DESIGNING AN ADJUSTABLE LOAD TOWER FOR FORKLIFT TESTING

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INTRODUCTION

- During R&D testing, the Hyster-Yale Group (HYG) forklifts are exercised on a test course which involves lifting a load onto and off of a platform at a specific height.
- Currently, HYG uses static load towers at a fixed height (see Figure 1).
- When a new test height is needed, HYG engineers need to manufacture a completely new tower, costing the company a lot of time, money, and materials.
- By switching to an adjustable load tower design, HYG will be able to improve the efficiency of their load testing.

Figure 1. HYG static load towers.

We need to design an adjustable latching mechanism for a new load tower at the Hyster Yale Group so that its height can be easily manipulated by forklifts during R&D testing yet still capable of supporting up to 5000 kg loads.

CRITICAL REQUIREMENTS & SPECS

Height adjusted via forklift

Strong enough to support max load

Safe for driver and supervisor

Feature	Spec
Height Range	2-5 m
Resolution	152.4 mm (6 in)
Time to Adjust	≤ 2 Hours
Weight Capacity	≥ 5000 kg
Load Dimensions	1.22x1.52 m (4x5')
Safety Factor	3-5

Table 1. Engineering Specifications

ACKNOWLEDGEMENTS

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References

PRELIMINARY DEVELOPMENT

Concept Generation

- The top two designs we developed were the oven rack (see Figure 2) and ratchet.
- We chose to further develop the ratchet due to welding fatigue concerns for the oven rack.

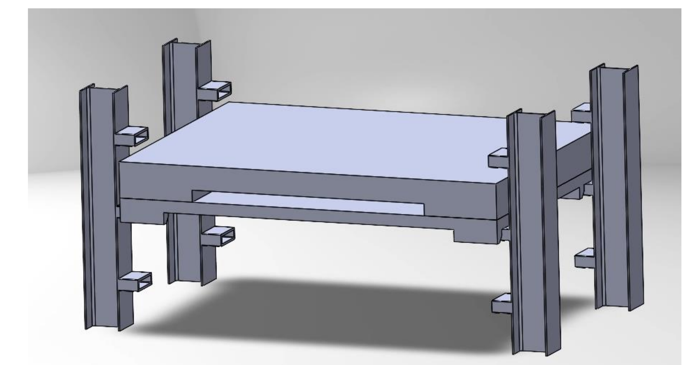

Figure 2. CAD model of oven rack design.

Prototype Iteration

- Design iterations mainly revolved around pawl/rack geometry and rack placement on the corner beams in order to achieve successful pawl actuation.

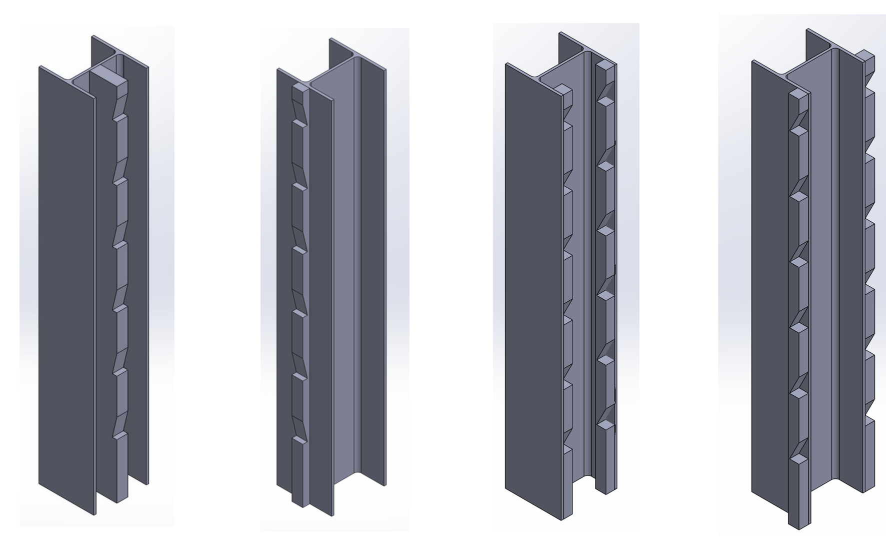

Figure 3. Design iteration on the rack.

