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## ABSTRACT

- The study conducted the theoretical analysis and the finite element simulation on Intermodal Freight Shipping (ISO) containers under different loading scenarios.
- Few studies and applications on permanent structures as building components cooperating with shipping containers
- The study is underway. Two stages need to be completed for the entire research:
  - Phase I--loading analysis and the Mises Stress Contours;
  - Phase II--energy performance of the structure
- Help understand the structural features and noticeably reinforced areas on the shipping containers by stimulating structural loading scenarios in real situation
- Carry out a participatory construction guide for shipping container building components.

## INTRODUCTION

### Objectives

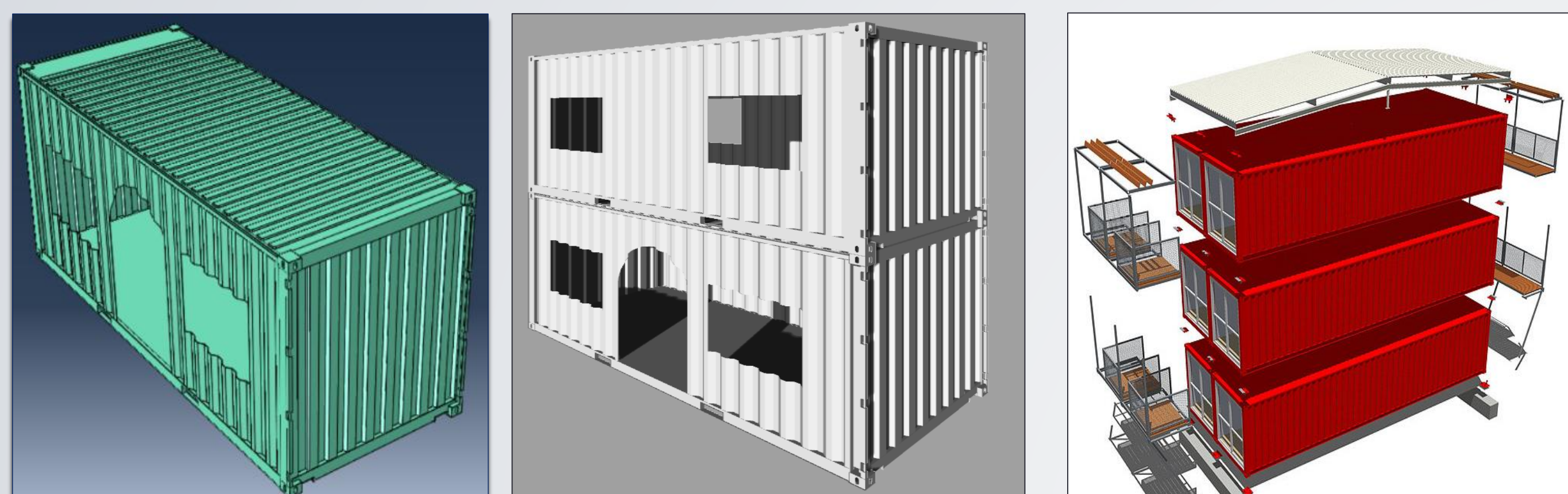
- Model and predict two-container structure reaction behavior via the finite element simulation
- Build a shipping container models via ABAQUS
- Distribute loads on edge beams and corner fittings from the top container to the bottom one
- Work toward finding and developing reinforcement
- Conduct energy performance analysis

### Background

- Recycling ISO containers with the pre-fabricated steel structure satisfies building standards, sustainability, and environmental and social acceptability.
- Several different pre-fabricated container housing solutions have already existed, but these solutions are still problematic
- Shipping containers need to be modified before recycling into a housing application.

### Significance

- Recycled containers could provide fast pre-fabricated structures for quick and quality structures in sustainable housing, disaster relief housing and public buildings.
- The sustainable development of shipping container structures have feature of time, money and energy saving to build homes, which leads an efficient manner satisfying both architectural design and engineering requirement.
- It is meaningful to be a next generation of technology- and green-oriented housing construction solutions.

