roof:** 10.5mm height, 50mm width and 460mm length
- **Edge walls (upper):** 8mm height, 8mm width and 460mm length
- **Edge walls (lower):** 10mm height, 10mm width and 460mm length

Figure 3: Dimensions of the beam constructed

You need to talk about how you utilised the raw material provided (eg: for the flanges, how did you achieve 10.5mm height and 50mm width using the materials given?)

These pieces were assembled together by attaching the Base with the lower Edge walls followed by the upper Edge walls and Roof. The Edge walls are spaced out to make the beam hollow like the figure below.

The dimensions of the beam constructed satisfied the conditions set, which were

- Width should not exceed 50mm
- Height should not exceed 75mm
- Length should be between 450mm and 500mm

The dimensions of the beam constructed were:

- Width: 50mm
- Height: 39mm
- Length: 460mm

Results

Team	Beam Type	Deflection (mm)	Met Criteria (y/n)	Volume (mm^3)	Fabrication (High, Medium, Low)	Comments
1	Hollow Tube	0.27	n	633800	Medium	Many layers, excess glue
2	I Beam	0.60	n	170100	Medium	Too many layers on top
3	I Beam	0.14	n	463000	Medium	
4	I Beam	0.40	n	540000	Medium	
5	T Beam	1.10	y	406800	High	
6	Complex Hollow	0.36	n	637000	Medium	

After thoroughly reviewing the results, it has been observed that only one team was able to meet the deflection requirements. All other groups made the beams too strong for it to meet the minimum deflection requirement of 1mm.

What is the direct correlation between the volume and deflection (ie: Are they directly proportional or inversely proportional?)

For all the teams that failed, the deflection was between 0.14mm to 0.6mm. A direct correlation between the volume of the beam and deflection can be seen in these cases. Team 3 had the lowest deflection at 0.14mm whereas Team 2 had the highest deflection at 0.6mm.

The only team that met the deflection criteria was Team 5. Their beam was unique compared to other teams. It had a simple T structure with a moderate volume and a high fabrication effort. Team 5 used less wood and glue to fabricate their beam. This allowed their beam to be flexible compared to other teams, which contributed to the success of their beam in the deflection requirements.

Comparison with other concepts

This section should go under the reflection

Fabrication and Beam Type

In comparison to other groups, fabrication of the beam was easier due to the double supports compared with the single, hard to balance I beam support. Additionally, other groups used less materials compared to the Hollow Tube beam which would explain how some beams had a higher deflection value.

Concept difference

I beams and Hollow Tube beams all have failed to meet the deflection criteria. This may be due to the thickness of those beams compared with the T beam which due to it having less materials managed to pass the criteria. Additionally, the T beam having a smaller or thinner base aided with its higher in comparison deflection.

Other Factors

Even though some beams have a smaller volume, they haven't deflected, which implies that the volume isn't the main component when dealing with deflection. However, some beams could have an excess of glue or layers, which resulted in higher stiffness and lower deflection.

Mapping Learning Outcomes

Perform and present calculations and design professionally in reports

This task involved basic measurement and volume calculations, which were presented professionally. However, due to a lack of knowledge about engineering formulas and calculations, only basic computations were demonstrated.

Work in a team to carry out design project work

The team communicates effectively and assigns tasks to each other from the onset of the lab. All members had an overview regarding what has to be contributed to the report. Regular interactions through the internet to share ideas, as well as conversations during class and team meetings, are extremely beneficial in improving team performance and building trust. The team handled this situation exceptionally.

Reflection

These are some of the measures to enhance this beam design's performance. To begin with, less glue will be used in the fabrication of the beam. The first beam used more than the necessary amount of glue which increased its weight significantly. Reducing the amount of glue allows for weight reduction while maintaining structural integrity. Second, the wall thickness of the hollow tube can also be slightly reduced. This would increase the amount of deflection for a given load, moving the beam toward the desired deflection range. On the other hand, this thickness cannot be made too thin because it will compromise strength. Lastly, other structures will be studied. The target would be to achieve the best compromise between strength, deflection and efficiency.

While going through with the project of constructing the beam, hands-on experience was gained in understanding the relationships between beam stress and beam stiffness on the cross sectional shape of the beam. This understanding was further clarified during the testing process. In addition, hollow tube shapes were demonstrated to function well when loaded (almost too good). Nevertheless, the gaps in optimal beam design persist as a result of the failure to make the beam perform up to deflection requirements and hence modifications will be done on several components of the beam for better performance.

The team's decision-making process had strengths and areas for improvement. Effective communication but extensive debating of designs were noted. Time framing and designated discussion leaders could have facilitated faster progress. Thorough analysis of the best options before final design choice could have made the decision more objective. The group should be more confident in selecting a design direction while leaving enough alternatives.

The first step involved in building the beam was to accurately cut the pieces of balsa wood into dimensions that were suitable for use. This was a time-consuming and difficult procedure. The balsa wood is very easily cut but extremely soft and likely to chip; it was necessary to take multiple passes in order to make each piece the correct size. In the second attempt, sharper tools will be utilized in order to clamp the wood tightly during the cutting process to have precise and cleaner cuts.

The only team that was able to pass the requirement had used much less wood and glue; this ensured that the beam would be strong yet deflect just enough to merely pass the required amount of deflection. Compared to the beam the team had constructed, it can be noted that there was significantly less usage of wood and glue, which contributed to the "over-strengthening" of the beam.

