

# **Booilever 2020**

**New Mexico Science Olympiad**

**February 22, 2020**

**Tim Hankins, Event Supervisor**

# Acknowledgments

- **Event co-supervisors:**
  - **Mary Nutt**
  - **Jim Ruff**
  - **Jim Shepherd**
  - **Tony Sowinski**

# Summary

- Objective of competition
- Rules for construction
- Testing
- Scoring
- Construction suggestions
- Formula for winning:

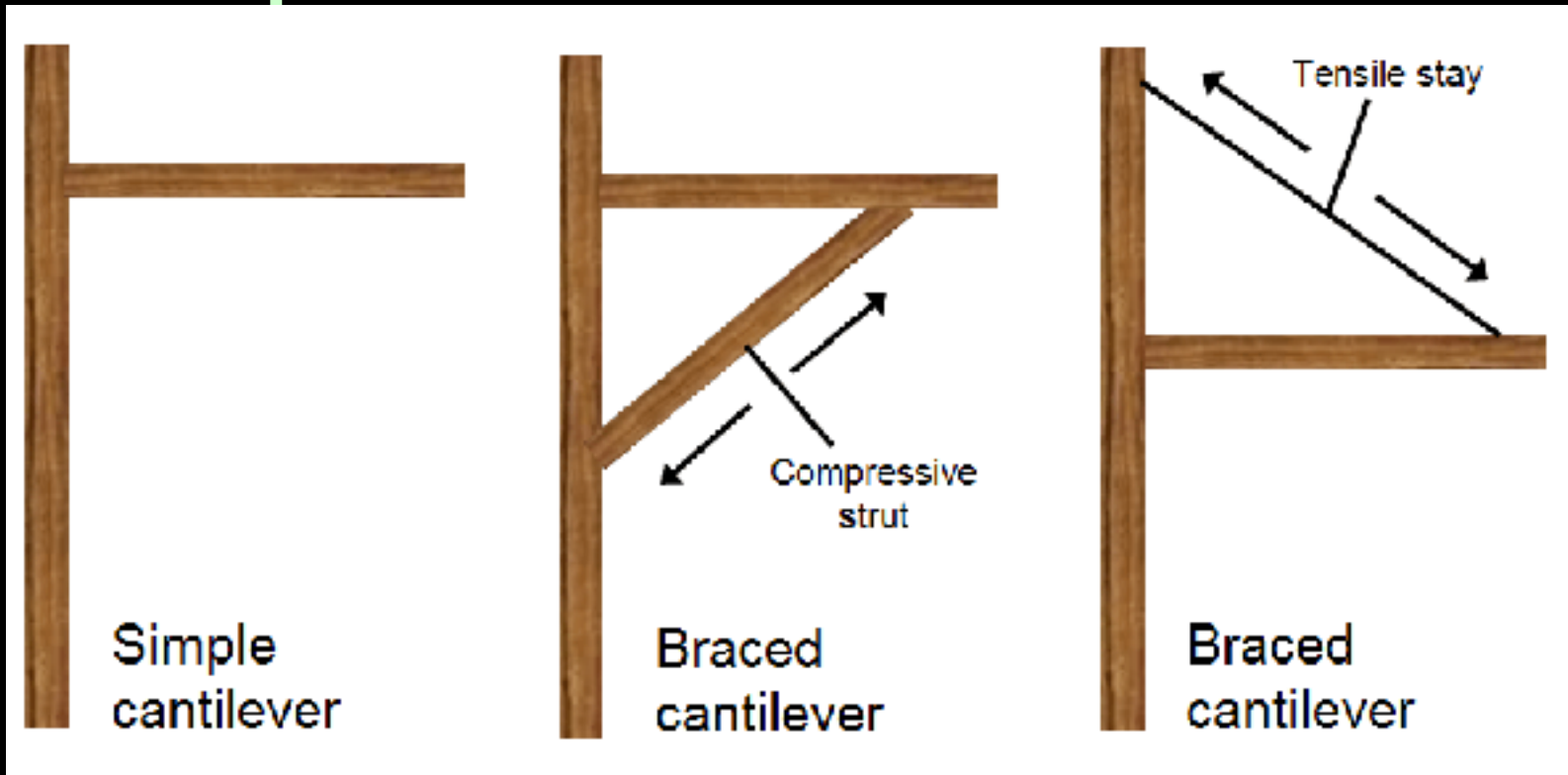
**Build and test**

# Pedantic comment

- “Boomilevers” are really “Cantilevers”
- Note on pronunciation:
- “Boomilever” gets a short “e” vowel sound
- “Cantilever” gets a long “e” vowel sound
- <http://www.pronouncekiwi.com>

# Definition

- “A cantilever is a rigid structural element, such as a beam or a plate, anchored at one end to a (usually vertical) support from which it protrudes.”