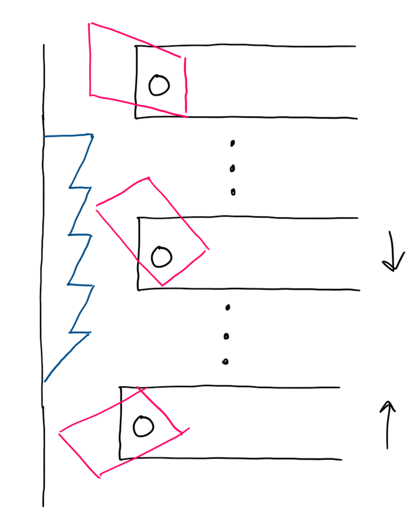

Figure 4. Pawl actuation.

FINAL DESIGN

- I-beams were replaced with box beams to reduce rack material.
- Rollers were added to accommodate platform misalignment.
- Material: Box beam (1018, 36-ksi), Rack (1045, 50-ksi), Pawl & Shaft (9310, 100-ksi)
- Premade Parts: Pillow block bearings and caster wheels.

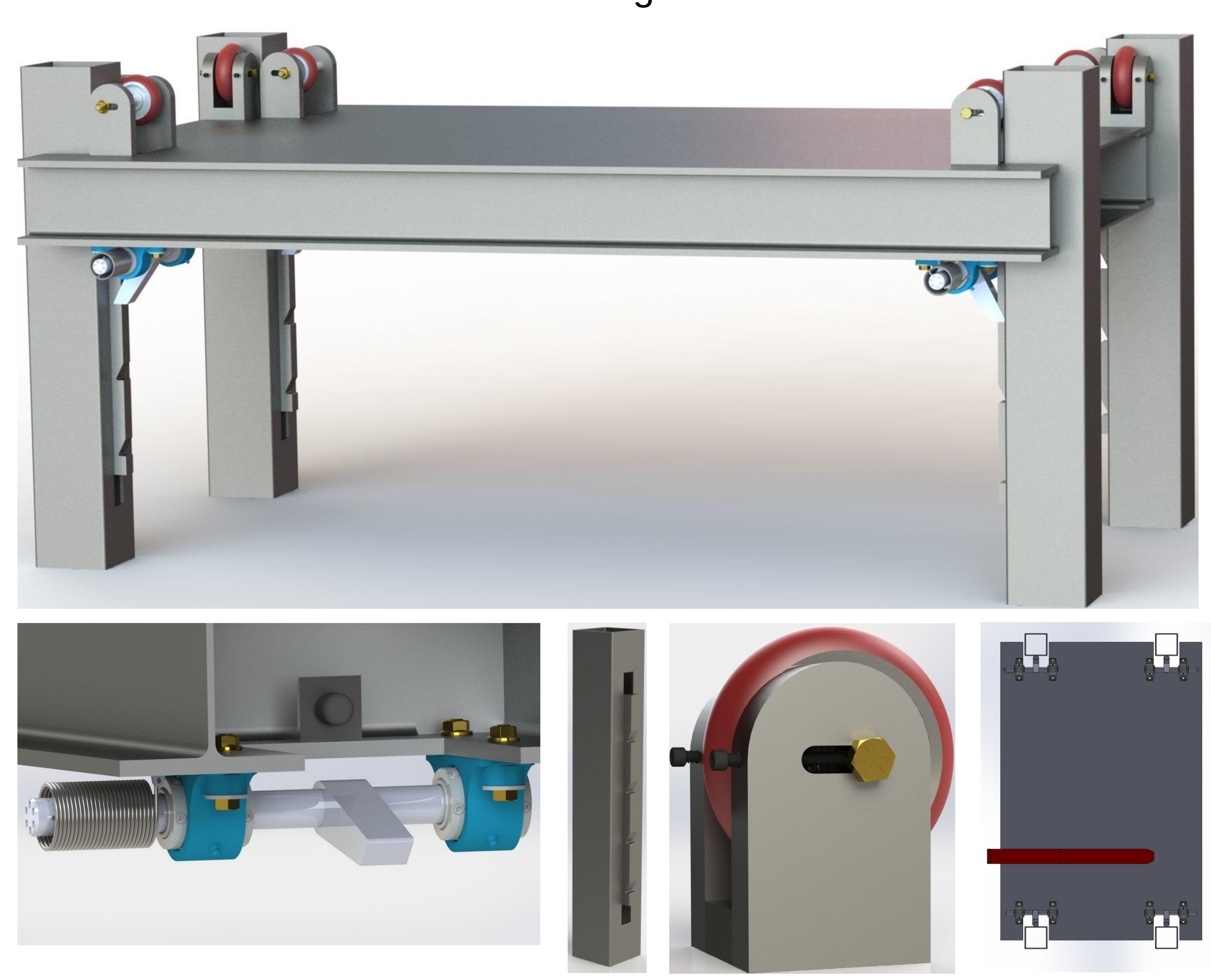

Figure 5. CAD models of final full-scale prototype.

