STATICS - BRIDGE PROJECT

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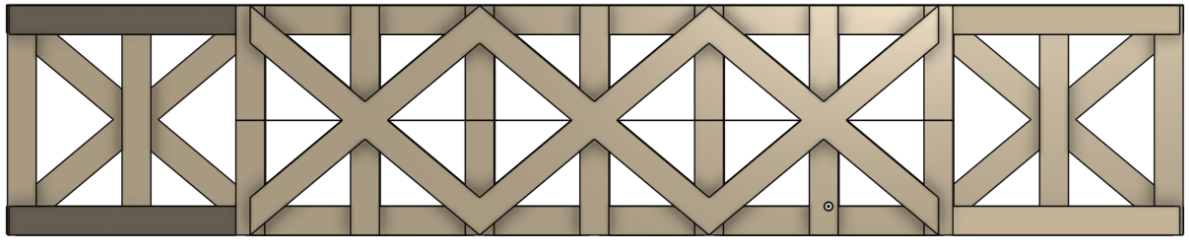
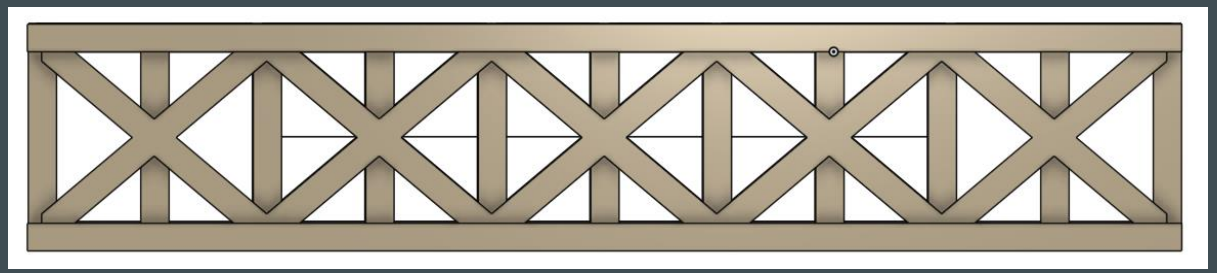
Problem Statement

Construct a bridge using light materials, calculate the force in each of the members given a known applied force, and verify stress points through FEA analysis