**Simple Cantilevers probably won't win**



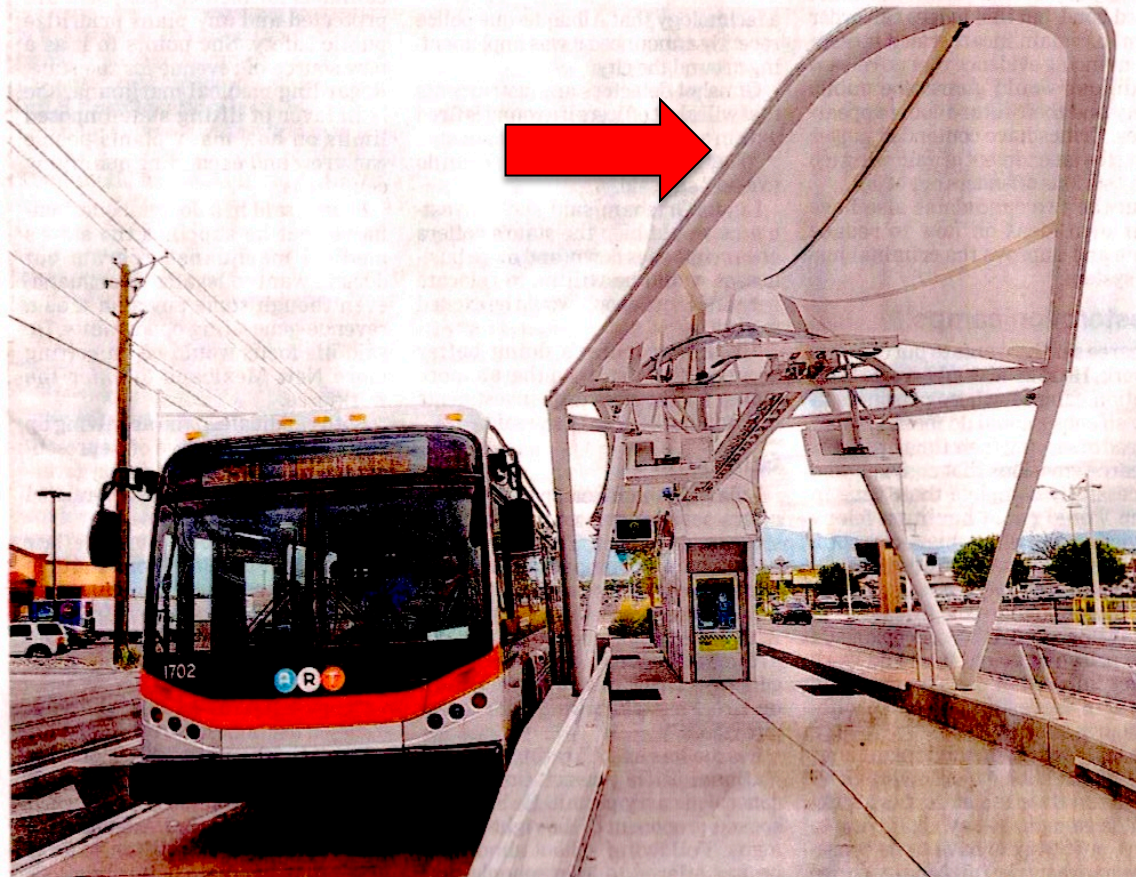
**At least 10 in this picture !!**





## Keller grounds new ART buses

City wants inspection of brake, equipment issues discovered during training



ADOLPHE PIERRE-LOUIS/JOURNAL

An ART bus pulls into the Yucca Station in Albuquerque in August.

**Another  
Simple  
Cantilever**

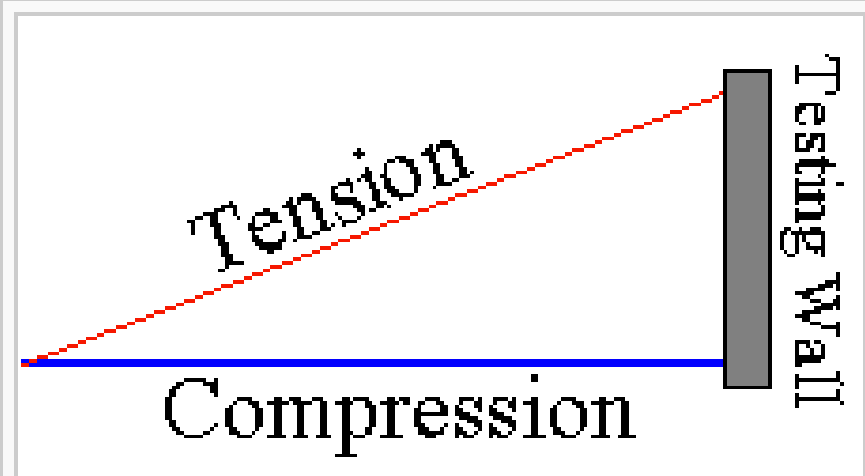
***Albuquerque  
Journal***  
**SO workshop  
day, last year  
November 2,  
2018**



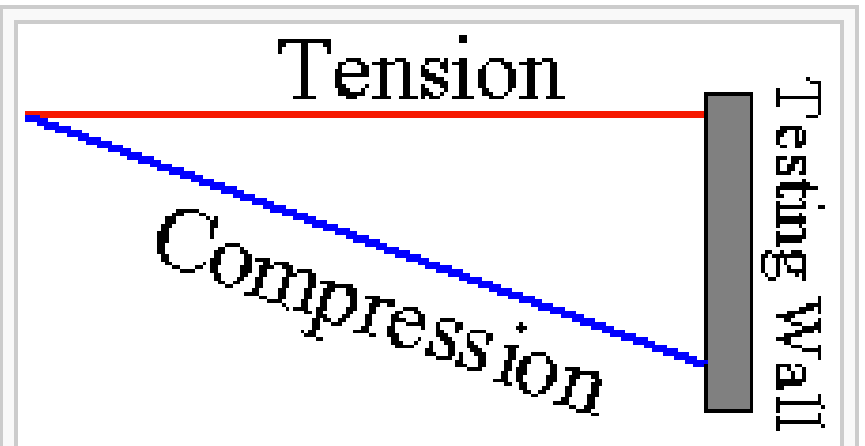
# Which type might win ??

Strength of tension member is independent of length.

Strength of compression member decreases with length (due to buckling).



