ADDITIVE MANUFACTURING OF A GANTRY CRANE

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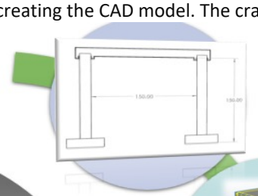
ABSTRACT

This project details the design, fabrication, and testing of a gantry crane that was created using SolidWorks for design and Ultimaker 2+ for 3D printing. The crane was able to lift weights more than ten times its own, showcasing the practicality and strength of 3D-printed components in substantial applications. The results confirmed the success of the project, providing new understanding into the capabilities of 3D printing technology in producing heavy machinery and emphasizing its adaptability, effectiveness, and cost benefits over traditional manufacturing techniques.

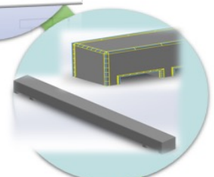
METHODOLOGY

Designing:

SOLIDWORKS served as the tool for creating the CAD model. The crane comprised of three primary components: the base, support, and beam.

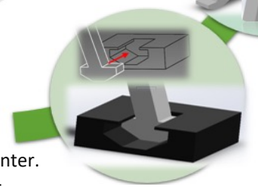


Design requirements;
1. 15cm span and height
2. Withstand minimum 10 times the weight of the crane



Beam Design:
1. Optimal thickness and width for robust load-bearing capacity
2. Strategic chamfers at critical points to prevent stress concentration
3. Incorporated teeth for secure fit, preventing beam movement during loading and ensuring consistent crane span

Support Design:
1. Tailored width and thickness for optimal load-bearing capacity
2. Strategically applied chamfers at critical points to mitigate stress concentration
3. Designed and adjusted cross supports for efficient stress distribution during loading



Support & Base Design;
1. Employed a two-piece printing approach to:
- Minimize the need for additional supports during printing
- Enhance support beam strength by aligning with the printing direction
2. Engineered a secure locking mechanism between the base and supports to facilitate easy and robust assembly.

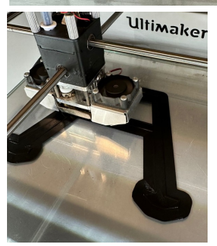
Fabrication:

Key parameter we set in the 3D printer.

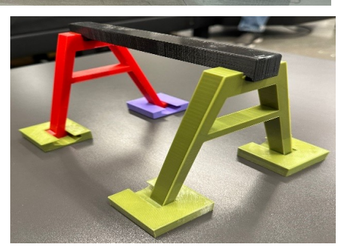
- Printer used – The Ultimaker 2+
- Nozzle size – 0.4mm
- Infill – 50%
- Pattern – Triangle
- Wall thickness – 0.8 mm
- Speed – 50mm/s
- Support – yes(tree design)
- Adhesion – yes
- Material Selection: PLA

Considerations during Printing:

- The printing direction is chosen carefully to attain the maximum stiffness along loading directions
- Selected fabrication parameters were crucial for accurately replicating a gantry crane with fidelity and strength, ensuring precise and robust construction.



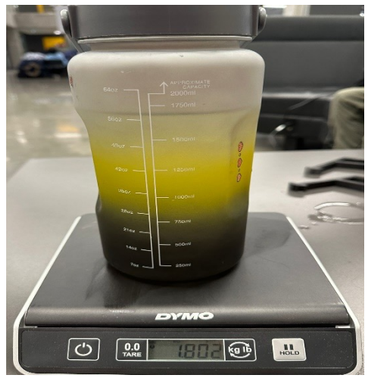
Printing process



Final assembled model

RESULTS

Weight of crane and the testing object



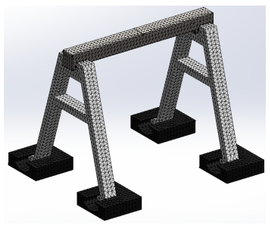
- The span and height was verified to measure as 15cm
- Crane Weight – 176g; Initial testing Object – 1.8kg
- The crane was positioned on a level desk, and the weight was cantered on the middle of the beam
- The crane effectively lifted a load that was 10 times its weight, and there was no observable failure in the beam

Testing the crane's ability to lift 10x it's weight

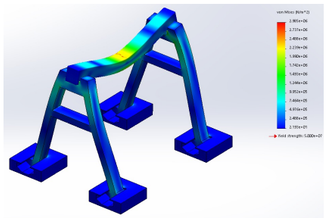
- The crane is subjected to rigorous testing in incremental steps until structural failure occurred at 40.82kg (90lbs)
- The crane managed to withstand a test weight of 70 pounds, equivalent to 31.75 kilograms
- Performance Ratio: Ms/Mi = 180; where Ms. = Mass lifted and Mi = Mass used to print

OTHER CONTRIBUTIONS TO THE PROJECT

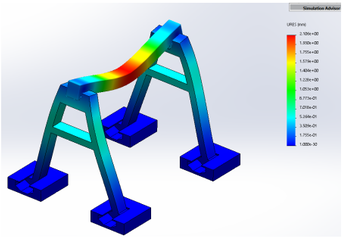
During the design phase of the crane, we performed multiple stress analysis at different stages using SOLIDWORKS to optimize the design of the components and ensure its capability to withstand the required weight with sufficient safety.



Fine mesh applied on structure



Stress distribution in the crane



Displacements in the crane

The analysis results allowed us to comprehend how stress is distributed within the components. Subsequently, we were able to implement adequate supports, appropriate thickness, and suitable radius at crucial points.

CHALLENGES

- Given the limited availability in the Makerspace lab, we adjusted the infill density to 50% to expedite the printing process
- A significant learning from this project was the benefit of pre-simulating prints using CURA, which minimized the need for multiple prints
- Our project adheres to the specified requirements

CONCLUSION AND FUTURE WORKS

- The crane's structure remained intact and undistorted throughout testing
- The crane was successfully able to support 10 times its own weight
- Impressively, the crane supported a weight of 31.75kg before it failed
- Looking ahead, we plan to explore superior 3D printing materials to further improve performance