RESULTS & VALIDATION

FEA Results

- Our FEA analysis proved the design was capable of supporting 5000kg with a safety factor of 3.7.

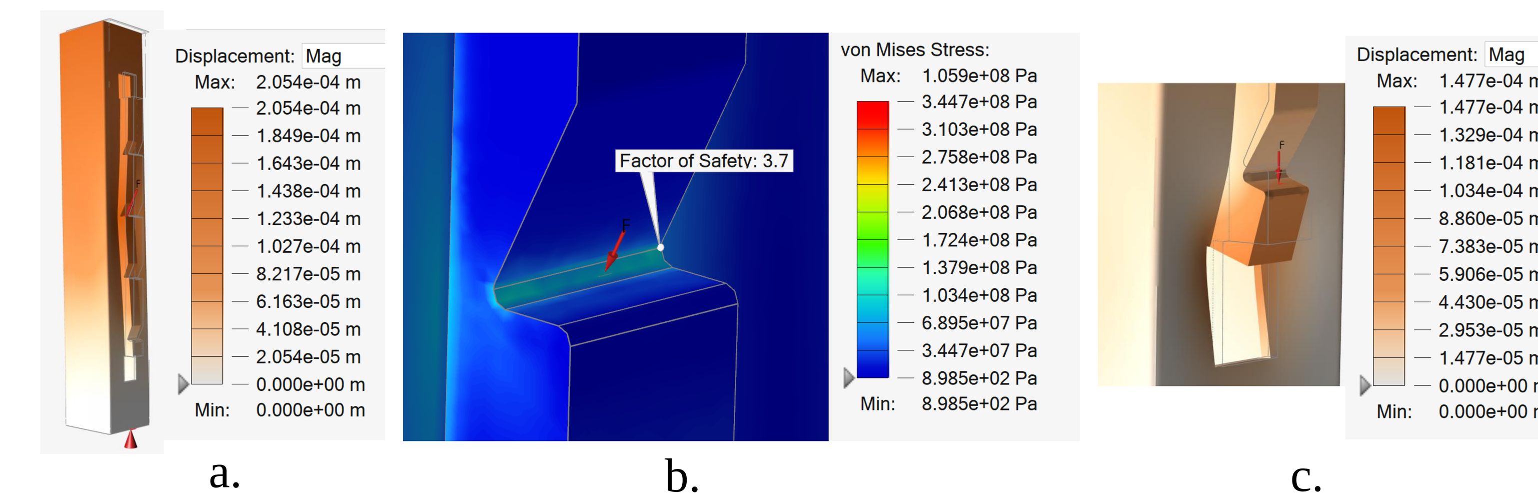

Figure 6: FEA analysis of the (a) deflection and (b) stress concentration of the rack. Deflection of the box beam slot is shown in (c).

