OXFORD BROOKES UNIVERSITY

Assessment cover

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Module No:	ENGR4003	Module title:	**Engineering Design and Practice I**

Assessment title :	**CAD CAE Assessment**

Due date and time: **1st May 2026**	**13:00**

Estimated total time to be spent on assignment:	16 hours per student

LEARNING OUTCOMES

On successful completion of this assignment, students will be able to achieve the module following learning outcomes (LOs): *LO numbers and text copied and pasted from the module descriptor*
LO1 : Use mathematical skills to solve various problems in engineering
LO2 : Design and understand electrical and electronic circuits when provided with a particular problem
LO3 : Evaluate and produce an Engineering design suitable for manufacture based on a provided design specification
LO4 : Analyse a design using integrated CAE tools such as motion, thermal and mechanical and stress
LO5 : Use standard machining tools and techniques to produce a working model from technical drawings
LO6 : Understand the basic managerial skills necessary to ensure the effective operation of a commercial organisation engaged in manufacture of an engineering artefact such as a sterling engine

Engineering Council AHEP4 LOs assessed (from S2 2022-23) *LOs copied and pasted from the AHEP4 matrix (add rows as required)*		
LO number	**LO text**	**Met? (Y/N)**
B3	B3: Select and apply appropriate computational and analytical techniques to model broadly-defined problems, recognising the limitations of the techniques employed.	
B4	B4: Select and evaluate technical literature and other sources of information to address broadly-defined problems.	
B5	B5: Design solutions for broadly-defined problems that meet a combination of societal, user, business and customer needs as appropriate. This will involve consideration of applicable health & safety, diversity, inclusion, cultural, societal, environmental and commercial matters, codes of practice and industry standards.	
B6	B6: Apply an integrated or systems approach to the solution of broadly-defined problems.	
B10	B10: Adopt a holistic and proportionate approach to the mitigation on of security risks	
B11	B11: Recognise the responsibilities, benefits and importance of supporting equality, diversity and inclusion	
B12	B12: Use practical laboratory and workshop skills to investigate broadly-defined problems	
B13	B13: Select and apply appropriate materials, equipment, engineering technologies and processes.	
B14	B14: Recognise the need for quality management systems and continuous improvement in the context of broadly-defined problems	
B15	B15: Apply knowledge of engineering management principles, commercial context, project management and relevant legal matters.	

STUDENT NAMES (ONLY IF GROUP ASSIGNMENT, OTHERWISE ANONYMOUS)

Student No:	Student Name:	Group Name and Number:
1.		

Statement of Compliance *(please tick to sign)*

☐ I declare that the work submitted is my own and that the work I submit is fully in accordance with the University regulations regarding assessments (*www.brookes.ac.uk/uniregulations/current*)

Use of AI Tools: You are required to use this form to declare which AI tools you have used and how you have used them. Please complete the form and attach it to your submission as an Appendix, if you have used such tools.

RUBRIC OR EQUIVALENT (BELOW)

FORMATIVE FEEDBACK OPPORTUNITIES

Feedback on your work will be provided in a range of ways at various times throughout this module, and different feedback will serve slightly different purposes. Feedback is designed to support your learning and help you to improve subsequent work, so you need to engage and get the most out of the feedback provided. Please note that feedback is provided throughout the module not just on formal tasks It will be provided on your work and contribution in class, on the formal assessment tasks and, in some circumstances, during staff office hour.

SUMMATIVE FEEDBACK DELIVERABLES

Deliverable content and standard description and criteria	Weighting out of 100%
CAD CAE Assessment	**30%**

Marking grid and peer marking form are attached at the end of this assignment.

ASSIGNMENT IN DETAIL

The assessment briefs can be found under Assessments tab on Moodle.

https://moodle.brookes.ac.uk/course/view.php?id=81028

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Requirement 3

To determine the best iteration of material for the eight M4 bolts. A Transient Thermal Study was carried out by using the simulation tool on Solidworks. Each material was tested using the same conditions to ensure a fair comparison.

This was done by applying an initial 25°C to the top of the bolt and convection at 25 degrees on the outer surfaces of the bolt to represent the air temperature around the bolt. Then a temperature load of 100°C at the bottom of the plate was applied to represent the heat source of boiling water.

Then finally each study ran for 600 seconds with a time increments of 25 seconds. This allowed comparison of temperature distribution across materials.

The reason a transient study was chosen for this simulation is because of how it will illustrate how the bolt heats over time rather than a final steady-state temperature study.

The results from the test are illustrated through the figures 1,2,3 and 4 which show the results.