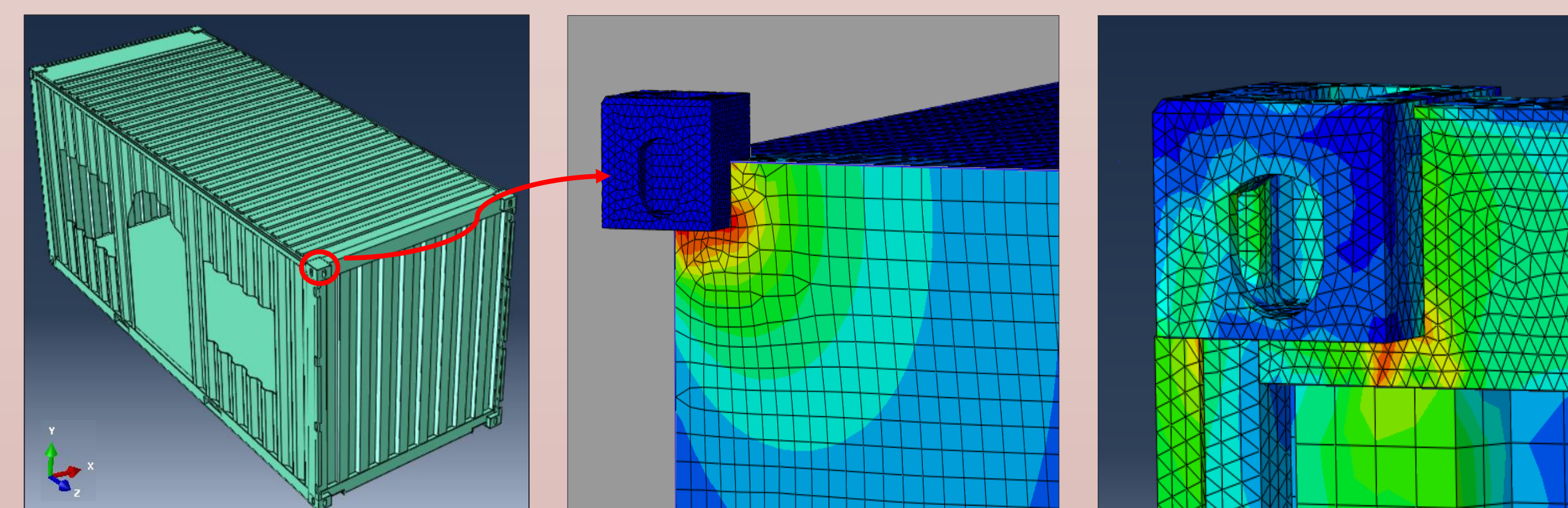


Figures. From single unit of shipping container to Keetwonen student housing in Amsterdam

## METHODS

### Stage Overview

- In Phase I, the study will take further investigation into a modified structure and load distribution on containers using finite element computer modeling.
- Different types of shipping containers will be studied, and a database will be created to show the different types and dimensions of containers.
- In Phase II, the infinite element analysis will be taken further using smaller mesh units, and energy performance analysis of the container will be conducted