Tension Boomilever

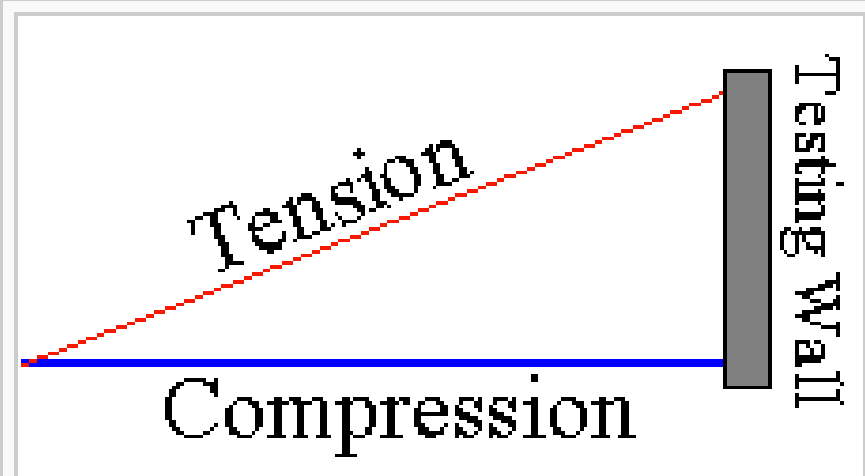


Compression Boomilever

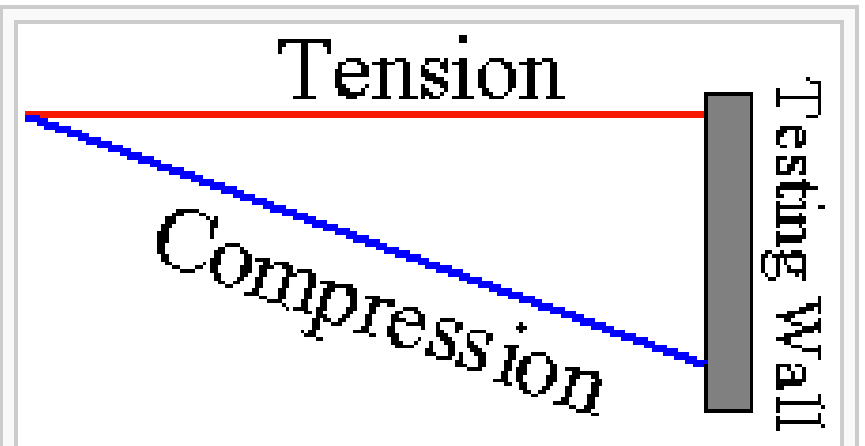
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Tension Boomilever



Compression Boomilever

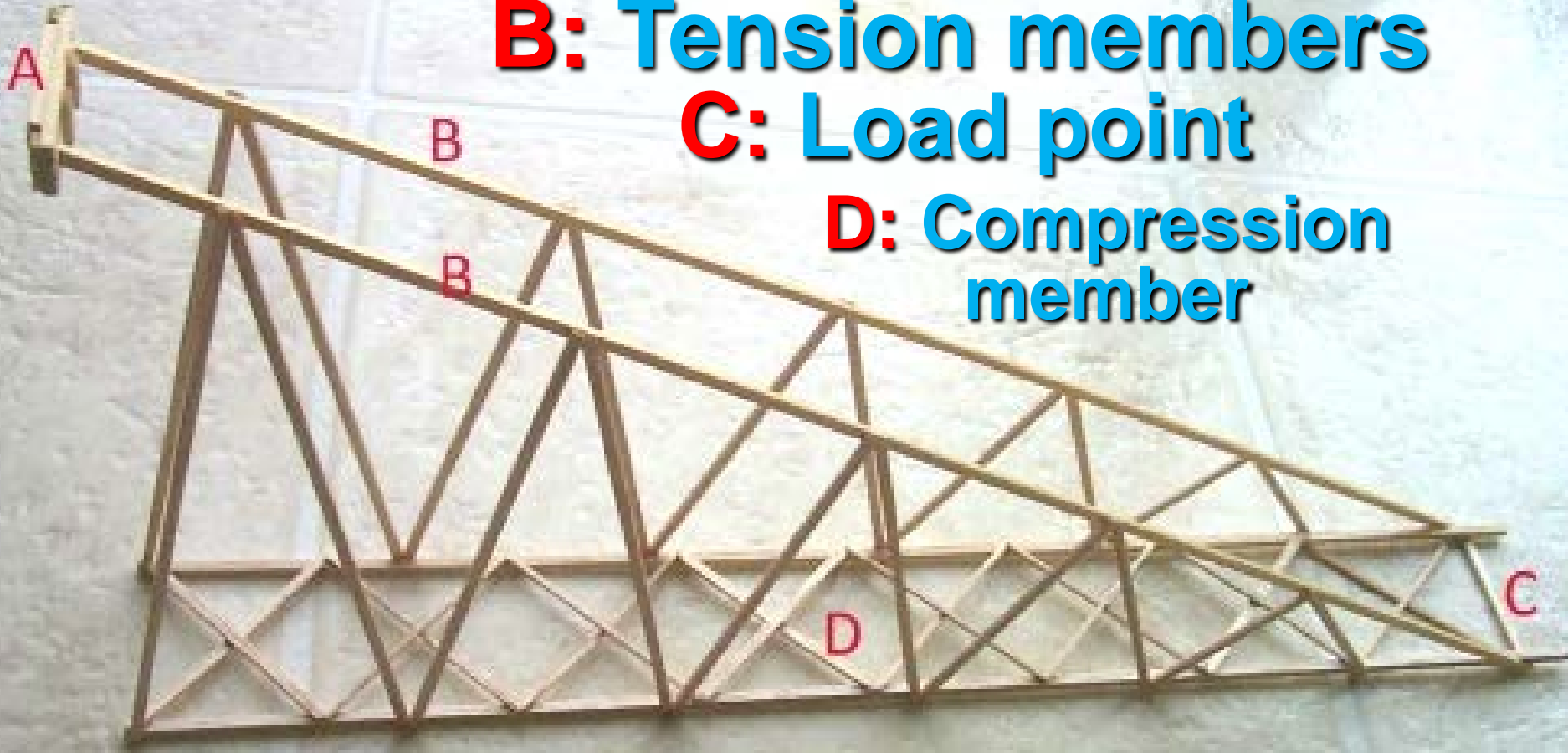
# A typical tension type boomilever

**A:** Hooks to the wall

**B:** Tension members

**C:** Load point

**D:** Compression member



from <http://www.scioly.org>

2/2/2007

# Objective of Competition

Design and build the most efficient cantilever =  
the *lightest* cantilever that will support up to 15 kg.

Cantilever structure for a wing hangar  
(a model of a BOAC hangar built in the  
1950s for maintenance of jetliners.)