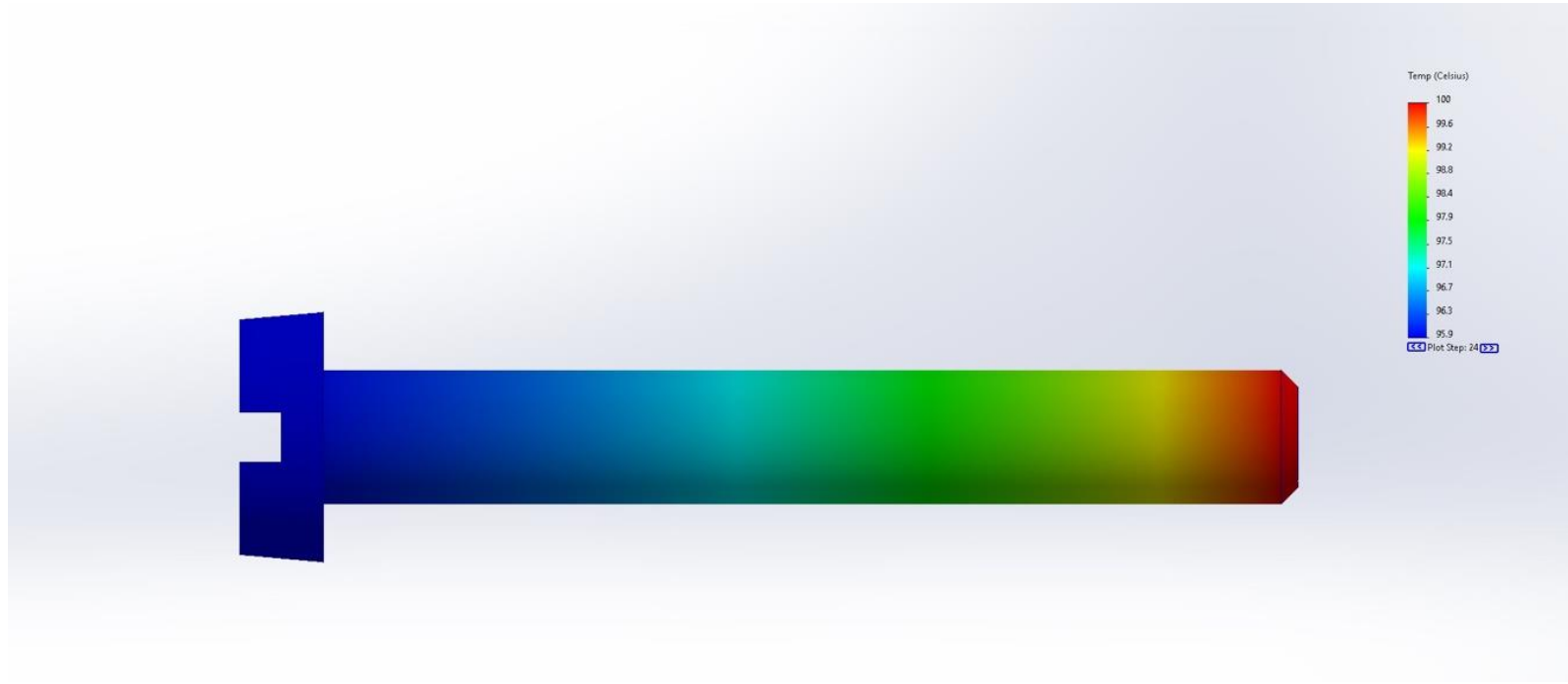


Figure 1 – Aluminium – Thermal Study Results

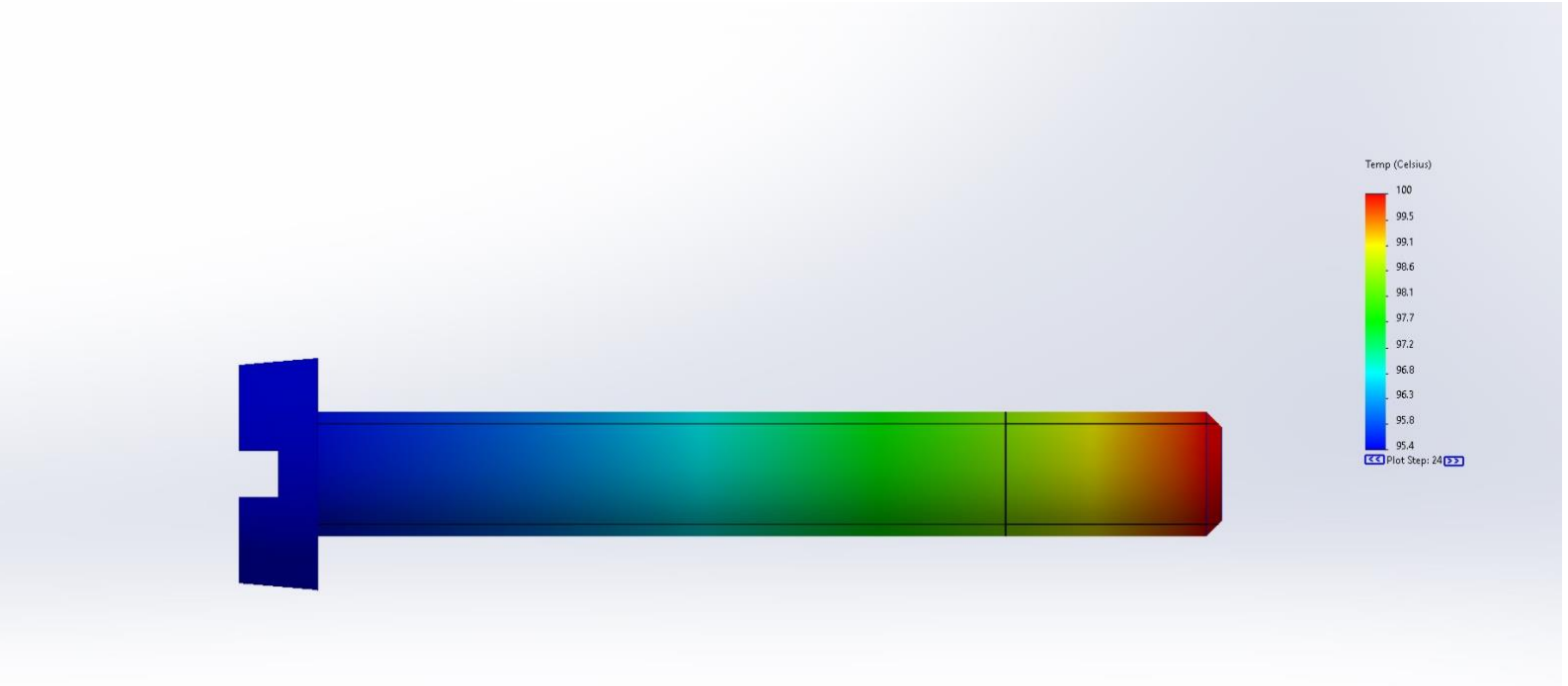


Figure 2 - Brass – Thermal Study Results

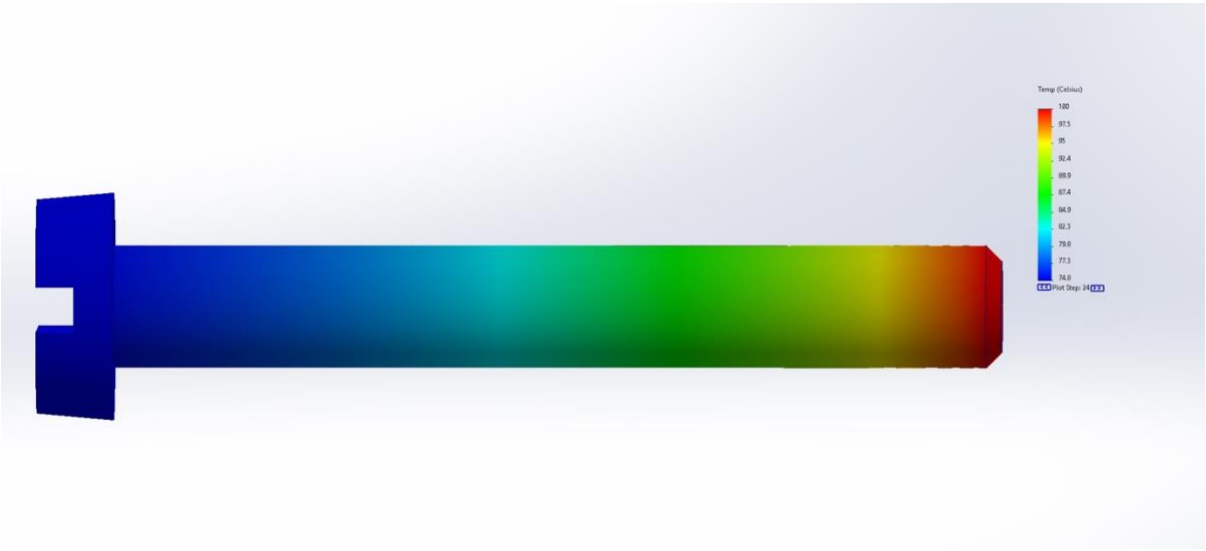


Figure 3 - Steel – Thermal Study Results

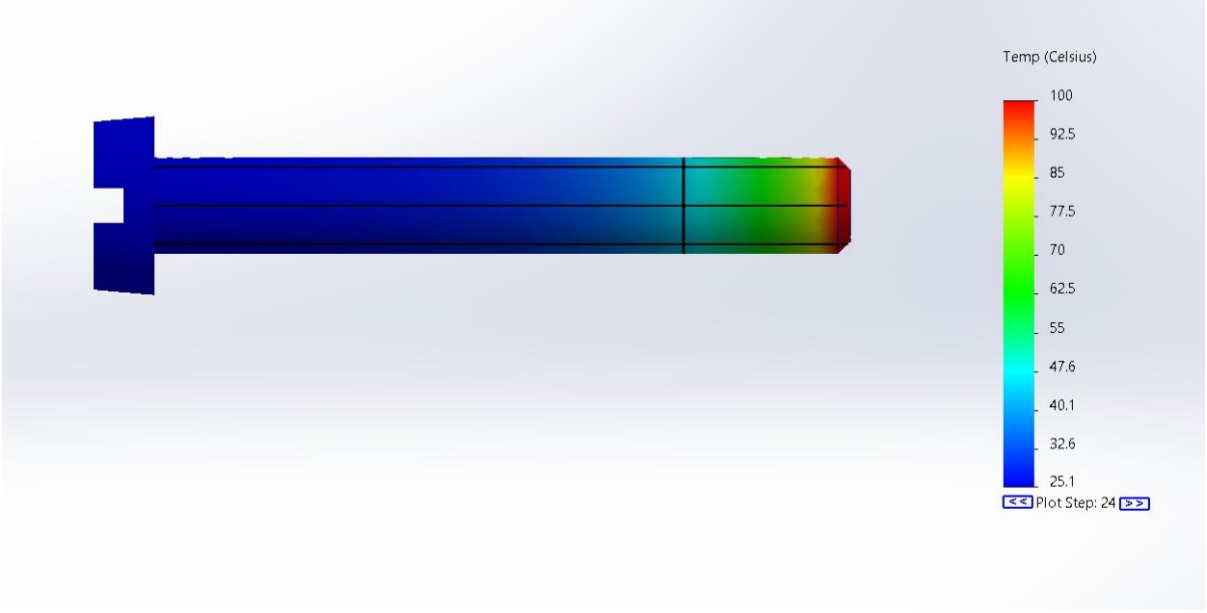


Figure 4 - Nylon - Thermal Study Results

Results Table Based on Solidworks Tests			
Material	Min Temp°C	Max Temp°C	Temp Drop°C
Nylon	25.1	100	74.9
Steel	74.8	100	25.2
Brass	95.4	100	4.6
Aluminium	95.9	100	4.1

Overall Statement from these results

These results are essential to finding the best material for the bolt because the Stirling engine relies on maintaining the temperature between the hot and cold regions. This means the material with highest temperature drop value is the best isolator. This displays Nylon performed best with 74.9 °C thermally followed by steel, Brass and Aluminium. This can be further shown through figure 1,2,3 and 4 which allow for visual look at the difference. This difference happens due to nylon having a lower thermal conductivity then the other materials which explains the larger temperature drop. However thermal performance alone is not enough to determine the best material. As cost and manufacturability need to be considered to.

Cost

Material	Cost	Approx. Price Per Bolt
Nylon	£0.53 for 8 (*Nylon Screw,* 2026)	£0.07
Steel	£3.72 for 60 (*Bolt World,* 2026)	£0.03
Brass	£17 for 100 (*Bolt World,* 2026)	£0.17
Aluminium	£2.67 for 50 (GWR, 2026)	£0.05
Overall Statement from these results		
