# "Virtual" Chair Deconstruction

## ARCH 614

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# Introduction

- Purpose: To take principles of static structural analysis and design and applying them to a real-world example.

- Objectives:
  - Virtually Model a real chair with its defined dimensions
  - Determine the design capacities of the chair based on its materials and connections
  - Add a realistic load to chair, trace the load through the chair's structural members, & input into multi-frame 3D to analyze the chairs response to the added load

# The Chair

- Manufacturer: IKEA

- Style: IVAR Dining Room Chair

- Construction Materials:
  - 2x2 No. 2 Dense (Assumed) Southern Pine
  - 5/8 Steel Screws (Assumed)

# Materials Analysis

- Design Capacities of Southern Pine:
  - Table of Dimensional Lumber 2" to 4" Thick, 2" & Wider
  - Values in Pounds Per Square Inch (psi)

| Size | Grade | Extreme Fiber Stress in Bending $F_b$ | | Tension Parallel to Grain $F_t$ | Horizontal Shear $Fv$ | Compression Perpendicular to Grain $F_c$ | Compression Parallel to Grain $F_c$ | Modulus of Elasticity $E$ |
|------|-------|------------------|-------------------|----|-----|-----|------|-----------|
| | | Single Member | Repetitive Member | | | | | |
| | No.1 | 1850 | 2130 | 1050 | 175 | 565 | 1850 | 1,700,000 |
| | No.1 NonDense | 1700 | 1950 | 900 | 175 | 480 | 1700 | 1,600,000 |
| **2x2** | **No.2 Dense** | **1700** | **1960** | **875** | **175** | **660** | **1850** | **1,700,000** |
| 2x3 | No.2 | 1500 | 1720 | 825 | 175 | 565 | 1650 | 1,600,000 |
| 2x4 | No.2NonDense | 1350 | 1550 | 775 | 175 | 480 | 1600 | 1,400,000 |
| 3x3 | No.3 and Stud | 850 | 980 | 475 | 175 | 565 | 975 | 1,400,000 |

# Chair Structure

- Use of individual columns, beams, girders
- Top plate acts as bracing for live loads on the chair
- The top plate sits on the horizontal members to transfer loads to the columns which are then transferred to the ground.
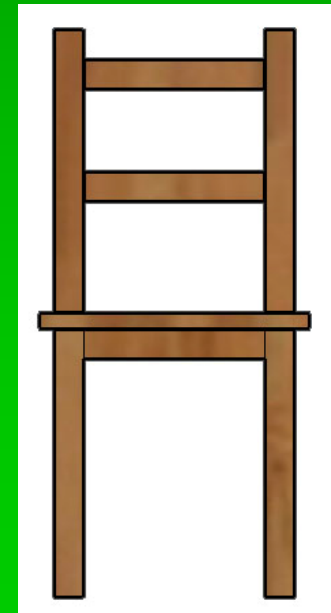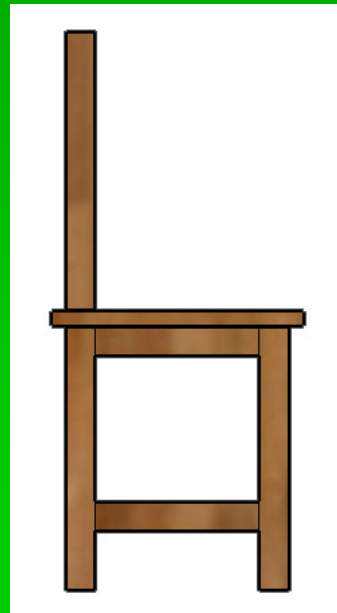
# Chair Assembly