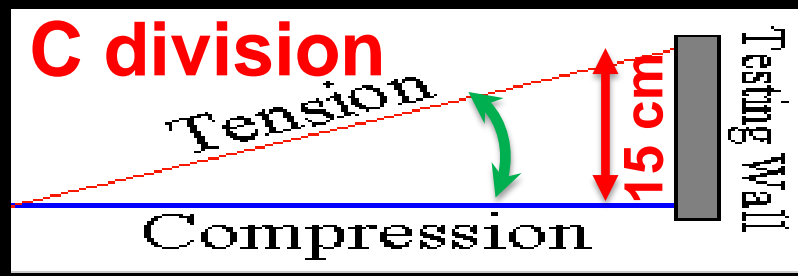
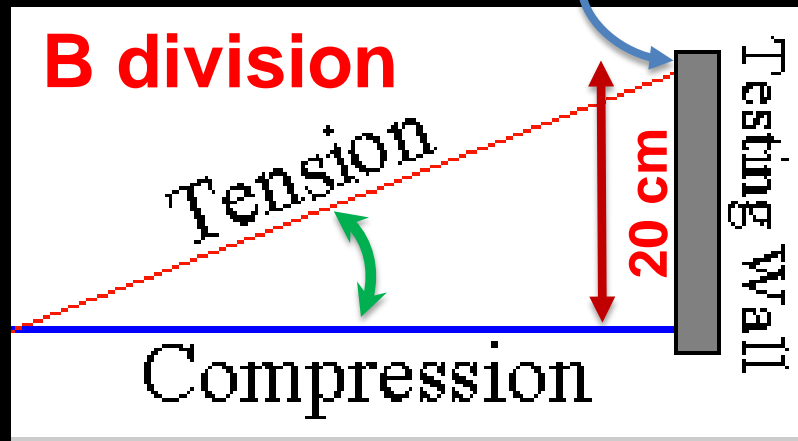
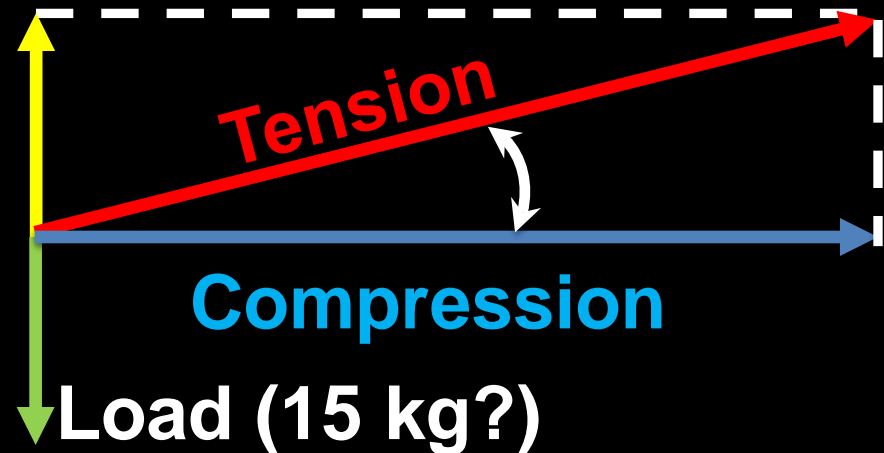
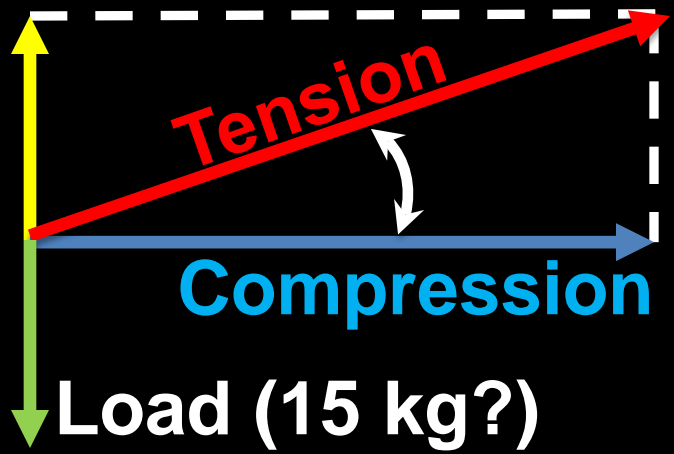


# Rules for Construction

- Wood and glue only. No paint. No labels.
- No maximum for wood piece length or width
- Lamination by competitor OK, but no plywood
- Boomilever attaches to Testing Wall using Mounting Hook
- \* Boomilever can't touch wall within 4 cm of wall centerline (new ! See later drawing)
- Must accommodate loading block and chain 40-45 cm from Testing Wall.
- Hook to bottom of Boomilever (maximum):
  - B Division: 20 cm
  - C Division: 15 cm

# Why is the “Hook to Bottom” (Contact Depth) specification different for B and C divisions?

**Hook**



# From [www.soinc.org](http://www.soinc.org) web site

*The Boomilever pictured here is only one possible configuration that satisfies rules.*