This illustrates the cost comparison of the material if bought from stores. This shows Steel is the cheapest per unit, with Nylon and aluminium in a close second and third with Brass in fourth. Overall, the results indicate that there is no major cost difference between aluminium, nylon, and steel. While brass is significantly more expensive. This suggests cost alone is not a strong influence on the material depending on budget of course. This allows for a greater emphasis on the thermal performance and manufacturability when choosing the material.		

Manufacturability

Nylon is good manufacturable material. Nylon M4 bolts are usually made from injection mounding. This is where plastic pellets are melted and injected into the mould cavity to form the threaded bolt shape (*Protolabs,* 2023) . This is an efficient process for large production volumes as it can produced at a low cost.

Steel has excellent manufacturability. With Steel M4 bolts using being made are made from cold heading to form bolt and thread rolling to create external threads (Aktas, S. and Kisioglu, Y, 2020). This process makes steel bolts inexpensive and widely available

Brass is a highly machinable material. So, CNC manufacturing is widely used when manufacturing the M4 Brass bolts as it produces accurate threads and a good finish (*CNC Machining Services*, 2026).

Aluminium has good manufacturability. So the M4 bolts will normally be made from machining or cold forming as the material is easy to shape and machine (*CNC Machining Services*, 2026).

Overall this shows how all the material can easily be manufactured. It also conveys how manufacturability is not a strong influence on the material. Therefore, it means thermal is the main consideration.

Assumptions/Simplifications/Limitations:	
1	• Constant ambient temperature of 25 c was chosen,
2	• The heat source (boiling water) assumed constant at 100 c
3	• Only thermal behaviour was considered.
4	• Mesh settings were done automatically through run this study to ensure computer could handle the study
5	• The simulation could have been run for longer than 600 s to determine if full thermal equilibrium was reached.

In conclusion this displays how all four materials are great choices but nylon is the preferred choice due to the better thermal insulation which helps reduce the unwanted heat transfer between the bottom and top plate of the Stirling engine. When combined with the low cost and good manufacturability it further illustrated Nylon being the ideal choice even though Steel, Brass and Aluminium are good practical alternatives. However due to their higher thermal conductivity than Nylon it made them less suitable for maintaining the temperature difference required for efficient Stirling engine performance

Requirement 4

A bridge was designed in Solidworks with the help of Solidworks simulation and was based off the truss bridge design. It needed span 10m while using as little material as possible. The bridge was required to be simply supported so had a roller on one side and a fixed geometry on the other side when simulations were run. The design also needed to have a flat walking surface, minimum width of 1m and withstand 100kg point load at midspan with a minimum factor of safety of 5. The maximum vertical deflection at the centre was required to remain below 2% of the span which is 200mm. The selected material also had to be isotropic.