The beam design was simple enough to see that it was just a basic hollow tube shape. However, some effort still went into the alignment of the tube sections and fitting them together due to the imprecise cuts. That the glue joints also added some more labor and time was neither unexpected nor a surprise. Overall, the beam was simple to construct and assemble.

You need to also reflect on your understanding of beams (What relevant knowledge you had prior to the experiment, what you gained during the exercise and what gaps you have identified?)

Conclusion

Your conclusion needs to be more brief (You dont need to talk in detail about the project again. Only the main outcomes and some future improvements are required, as the conclusion serves as a summary to your report)

The first experiment performed was the balsa beam design project. After collectively weighing the benefits of one beam as opposed to another, a choice of making a hollow tube structure was made because it was believed to be the best strength-weight ratio. Collaborative teamwork was essential in deciding the structure of the beam. since it would allow ideas to be shared, as they were moved towards the end of this project.

The main target or goal was to make a beam that would deflect between 1.0 - 6.5mm whilst under a load of 2.5kg over a span of 400mm. However when the testing of the beams started, the hollow tube beam deformed only 0.27mm which did not meet the requirement for this project. Nevertheless, the design will be improved in multiple ways after further research in order to meet the criteria.

Although the initial beam design was decent, it was noted that there is definitely scope for improvements of this beam. Various strategies were also thought of to improve the structural design, including minimizing wall thickness or decreasing the quantity of glue. During this process, the team learnt a lot about engineering design, fabrication of parts and effective communication. Going forward, the beam will be modified and improved in order to meet the criteria for the next project.

In conclusion, the project was a great overview of how to use engineering concepts in a practical design challenge. Although the beam failed to meet deflection criteria, weaknesses and possible improvement points were identified and certain notes were taken regarding these concepts. The work done for the experiment gave insight into what it would be like working in an engineering team and lessons that will make future projects better.

References

- [1] S. E. R. S. I. P. China Suzhou City, Jiangsu Province, “I Beam VS Hollow Section,I Beam VS Hollow Section.” Available: https://www.union-steels.com/newsdetail/i-beam-vs-hollow-section.html
- [2] Alan, “Hollow shaft vs. Solid shaft: Which one’s more resistant to torsion?,” *Physics Stack Exchange*. https://physics.stackexchange.com/questions/355224/hollow-shaft-vs-solid-shaft-which-ones-more-resistant-to-torsion (accessed Jan. 29, 2024).
- [3] A. Benmusa, “Hollow Steel Section (HSS) Profiles,” *Beamcut*, Jan. 21, 2020. https://beamcut.com/hollow-steel-section-hss-profiles/ (accessed Jan. 29, 2024).

You need to have more than one meeting, as per submission guidelines

Appendix A: Minutes of team meetings

Date: 24-1-2024
Time: 5:00pm - 6:00pm
Purpose: Discuss the roles of each member and the deadline of the main draft of the report.
Attendance:

Names:	Present	Late	Absent
[redacted]	x		
	x		
	x		
	x		

A list of actions:

- [redacted]
  - Description, Problems and Chosen Concept
    - Due by: Friday, 26-01-2024
- [redacted]
  - Comparison, Results and Ground Rules
    - Due by: Friday, 26-01-2024
- [redacted]
  - Statement of Purpose, Brainstorming and Mapping Learning Outcomes
    - Due by: Friday, 26-01-2024
- [redacted]
  - Conclusion, Reflection, Cad designs and sketches
    - Due by:Friday, 26-01-2024

Follow up: Target met by each member within time limit and discussions have been conducted within meetings with no absence from members.
Next meeting: Week 4, 31-01-2024

Appendix B: Team Ground Rules

Team ground rules incomplete

- Come to class and team meetings on time
- Come to meetings with assignments and other necessary preparations done
- Respect one another
- Help each other when the need arises
- Communication through designated channels
- Maintain a consistent format for fonts and writing style
- Commit to timeline and submit within deadline
- Constructive feedback and assisting fellow members
- Record references used and where they are used

Lab 1A Report -

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

85/100

PAGE 1

PAGE 2

Text Comment. -1

Text Comment. -1

Text Comment. 5

Text Comment. 10

Text Comment. 5

Text Comment. 15

Text Comment. 9

Text Comment. 35

Text Comment. 5

Text Comment. 3

Text Comment. 85

PAGE 3

PAGE 4

Text Comment. Be careful of typos (Force applied is "24.5N". Not "245N")

PAGE 5

Text Comment. Why is there a reference when you are talking about the project requirements?

Text Comment. You didnt mention the distance between the 2 supports

PAGE 6

Text Comment. You need to talk about how you utilised the raw material provided (eg: for the flanges, how did you achieve 10.5mm height and 50mm width using the materials given?)

Text Comment. What is the direct correlation between the volume and deflection (ie: Are they directly proportional or inversely proportional?)

PAGE 7

Text Comment. This section should go under the reflection

PAGE 8

Text Comment. You need to also reflect on your understanding of beams (What relevant knowledge you had prior to the experiment, what you gained during the exercise and what gaps you have identified?)

PAGE 9

Text Comment. Your conclusion needs to be more brief (You dont need to talk in detail about the project again. Only the main outcomes and some future improvements are required, as the conclusion serves as a summary to your report)

PAGE 10

Text Comment. You need to have more than one meeting, as per submission guidelines

Text Comment. Team ground rules incomplete