CAD DESIGN



TOP



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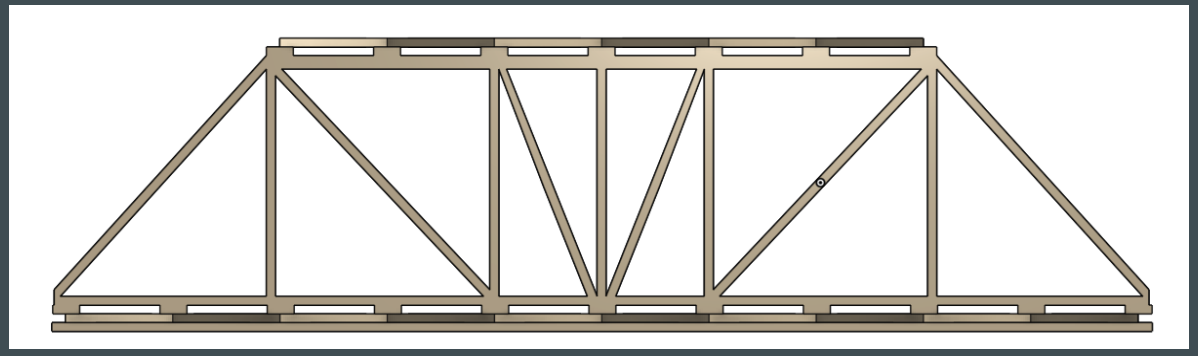
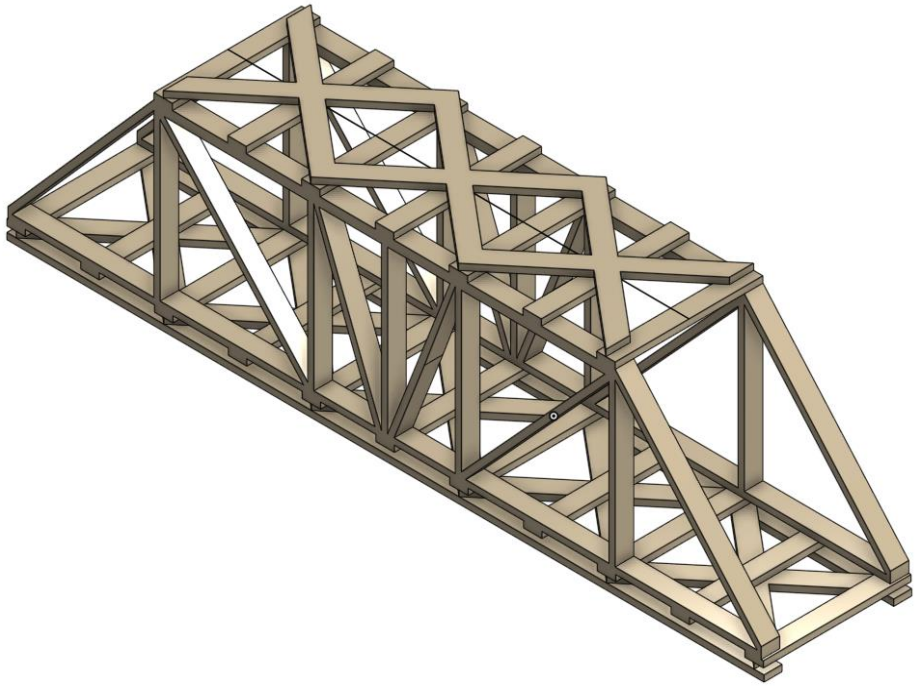
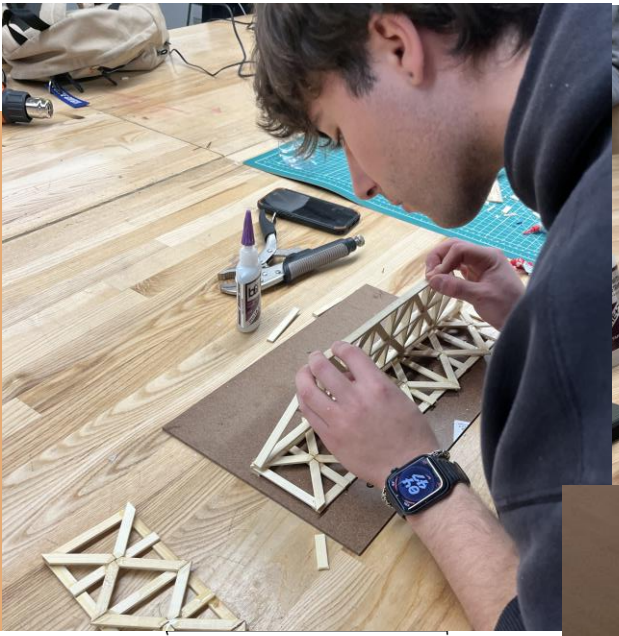
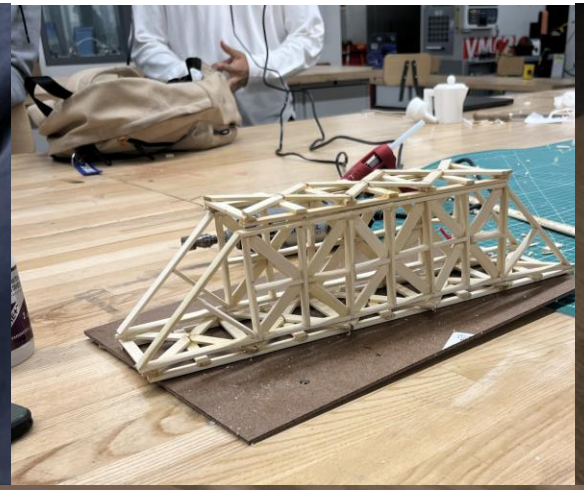