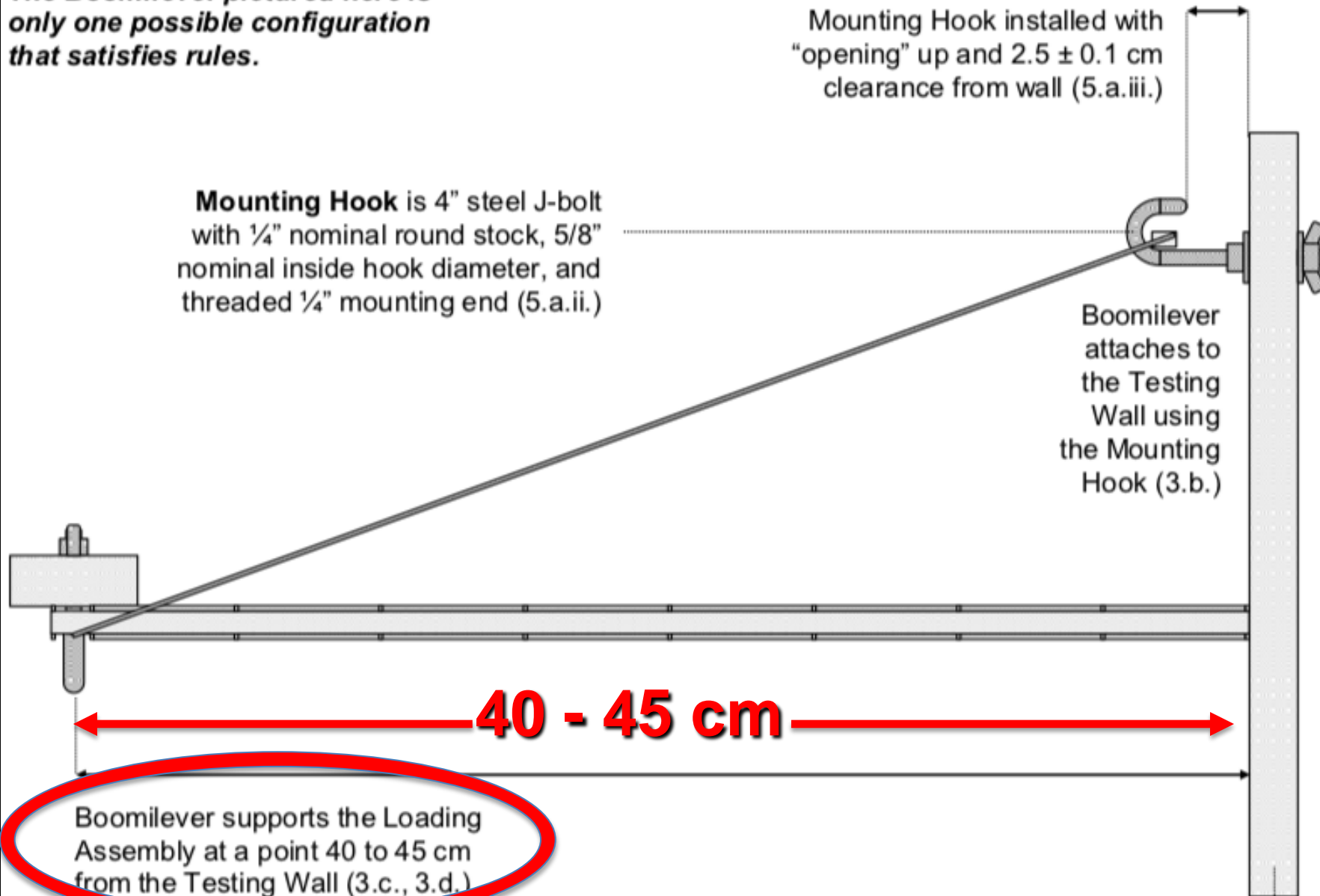
Mounting Hook installed with "opening" up and  $2.5 \pm 0.1$  cm clearance from wall (5.a.iii.)

Mounting Hook is 4" steel J-bolt with  $\frac{1}{4}$ " nominal round stock,  $\frac{5}{8}$ " nominal inside hook diameter, and threaded  $\frac{1}{4}$ " mounting end (5.a.ii.)

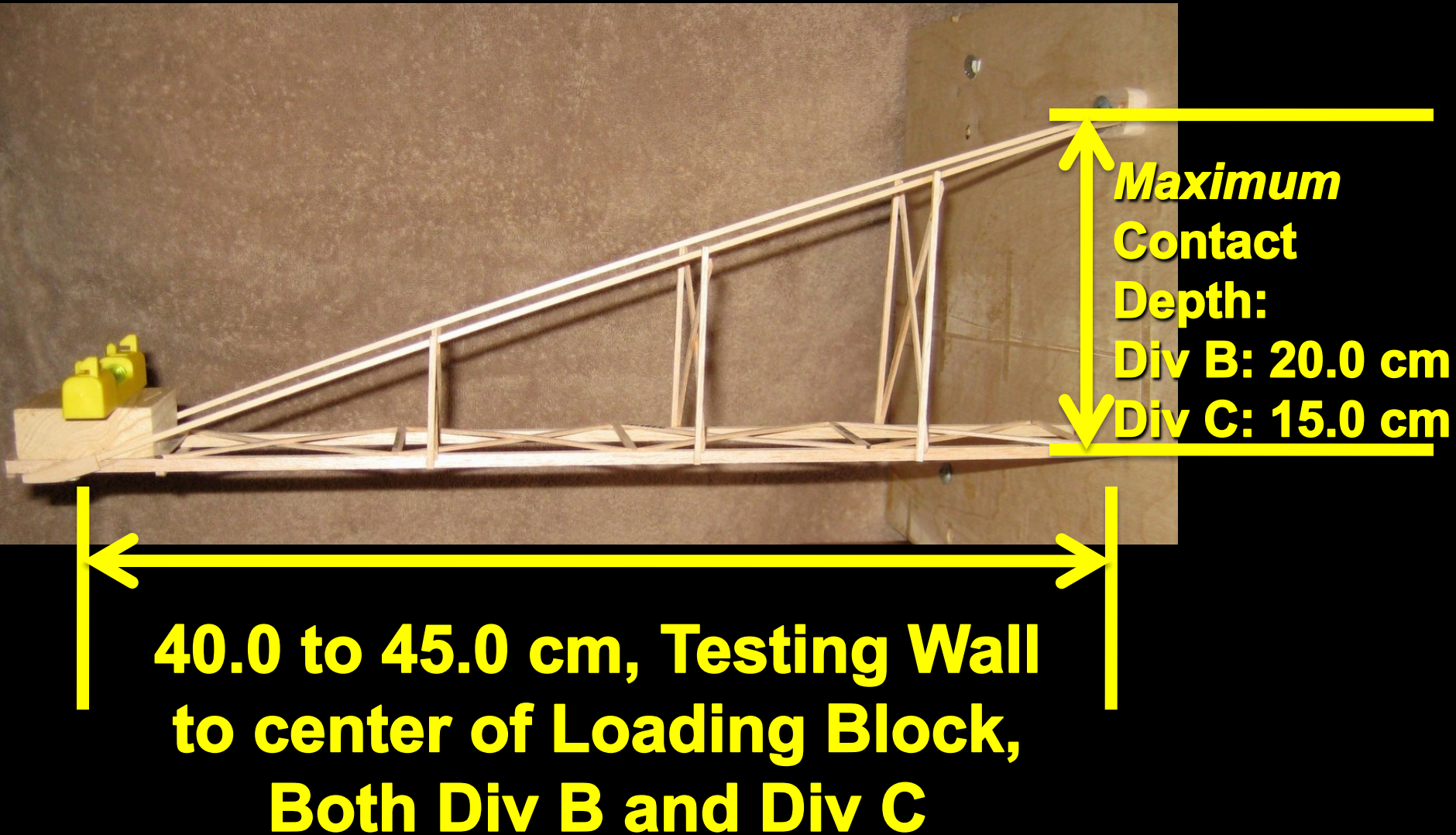
Boomilever attaches to the Testing Wall using the Mounting Hook (3.b.)