Test 1 – Original Bridge – Alloy Steel

This is the baseline design. It was based of research which determined the type of choice of bridge which was a Truss Bridge. As shown through figure 1 it displays the first iteration of the design with 10m between the support and a width of 1580mm. When making the bridge the Welderment tool was used as it allowed material inside of the beams to be cut out which allowed weight to be saved.

As this was the first iteration the tests being done would determine what the next steps would be.

The material chosen first for this design was alloy steel because of how it used around the world.

The results shown through figure 5, 6 and 7 show a max displacement of 1.12mm with a factor safety that meets the requirements of 5. This means that I a lot of material can be taken out. It even had mass of 13,705.92kg

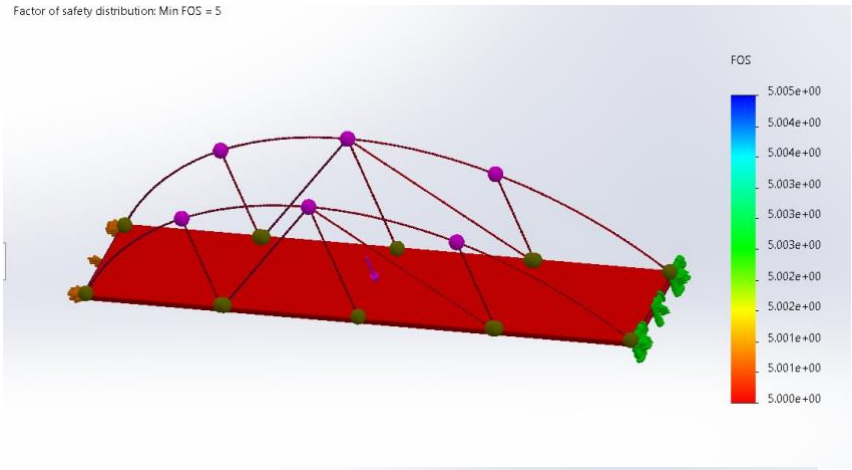


Figure 5 -Test 1 – Factor Of Safety

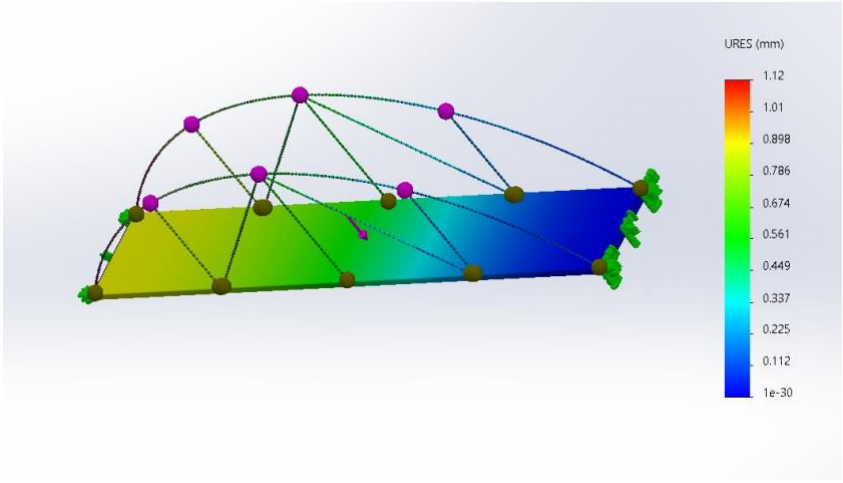


Figure 6 – Test 1 - Displacement Test

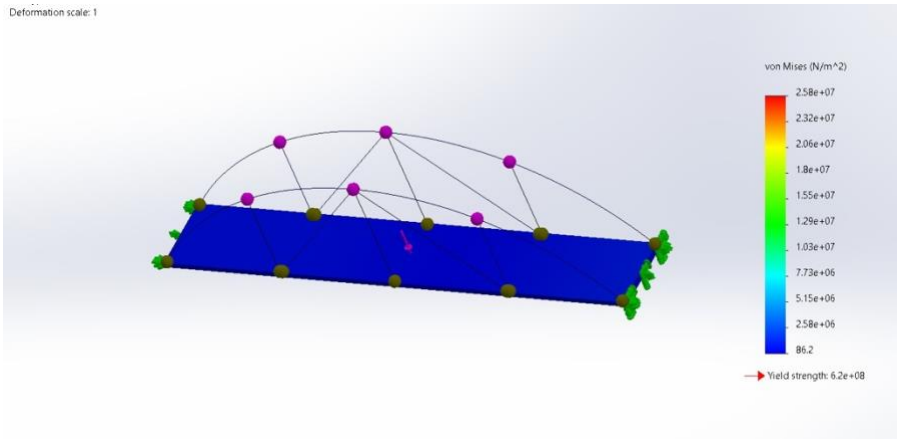


Figure 7 – Test 1 – Stress Test

Test 2 – Change of Dimensions – Alloy Steel

The bridge geometry was then modified to reduce material usage while maintaining the same loading and support conditions. This was done by reducing the boss extrude to 20mm. This allowed a lot of material to be saved with the