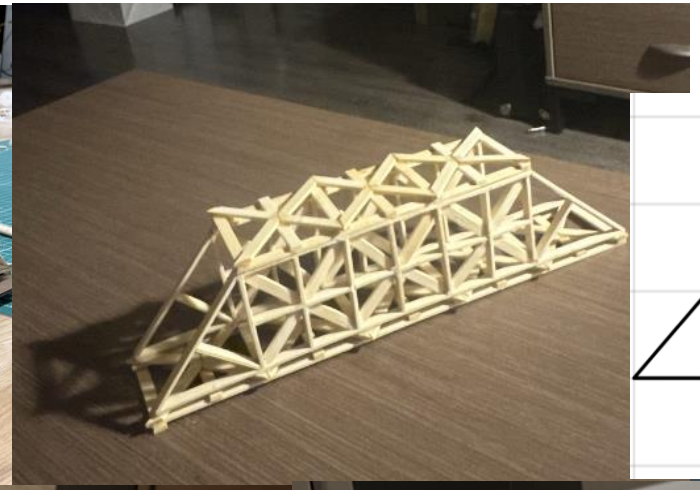
SIDE

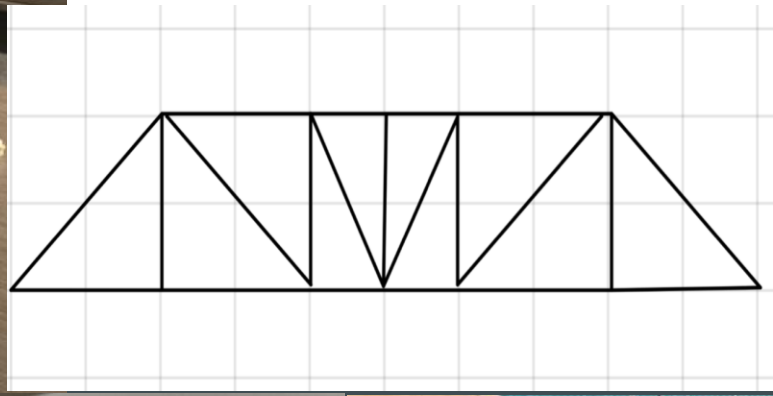


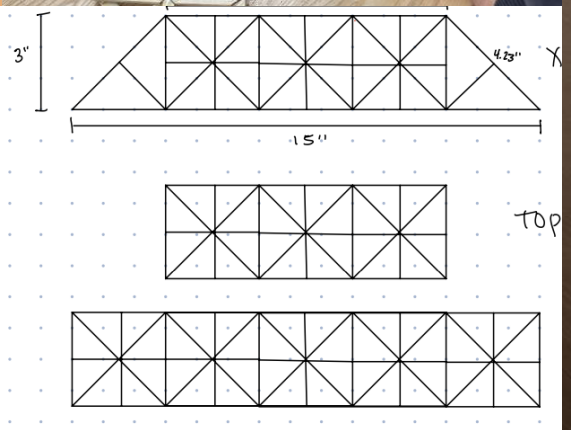
BUILD PROCESS – WHAT WE BUILT

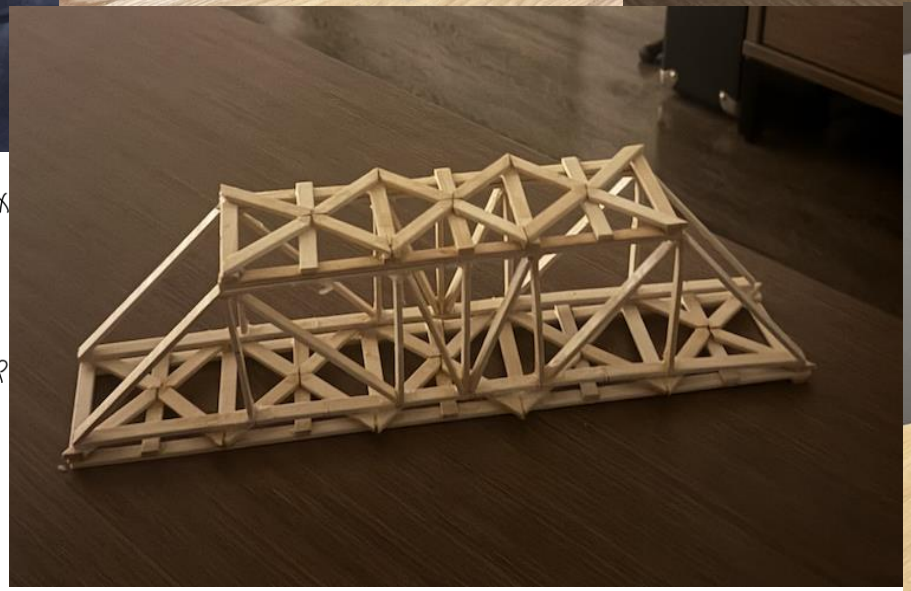


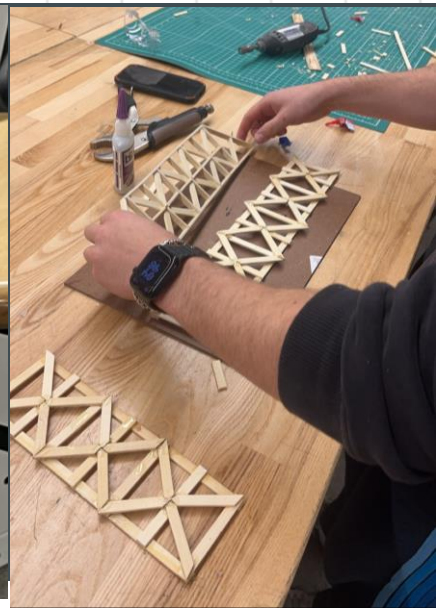






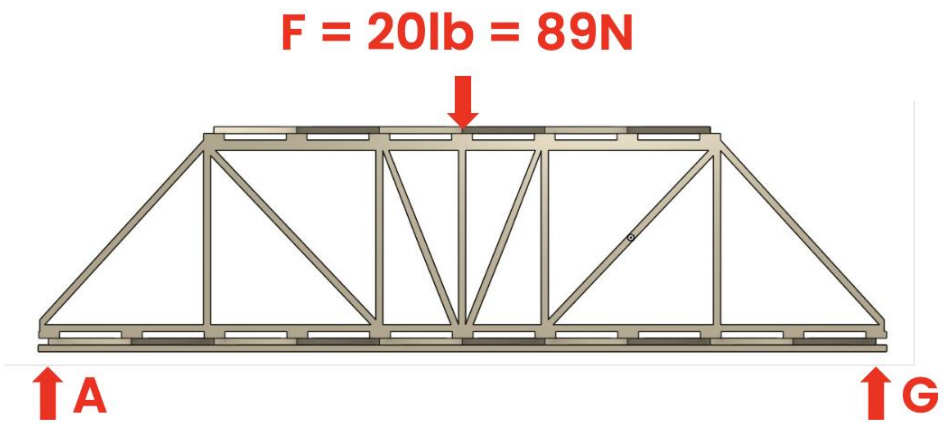






CALCULATIONS

Methodology: Method of Joints



Vertical Force:

$$\sum F_y = 0$$

$$\sum F_y = A_y + G_y - F = 0$$

$$A_y + G_y = 89N$$

Moment About A:

$$\sum M_A = -(F)(7.5in) + (G_y)(15in) = 0$$

$$G_y = \frac{(F)(7.5)}{15} = 89/2 = 44.5N$$

Force A:

$$A_y + G_y = F$$

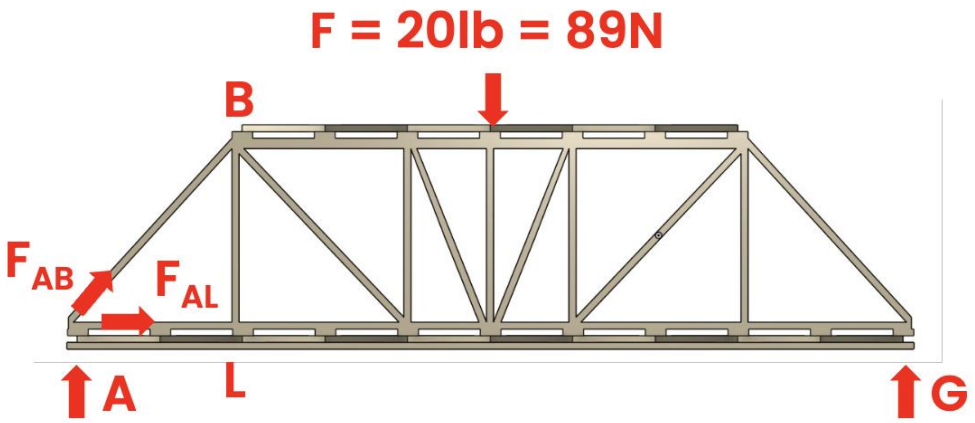
$$A_y = F - G_y = 89 - 44.5 = 44.5$$

Summary:

$$A_y = G_y = 44.5N$$

CALCULATIONS

Method of Joints: Joint A



$$\sum F_y = 0 = A_y - F_{AB}sin(45)$$

$$F_{AB} = \frac{A_y}{sin(45)} = \frac{44.5}{0.7071} = 62.9\mathbf{N},\ \mathbf{Tension}$$

$$\sum F_x = 0 = F_{AL} - F_{AB}cos(45)$$

$$F_{AL} = F_{AB}cos(45) = (62.9)cos(45) = 44.5\mathbf{N},\ \mathbf{Tension}$$

Calculations

Summary

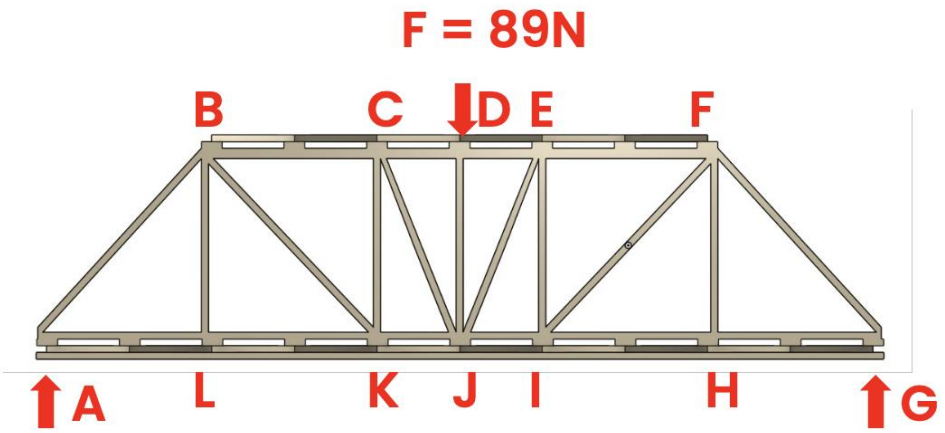


Table 1: Forces in Left-Side Members

Member	Force (N)	Type
A–L	44.5	Tension
A–B	62.9	Tension
B–L	44.5	Compression
L–C	62.9	Tension
C–K	44.5	Compression
K–D	49.8	Tension
D–J	178	Compression
C–D	89.0	Tension
B–C	44.5	Tension
L–K	0.0	Zero-Force
K–J	22.3	Compression