**40 - 45 cm**

Boomilever supports the Loading Assembly at a point 40 to 45 cm from the Testing Wall (3.c., 3.d.)



# Dimensions

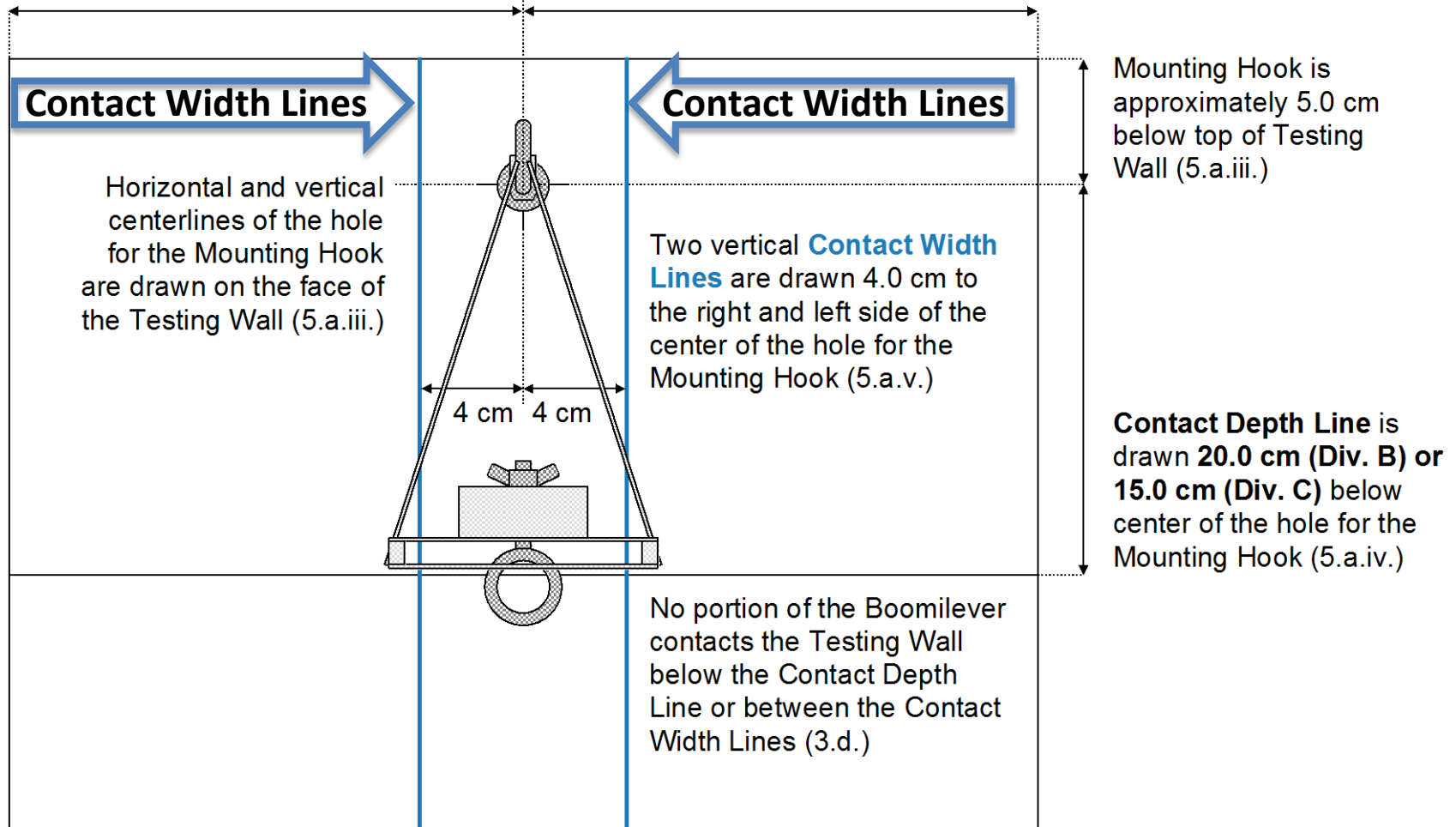




# From [www.soinc.org](http://www.soinc.org) web site

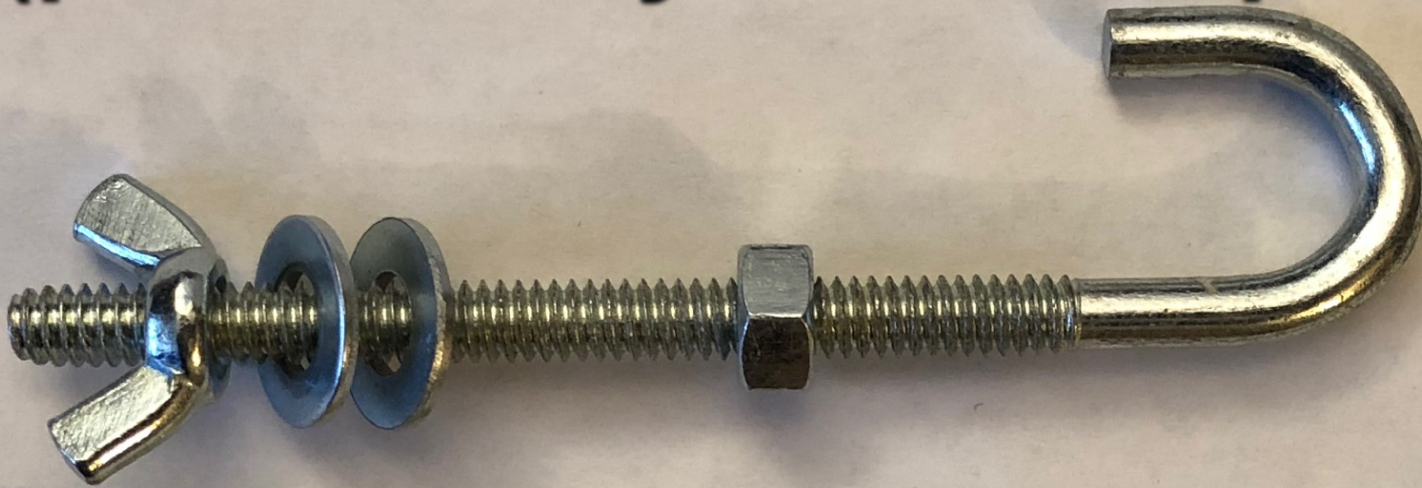
## “Front view”