The results shown through figure 8,9 and 10 show a max displacement of 21.8mm with a factor safety that meets the requirements of 5. With the change to reduce material used the mass dropped to 2,754.99kg

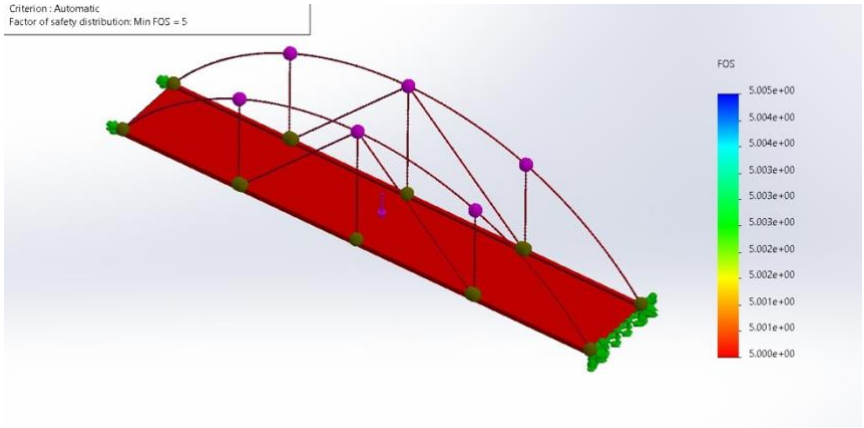


Figure 8 – Test 2 – Factor of Safety

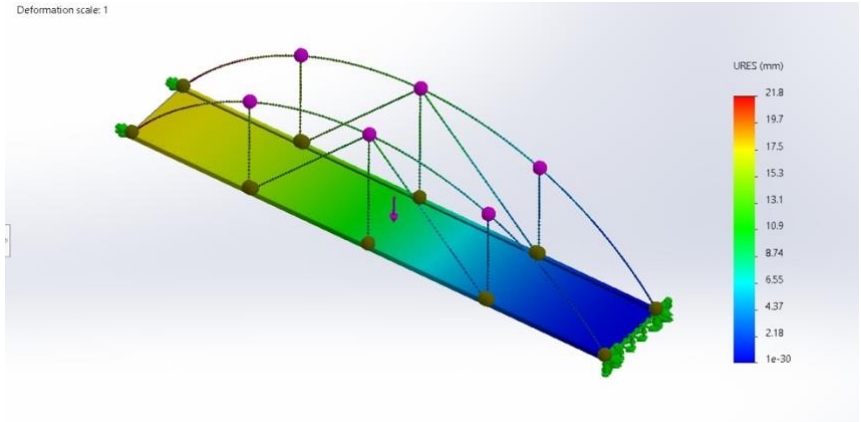


Figure 9 – Test 2 – Displacement Test

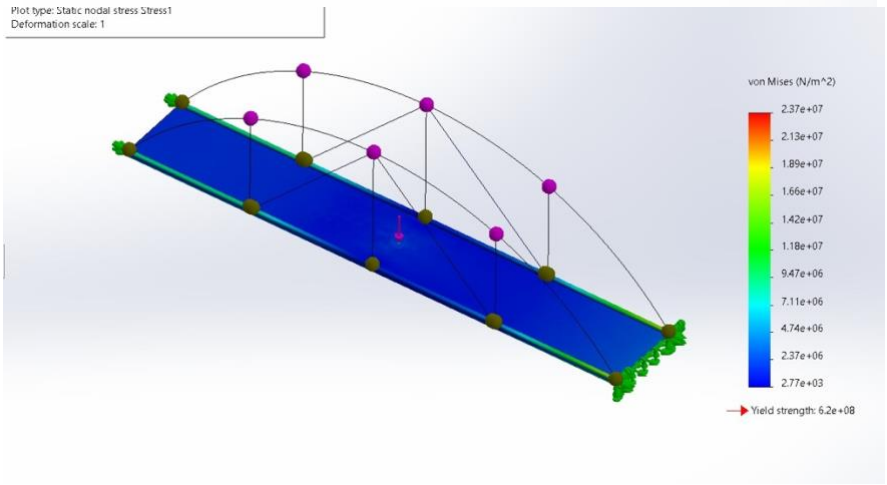


Figure 10 – Test 2 – Stress Test

Test 3 – Change of Material -

After the last test a new test was now done by a change of material to reduce the mass of the bridge. 6061 Aluminium was the chose material as it was isotropic and offered a great strength to weight ratio. This test was done to determine if a lighter material could still satisfy the requirements.

The results shown through 11, 12 and 13 show a maximum displacement if 66.4mm but it failed with to reach the minimum factor of safety of 5. However, the weight was 966.04kg. Also, with no design changes only material and it failing the safety of 5 and with this assignment not asking for changes in weight only in changes in how much material is used it means aluminium isn't a sensible choice.