- The individual structural members are brought together by simple butt joints
- The outside columns are screwed into the interior girders & beams using 5/8 inch screws
- The top seat plate is then screwed on top of the structural frame
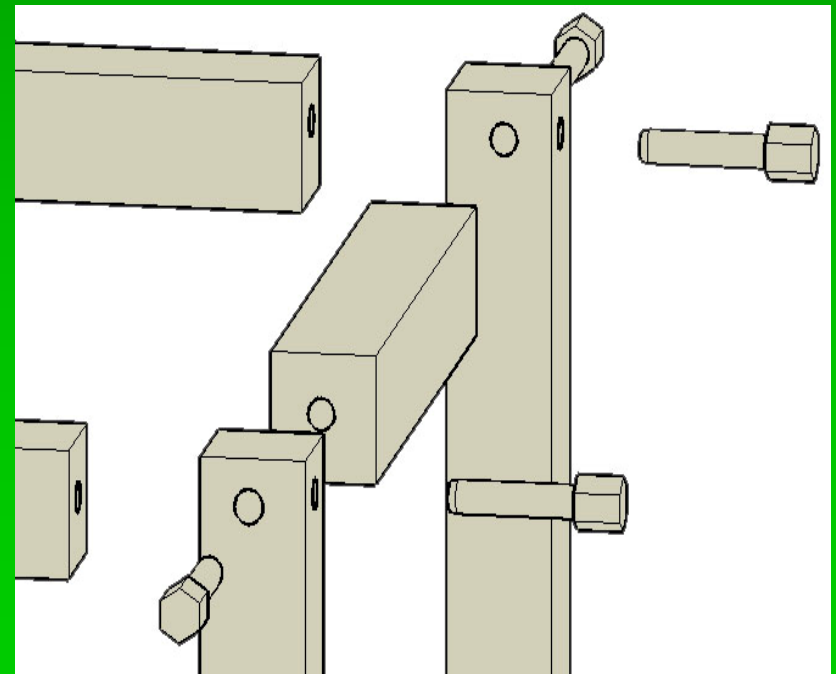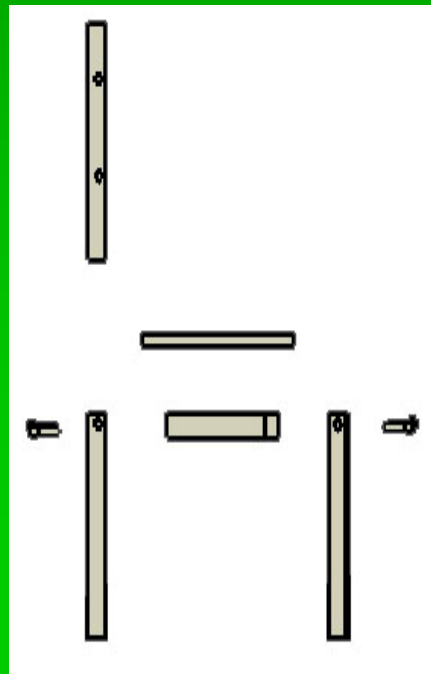