Table 2: Forces in Right-Side Members

Member	Force (N)	Type
H–G	44.5	Tension
F–G	62.9	Tension
F–H	44.5	Compression
I–F	62.9	Tension
E–I	44.5	Compression
D–I	49.8	Tension
D–E	89.0	Tension
E–F	44.5	Tension
I–H	0.0	Zero-Force
J–I	22.3	Compression
J–E	199	Tension

Full Calculations – A

1.1 Reactions A and G

Vertical Force:

$$\sum F_y = 0$$

$$\sum F_y = A_y + G_y - F = 0$$

$$A_y + G_y = 89N$$

Moment About A:

$$\sum M_A = -(F)(7.5in) + (G_y)(15in) = 0$$

$$G_y = \frac{(F)(7.5)}{15} = 89/2 = 44.5N$$

Force A:

$$A_y + G_y = F$$

$$A_y = F - G_y = 89 - 44.5 = 44.5$$

Summary:

$$A_y = G_y = 44.5N$$

1.2 Joint A

$$\sum F_y = 0 = A_y - F_{AB} sin(45)$$

$$F_{AB} = \frac{A_y}{sin(45)} = \frac{44.5}{0.7071} = 62.9\textbf{N, Tension}$$

$$\sum F_x = 0 = F_{AL} - F_{AB} cos(45)$$

$$F_{AL} = F_{AB} cos(45) = (62.9) cos(45) = 44.5\textbf{N, Tension}$$

1.3 Joint B

$$\sum F_y = 0 = -F_{AB,y} + F_{BL} = 0$$

$$F_{BL} = F_{AB,y} = 44.5\textbf{N, Compression}$$

$$\sum F_x = 0 = -F_{AB,x} + F_{BC} = 0$$

$$F_{BC} = F_{AB,x} = 44.5\textbf{N, Tension}$$

Full Calculations – B

1.4 Joint L

$$\sum F_y = 0 = -F_{AL} + F_{LC}sin(45) = 0$$

$$F_{LC} = \frac{F_{AL}}{sin(45)} = \frac{44.5}{0.7071} = 62.9\text{N, Tension}$$