**Mounting Hook** is horizontally aligned halfway between the sides of the Testing Wall (5.a.iii.) and cannot be adjusted by competitors (4.Part II.c.)



**Testing Wall** (provided by the Event Supervisor) is a vertical, solid, rigid surface at least 30 cm high, 40 cm wide and  $\frac{3}{4}$ " thick (5.a.i.)

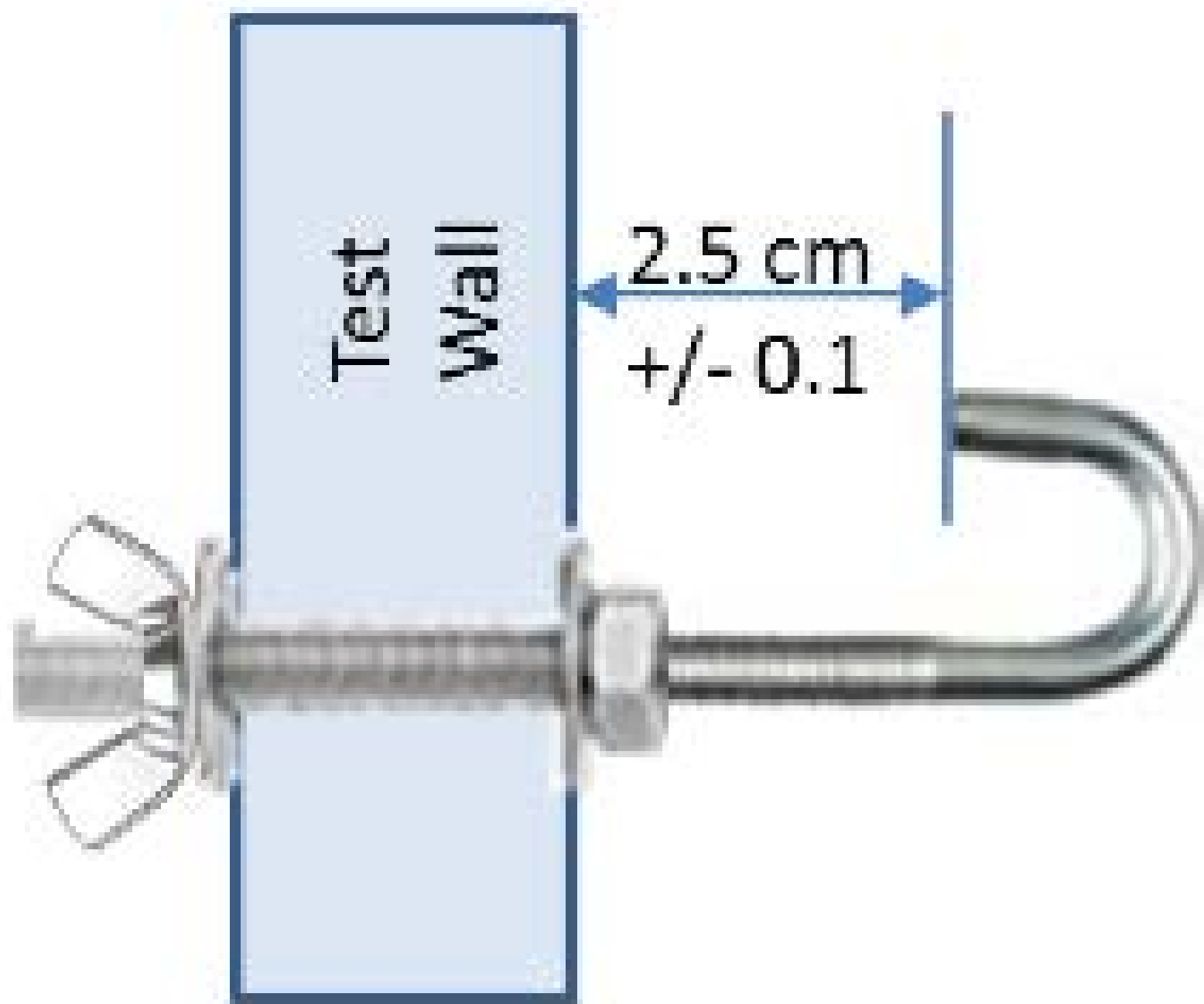
# The Hook (provided by Event Supervisor)



**National Hardware N232-892**

**\$1.49 at Tractor Supply**

**\$4.43 at Amazon**



Test  
Wall

2.5 cm  
+/- 0.1

# Check-In

- **Eye protection required.**
- **Team measures Boomilever mass.**
- **Team submits Estimated Load Supported Score (used only to break a tie score)**
- **No alterations, substitutions, repairs after check-in.**

# Testing

**Loading Block:** 5.0 cm x 5.0 cm x approx 2.0 cm, placed 40 to 45 cm from the Test Wall.

**Loading Rod:** ¼-inch threaded eyebolt through center of Loading Block. Eyebolt no longer than 3 inches.

# Test Setup (Booilever, 2019)





Science Olympiad

FOREHORSE

WITCH

# Testing (continued)

- **Eye protection required.**
- **No outside assistance, communications, materials.**
- **6 minutes allowed for setup *and* testing. (Goes fast!!)**
- **Contestants hook Boomilever to the Test Wall, assemble Loading Block, eyebolt, chain, bucket, etc., and place Loading Block on Boomilever, centered on Test Base Opening.**
- **Contestants may adjust Boomilever until sand loading starts.**



# Testing (continued)

**Bucket Stabilization sticks permitted.**

**No hands on sand bucket.**

**Contestants add sand until**

- Failure occurs.
- Maximum load is reached (15 kg).
- Time expires (6 minutes). (Goes by very fast!)
- Boomilever touches below the Contact Depth line or within Contact Width Lines

**Failure definition:**

- Complete Boomilever breakage.
- Any part of load supported by anything other than the tower.