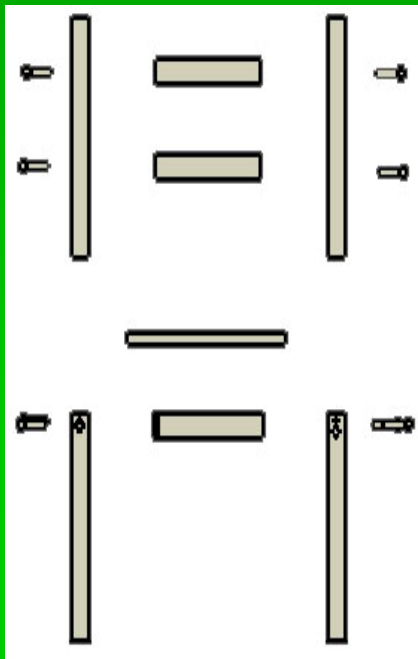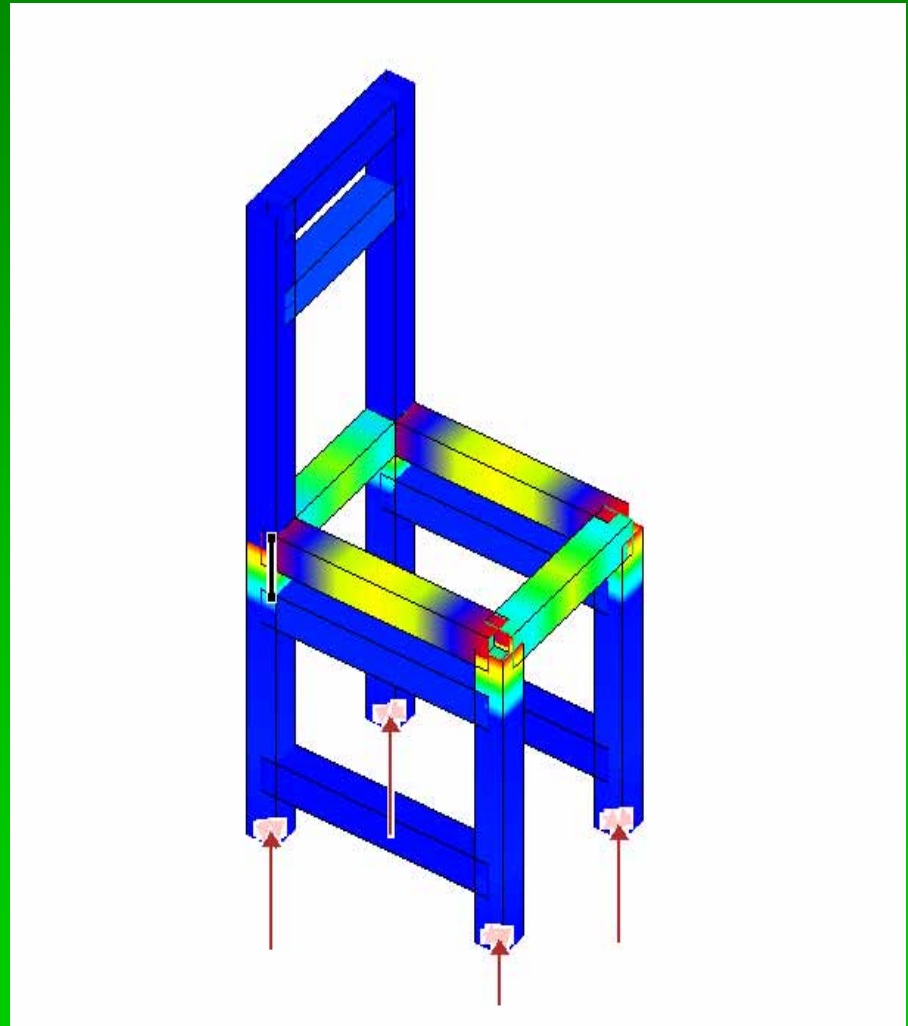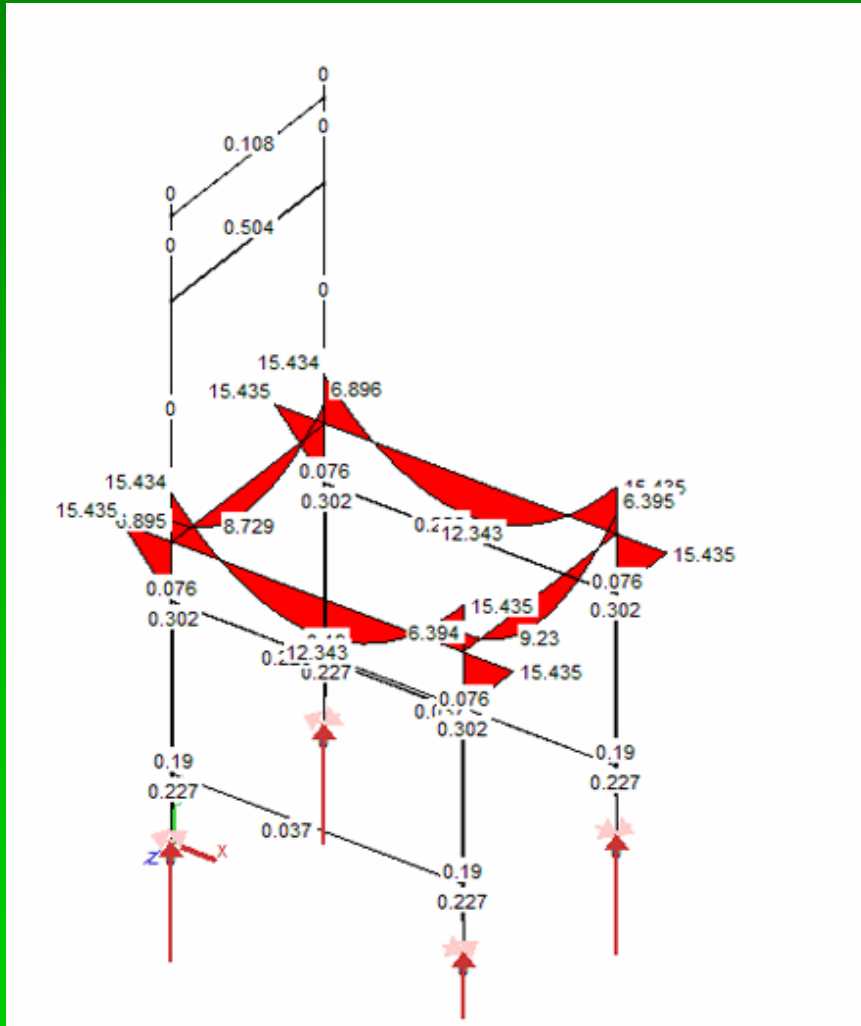
# Load Analysis Problems