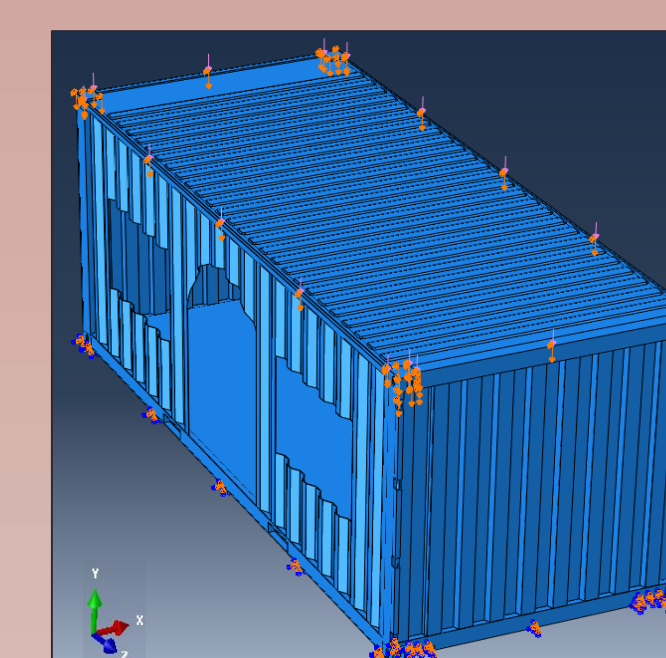
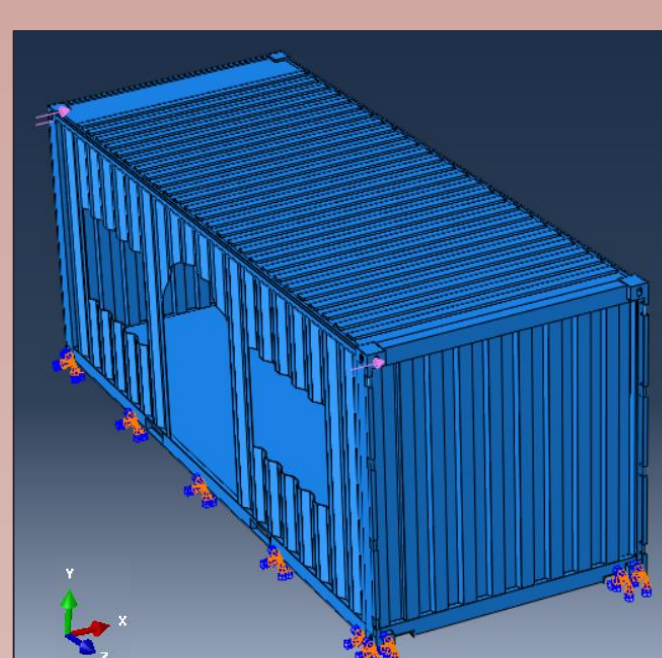
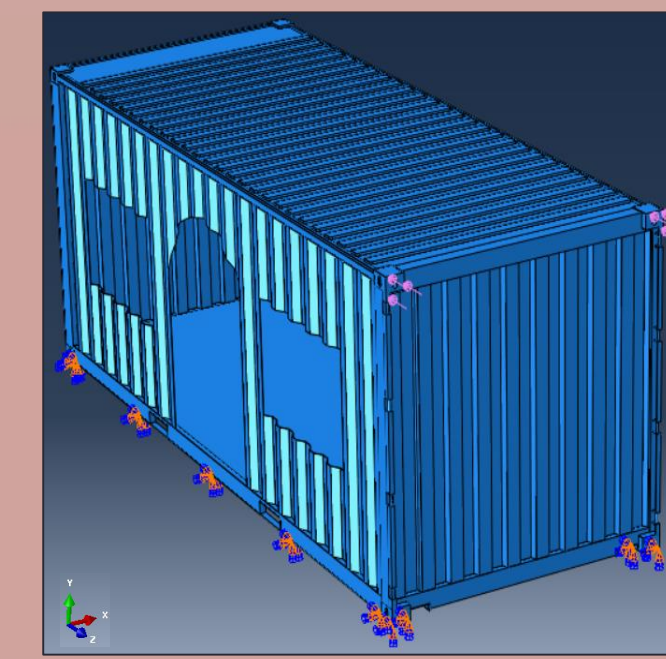
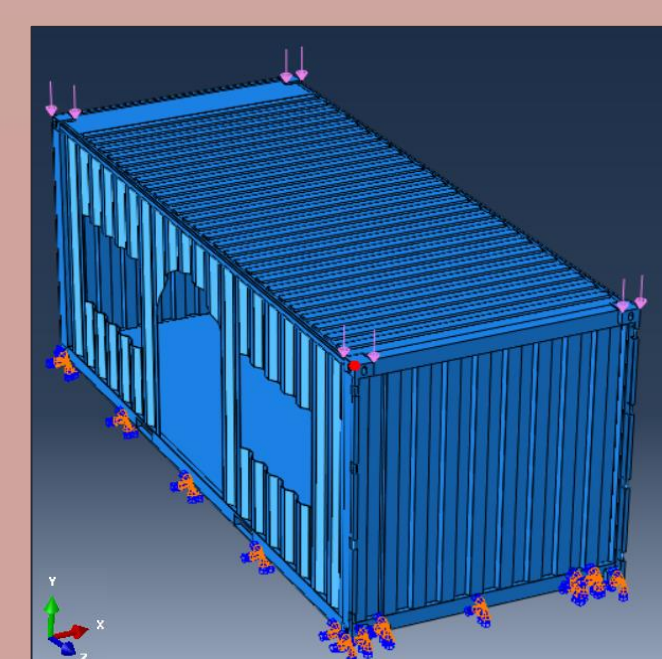
Figures. Finite element model from the large to the details

### Shipping Container Type Study

1st Character Size-Code	Container Length (ft)	2nd Character Size-Code	Container Height (ft)	Container Width (ft)
1	10	0	8	8
2	20	1	8	8
3	30	2	8-6in	8
4	40	3	8-6in	8
8	35	4	9	8
9	45	5	9-6in	8
A	23-5.5in	6	>9-6in	8
B	24	7	4-4in	8
C	24-4.5in	8	4-3in	8
D	24-5.3in	9	<4	8
E	25-7.8in	C	8-6in	8<Ws8.2
F	26-6.9in	D	9	8<Ws8.2
G	41	E	9-6in	8<Ws8.2
H	43	F	>9-6in	8<Ws8.2
K	44-7.4in	L	8-6in	8<Ws8.2
L	45	M	9	>8.2
M	48	N	9-6in	>8.2
N	49	P	>9-6in	>8.2
P	53			

### Loading Scenarios

1. Loads on the Top Corners
2. Loads on the Top Side Corners in X-direction
3. Loads on the Top Side Corners in Z-direction
4. Loads on the Top Beams and Corners



## RESULTS

Loading Scenarios				
Original Container				
Container Stress & Exaggerated Deflection				
	(a)	(b)	(c)	(d)

## CONCLUSIONS

- Based on the finite element model, the container stiffness under each of loading scenarios had been shown.
- For all loading scenarios, the calculated maximum elastic load for corner castings and top beams reached the corresponding loads specified in ISO code and standard.
- A more comprehensive evaluation involving finite element simulation on stiffness of container sidewalls, top beams and corner castings would be further studied.
- The research is currently underway to analyze energy performance of shipping container structures under different loading scenarios.
- The research is currently underway to bring participatory construction guide to the container structures market.

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