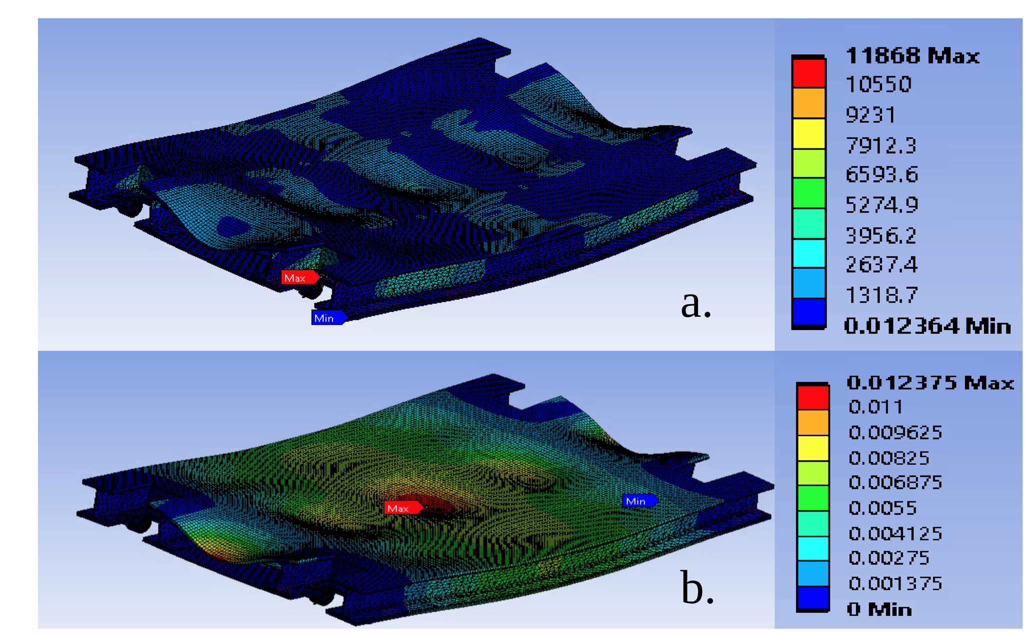

Figure 7: FEA analysis of the (a) deflection and (b) stress concentration of the platform

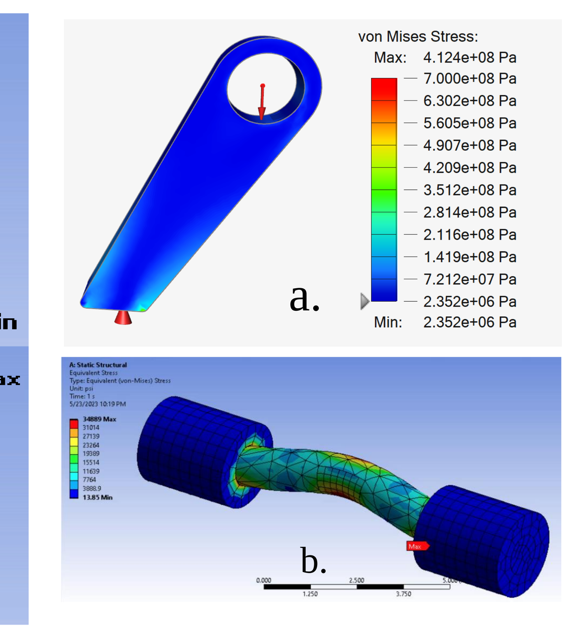

Figure 8: Stress concentration of the (a) pawl and (b) shaft.

Spring Design

- Resting position of pawl is horizontal
- Spring constant:13.78 lbf*in/turn
- Spring body turns: 25.5 turns
- Fatigue factor of safety: 1.81
- Diameter: AWG 8 (0.1285")

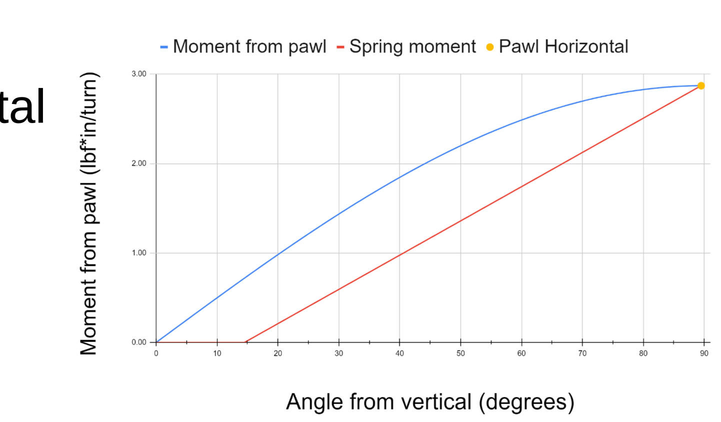

Figure 9: Vertical pawl angle vs. moment

Scaled Prototype

- Used a scale factor of 2.5.
- Found the addition of rollators does limit unwanted lateral motion, improving the ease of operation.

CONCLUSION & FUTURE WORK

- Design successfully allows easy upwards and downwards height adjustment with a safety factor of 3.7.
- Still needs further validation testing using an actual forklift to test lateral misalignment and tilting effects at 5m.
- For further development, we recommend a secondary Scott Russell pin mechanism for extra security.

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