- Assumed Load 1
  - A 500 lb person applying a vertical (y-axis) point load in center of chair
  - No lateral (x-axis) force on assumed load 1
- Assumed Load 2
  - A 500 lb person seated normally applying a vertical (y-axis) point load of 333 lbs (2/3 of weight)
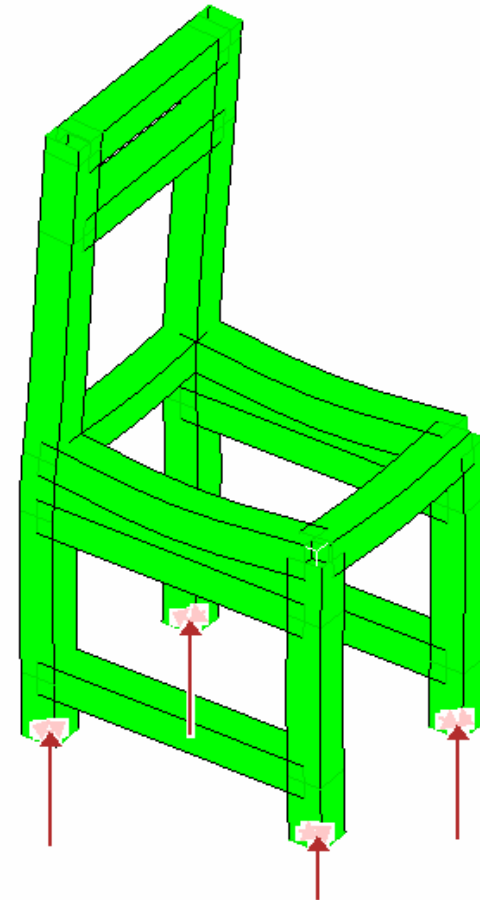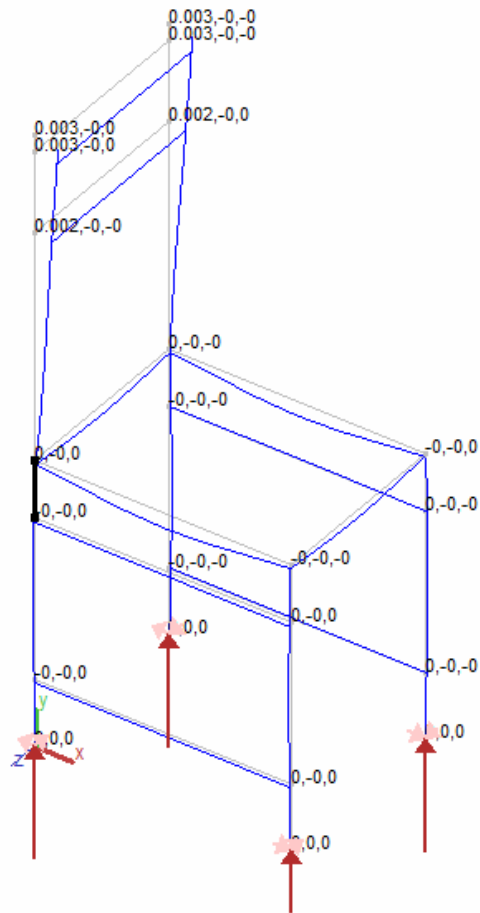  - A lateral (x-axis) load of 167 lbs (1/3 of weight)