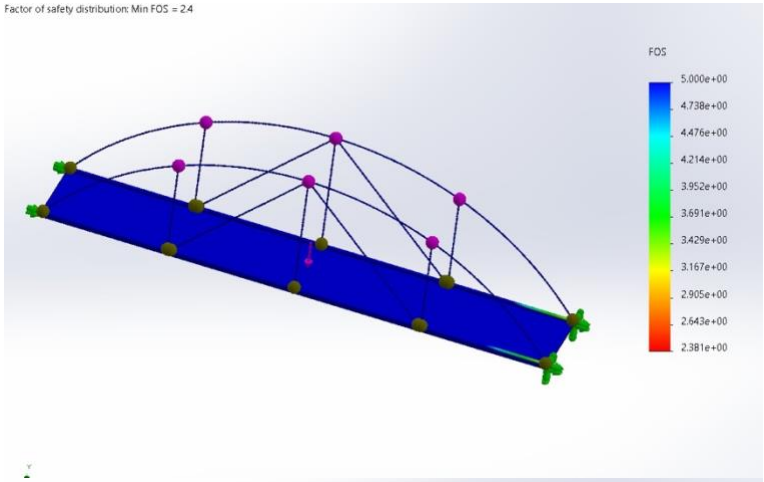


Figure 11 – Test 3 – Factor of Safety Test

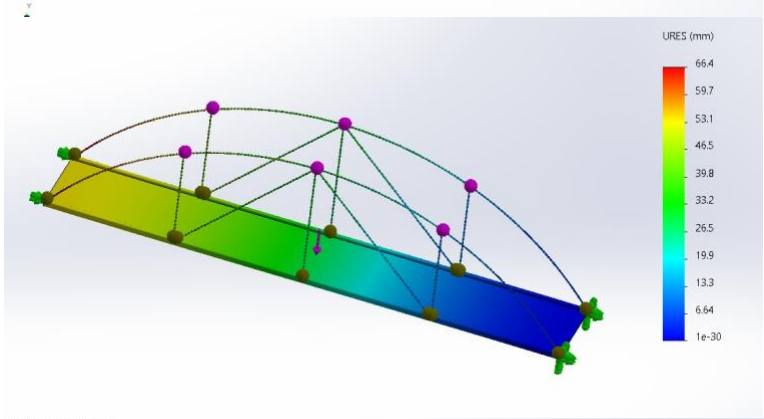


Figure 12 – Test 3 – Displacement Test

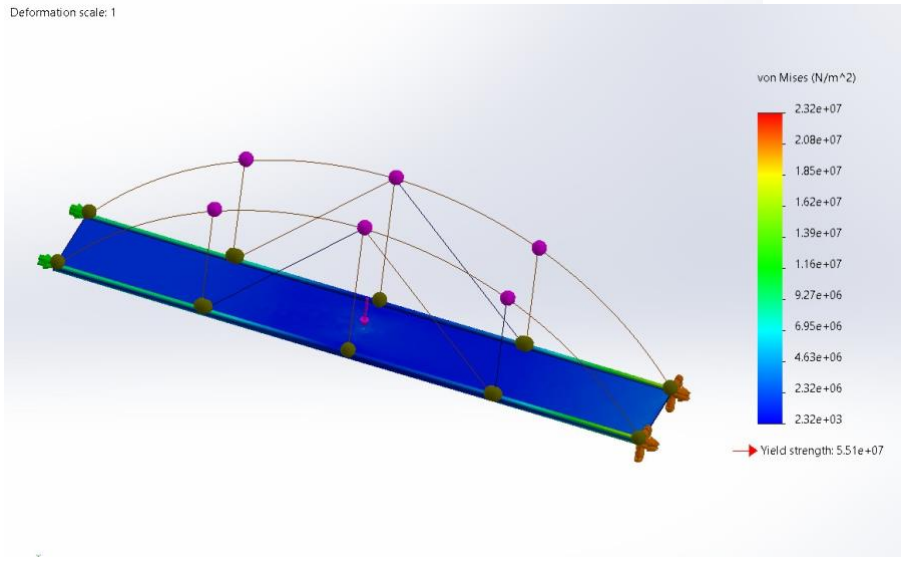


Figure 13 – Test 3 – Stress Test

Test 4 – Reduction of material

The final of test the aim of this was to reduce the material as much as possible. This was done by reducing bottom rectangular tubes from 120 x 80 x 8. This reduced the weight to 2,463.58kg. It also had a displacement of 3.1mm while also having a factor safety that met the requirement of 5.

This displays how this design is sufficient as shown through figures 14, 15 and 16 as it meets the requirements. With attempts to reduce the material used through design changes and material changes. This meant Test 4 was the best bridge with the material chosen being alloy steel.