$$\sum F_x = 0 = -F_{BL} + F_{LK} + F_{LC}cos(45) = 0$$

$$F_{LK} = F_{BL} - F_{LC}cos(45) = 0N$$

1.5 Joint C

$$\sum F_y = 0 = F_{LC} = F_{CK} = 44.5\text{N, Compression}$$

$$\sum F_x = 0 = F_{CD} - F_{BC} - F_{LC} = 0$$

$$F_{CD} = F_BC + F_{LC} = 89\text{N, Tension}$$

1.6 Joint K

$$\sum F_y = 0 = -F_{CK} + F_{KD}sin(\theta)$$

$$sin(\theta) = \frac{3}{3.354} = 0.8944$$

$$F_{KD} = \frac{F_{CK}}{0.8944} = 49.8\text{N, Tension}$$

$$\sum F_x = 0 = F_{KJ} + F_{KD}cos(\theta)$$

$$F_{KJ} = -F_{KD}cos(\theta) = 22.3\text{N, Compression}$$

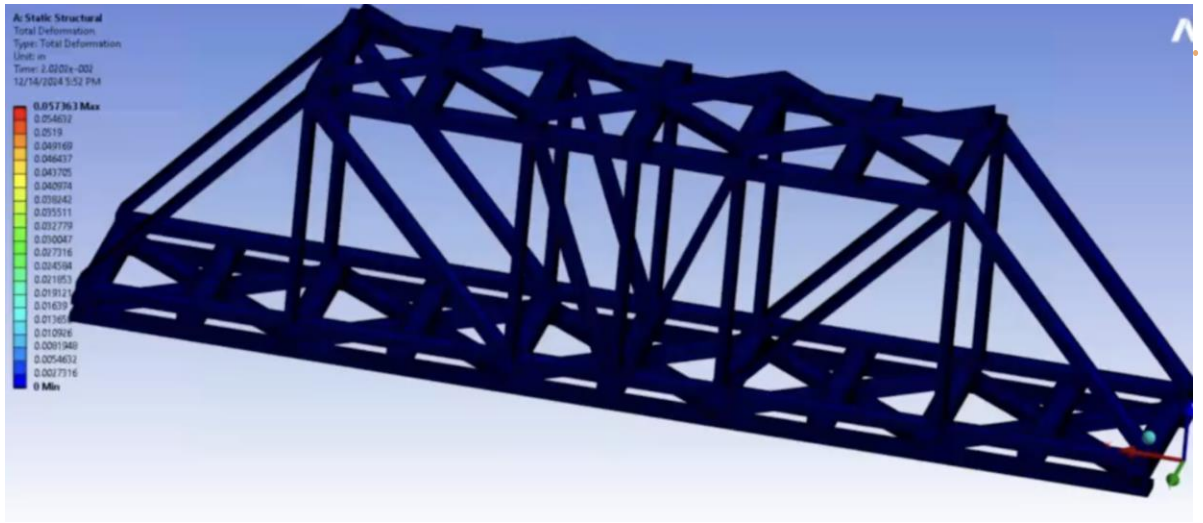
1.7 Joint D

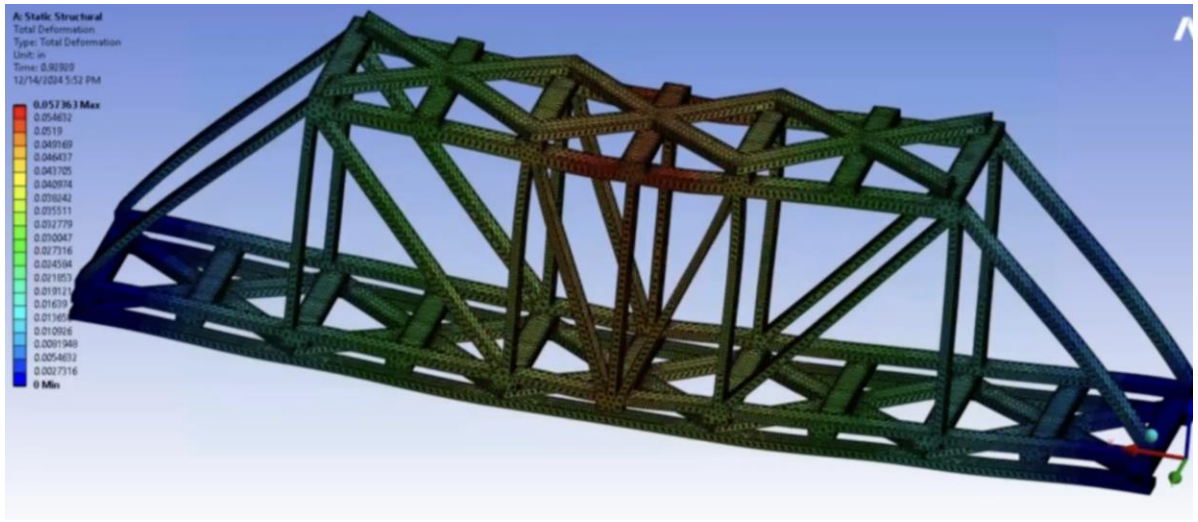
$$\sum F_y = 0 = -F - F_{KD}\sin(\theta) - F_{DI}\sin(\theta) + F_{DJ}$$

$$F_{DJ} = 178\,\text{N, Compression}$$

$$\sum F_x = 0 = -F_{CD} - (F_{KD}\cos(\theta)) + F_{DE} + (F_{DI}\cos(\theta)) = 0N$$

CONFIRMATION OF CALCULATIONS: FEA – TOTAL DEFORMATION*





*Given the complexities of glue as joints, the FEA is analogous to loading onto a carved block of wood. The total deformation should be used as general verification of calculations.