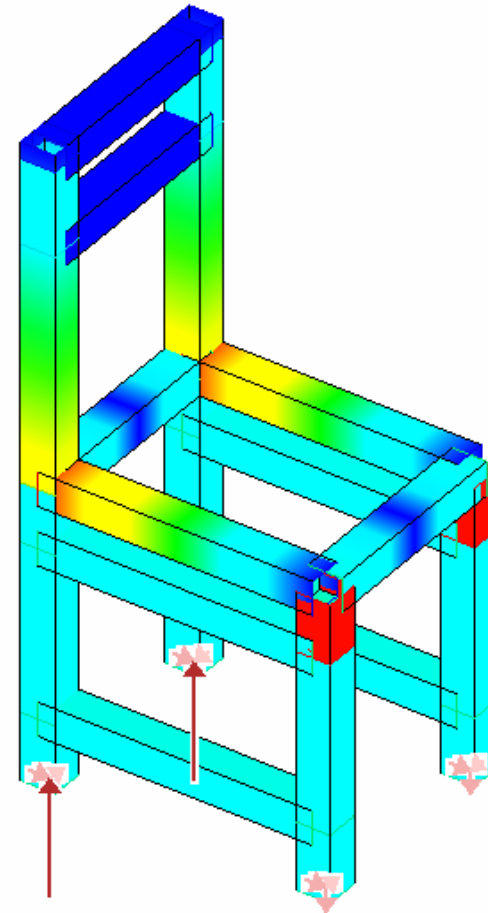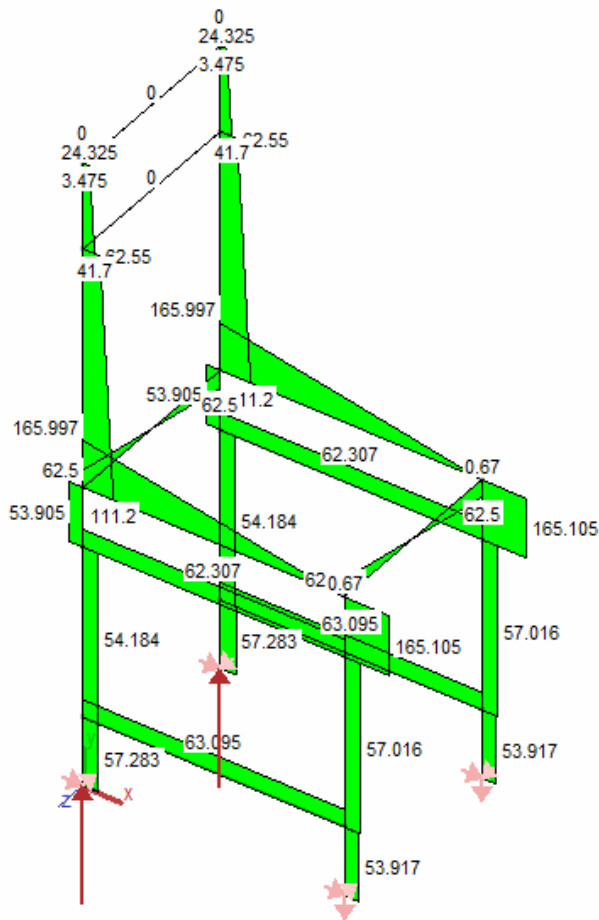
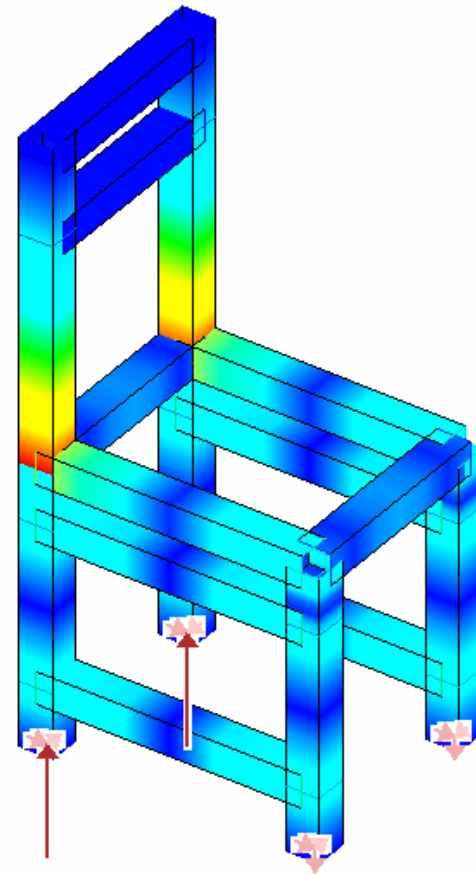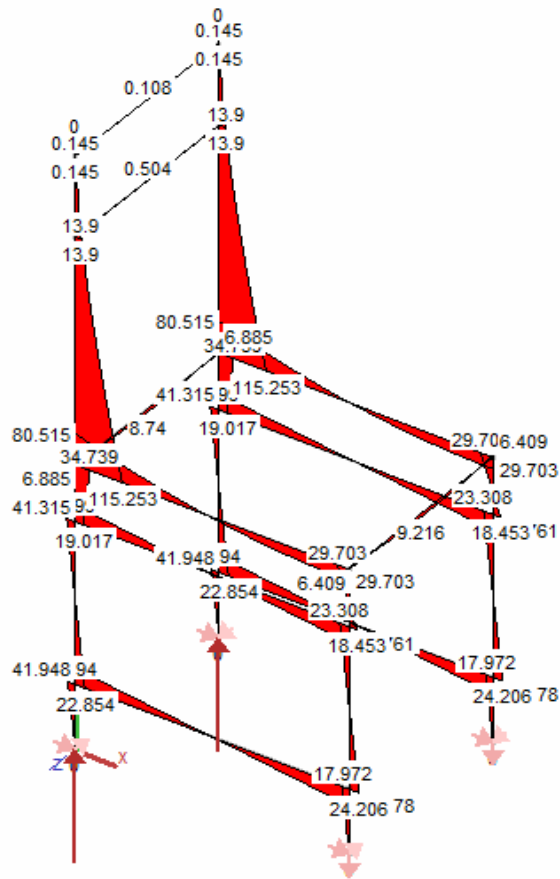# Load 1 Shear Results
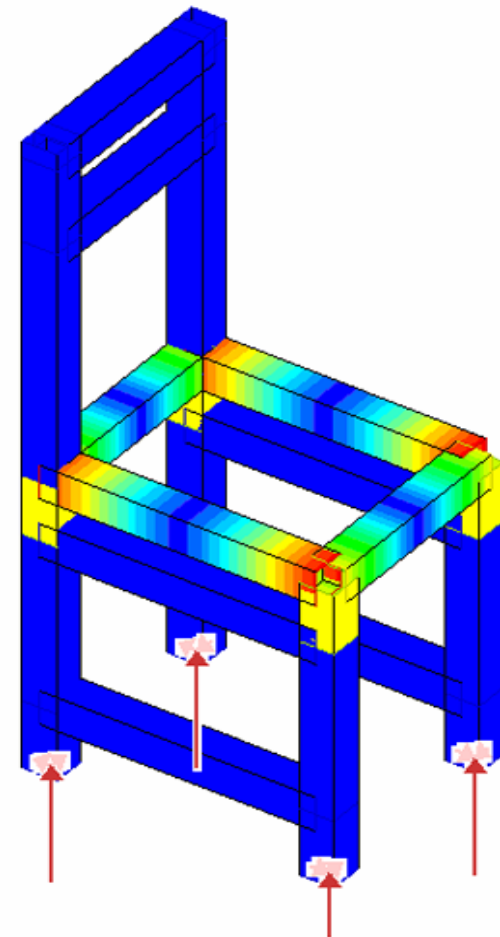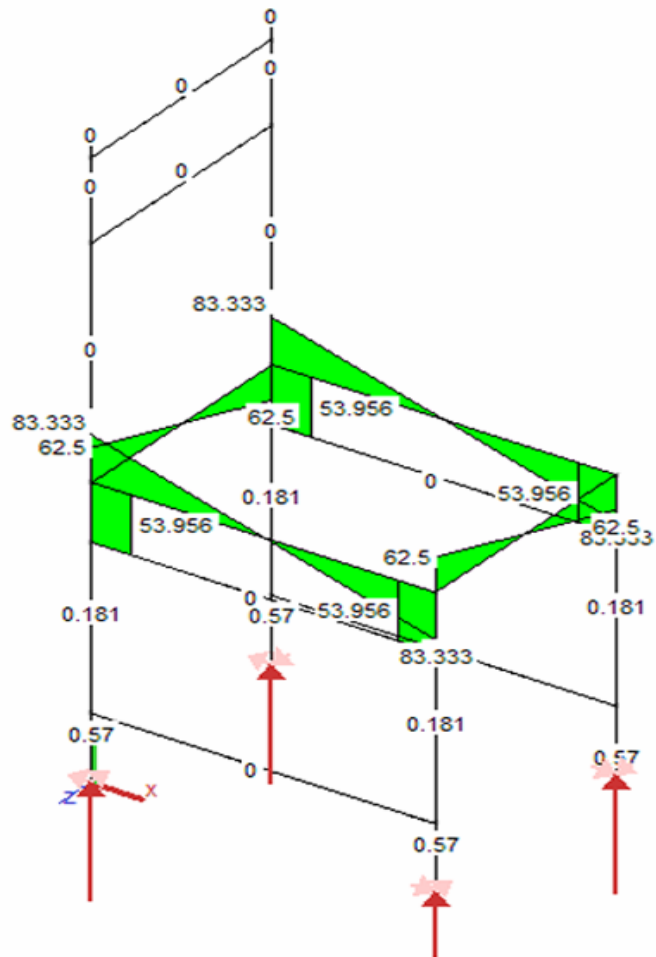
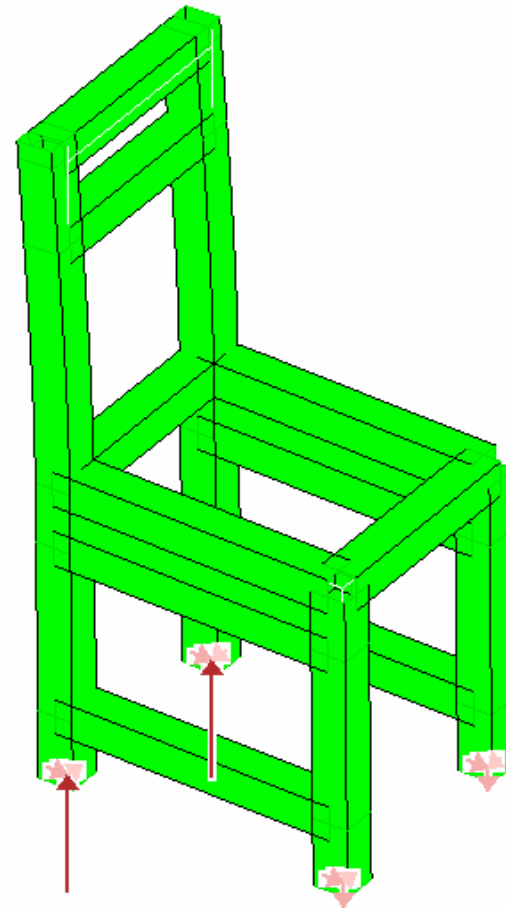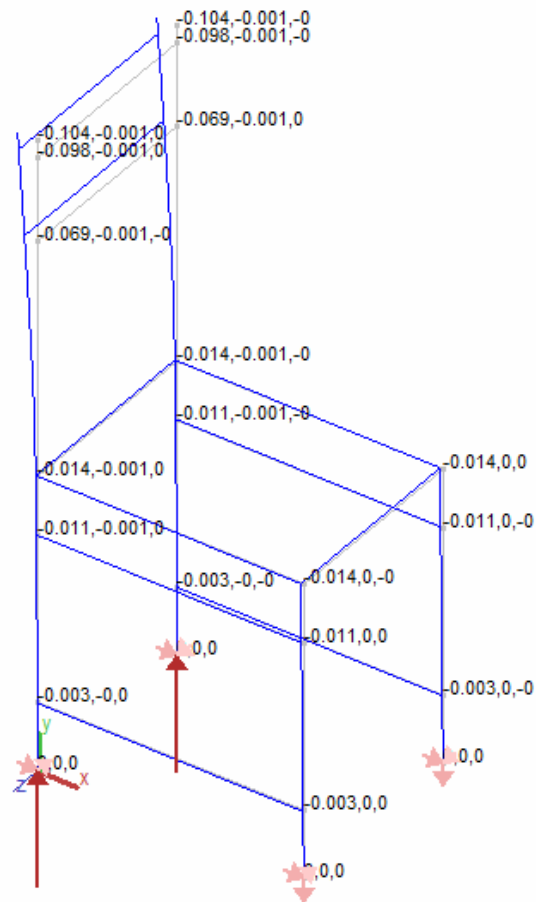# Load 1 Moment Results

# Load 1 Deflection Results

# Load 2 Shear Results

# Load 2 Moment Results

# Load 2 Deflection Results

# Conclusions

- Based on these findings, a 500 pound person does not come close to the capacity of the beam which leads us to assume that the <u>connections</u> would fail before the pine members would fail.

- In addition, the load capacities of the 5/8 screws would be able to handle the 500 lb load without any problems.

# References

Works Consulted

IKEA USA and the Ivar Chair;
   http://www.ikea.com/us/en/catalog/products/68156009

Southern Pine Design Values from the Southern Pine Council;
   http://southernpine.com/designvalues1.shtml

Dixieline Probuild;
   http://www.dixieline.com/woodjoint/woodjoints.html