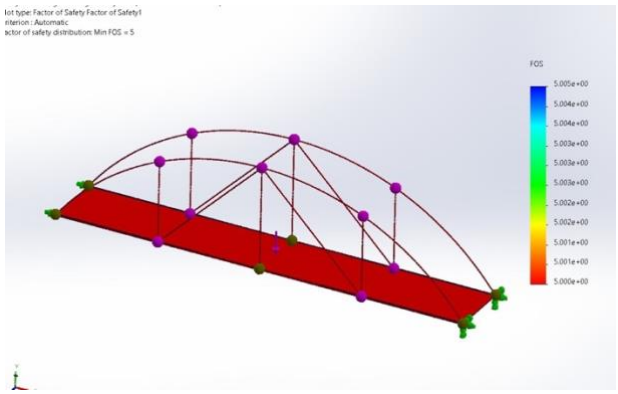


Figure 14 – Test 4 – Factor Of Safety

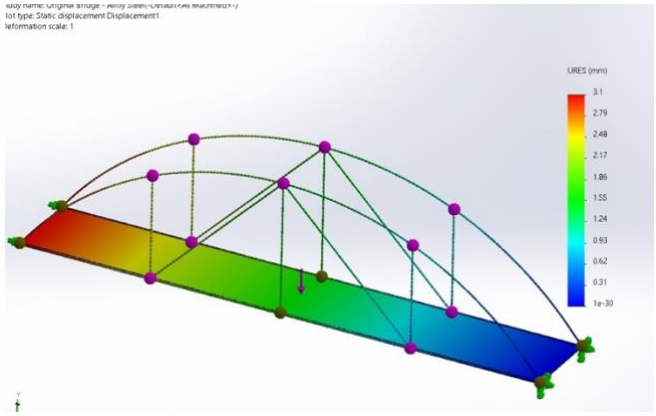


Figure 15 – Test 4 – Displacement Test

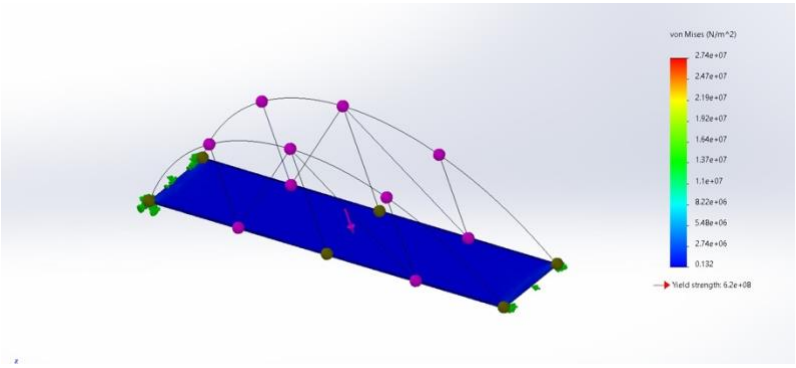


Figure 16 – Test 4 – Stress Test

Assumptions and Simplifications	
1	The assumptions and simplifications for requirement 4 was that dynamic effects from walking, bouncing or vibration were not considered in the simulation of the studies.
2	The 100kg force was simplified as 981N vertical downward load at the centre of the deck.
3	The mesh settings were done automatically during run this study. This was to ensure the computer would be able to handle the study.
4	Finally, any welding defects were not considered in the simulations as everything was considered to be perfect.

Table of results						
Test	Material	Key Change	Deflection	Minimum FoS of 5	Mass	Pass/Fail
1	Alloy Steel	Baseline Test	1.12mm	Achieved	13,705.92kg	Pass
2	Alloy Steel	Change of Dimensions	21.8mm	Achieved	2,754.99kg	Pass
3	Aluminium - 6061	Change of Material	66.4mm	Failed	966.04kg	Fail
4	Alloy Steel	Reduction of Material	3.1mm	Achieved	2,463.58kg ,	Pass
Overall this shows the best design to fit all of the requirements is Test 4 as it saves the most of amount of material while meeting the Factor of Safety and Deflection requirements when having a point load of 981N and the design requirements. It also had the least amount of weight. As Test 4 improved on Test 2 by reducing mass by a further 291.41 kg while maintaining acceptable deflection and factor of safety						

References

A Beginner's Guide to Injection Moulding (2023) *Protolabs.com*. Available at: https://www.protolabs.com/en-gb/resources/guides-and-trend-reports/a-beginner-s-guide-to-injection-moulding/.

Aktas, S. and Kisioglu, Y. (2020) 'Effects of thread rolling processing parameters on mechanical properties and microstructures of high-strength bolts', *Materials Testing*, 62(10), pp. 1017–1024. Available at: https://doi.org/10.1515/mt-2020-621010.

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M4x6 Cheesehead Sloted Nylon Screw (2026) *Orbitalfasteners.co.uk*. Available at: https://www.orbitalfasteners.co.uk/products/m4-x-6-cheesehead-slotted-nylon-screw-grade-66-natural (Accessed: 26 April 2026).

M6 x 12mm Hexagon Setscrews (DIN 933) - Aluminium 7075 (2026) *GWR Fasteners Limited*. Available at: https://www.gwr-fasteners.co.uk/m6-x-12mm-hexagon-setscrews-din-933---aluminium-7075-93862-p.asp (Accessed: 26 April 2026).