**Scoring slightly more complex  
this year:**

**Bonus of 5000 grams**

***IF and only IF***

**boomilever supports the  
maximum load of 15,000  
grams.**

**Load score = Load supported (grams) + Bonus**

$$\text{Score} = \frac{\text{Load Score (grams)}}{\text{Boomilever mass (grams)}}$$

**Example:**

**Boomilever Mass = 15 grams**

**Load supported = 15,000 grams**

**Load score = 15,000 grams + 5000 (Bonus)**

$$\text{Score} = \frac{20,000 \text{ grams}}{15 \text{ grams}} = \boxed{1333}$$

**Load score = Load supported (grams) + Bonus**

$$\text{Score} = \frac{\text{Load Score (grams)}}{\text{Boomilever mass (grams)}}$$

**Another Example:**

**Boomilever Mass = 15 grams**

**Load supported = 12,000 grams (it broke!)**

**Load score = 12,000 grams + 0 (bonus)**

$$\text{Score} = \frac{12,000 \text{ grams}}{15 \text{ grams}} = \boxed{800}$$

# Scoring

**Load score = Load supported (grams) + Bonus**

$$\text{Score} = \frac{\text{Load Score}}{\text{Boomilever Mass}}$$

**Expected winning scores at Nationals: 2000-2500**

**This requires Boomilever mass of no more than  
7.5 to 10 grams !**

**NOT EASY!!**

# Scoring (Continued)

## Scoring in three Tiers:

**Tier 1: Holds any load and no violations.**

**Tier 2: Holds any load with any violations.**

**Tier 3: Can't load Boomilever.**

# Check List

We will use a 2020 score sheet that looks something like this, which is from [www.soinc.org](http://www.soinc.org)



## BOOMILEVER B/C – 2019

Rank: \_\_\_\_\_

Final Score: \_\_\_\_\_

Team Number: B/C \_\_\_ Team Name: \_\_\_\_\_

Student Names: \_\_\_\_\_

4.Part I.c. Team's Estimated Load Score (first tie breaker) **1.** \_\_\_\_\_

6.c.iv. Boomilever is able to be loaded (e.g. able to accommodate Loading Block, Loading Assembly, participants wearing eye protection) (If N, Tier 4) **2. Y N**

6.a. Mass of Boomilever (in grams to the closest 0.01 g) **3.** \_\_\_\_\_

### Construction and Competition Parameters

2.a. Team enters only one Boomilever, built prior to the competition. Y N

2.c. Participants bring no equipment such as levels or squares. Y N

3.a. The Boomilever is a single structure, with no separate or detachable pieces. Y N

3.a. The Boomilever is constructed of wood and bonded by adhesive with no other materials used. Besides ink, barcodes, or markings from the construction process, the wood is not painted, color enhanced, or affixed with tape/preprinted/paper labels. Adhesive tapes are not used. Y N

3.b. The Boomilever is designed to attach to the Testing wall using the Mounting Hook Y N

3.c.,3.d. The loading point on the Boomilever is constructed to permit placement of and completely support the Loading Assembly at the loading point (40 cm - 45 cm from the testing wall). Y N

3.e. Boomilever only touches the testing wall above the Contact Depth Line before and throughout loading. The Contact Depth Line is 20 cm (Div B) and 15 cm (Div C) below the center of the hole for the Mounting Hook. Y N

3.f. Students are able to answer questions regarding the design, construction, and operation of the device. Y N

4.Part I.d. Alterations, substitutions, and repairs are not made to the Boomilever after check-in process is started. Y N

4.Part II.a. Once participants enter the event area to compete, they do not leave or receive outside assistance, materials, or communication until they are finished competing. Y N

4.Part II.c. Participants place the Boomilever on the Testing Wall and assemble the Loading Assembly as required to load the Boomilever. Y N

4.Part II.d. Once loading of sand has begun, the Boomilever is not further adjusted. Y N

4.Part II.f. Participants do not directly contact the bucket except by using the tips of the provided bucket stabilizing sticks. Y N

**ALL CONSTRUCTION AND COMPETITION PARAMETERS MET (IF N, TIER 3)** **4. Y N**

6.a. Load Supported (including the Loading Assembly; in grams; 15,000 g max) **5.** \_\_\_\_\_

General Rule: Disqualified (notify the team and their coach as soon as possible) **6. Y N**

# Construction suggestions

- **First !!!!**
- **Read the wikis on the National Science Olympiad site. Start at [scioly.org/wiki/index.php/Boomilever](http://scioly.org/wiki/index.php/Boomilever)**
- **“Aia’s Boomilever Guide”**
- **These are lengthy, and have good info.**
- **Read them !!!**



# Construction suggestions

- **“Balsa wood has the highest strength to weight ratio of any wood.” (But for tension members bass wood might be better.)**
- **Many on-line sources (Google “balsa wood supplier”)**
- **Typical price for 1/16” x 1/16” x 36”:  
\$0.14, though it comes in many grades and sizes.**

# Construction suggestions: Glue

**Glue is much heavier than balsa wood!!**

- **Super glue = CA = CyanoAcrylate**  
probably the easiest to work with, *if used correctly! See next panel!!*
- **Gorilla glue (discussed in wiki).**

# Construction suggestions: Glue

See excellent 3-page article:

## **“Minimizing Weight Gain While Maximizing Strength When Gluing Balsa”**

by Jeff Anderson

[http://soinc.org/sites/default/files/uploaded\\_files/glueweight.pdf](http://soinc.org/sites/default/files/uploaded_files/glueweight.pdf)

### **Minimizing Weight Gain While Maximizing Strength When Gluing Balsa**

**Contributed by:**

**Jeff Anderson**

**MI SO Board Member**

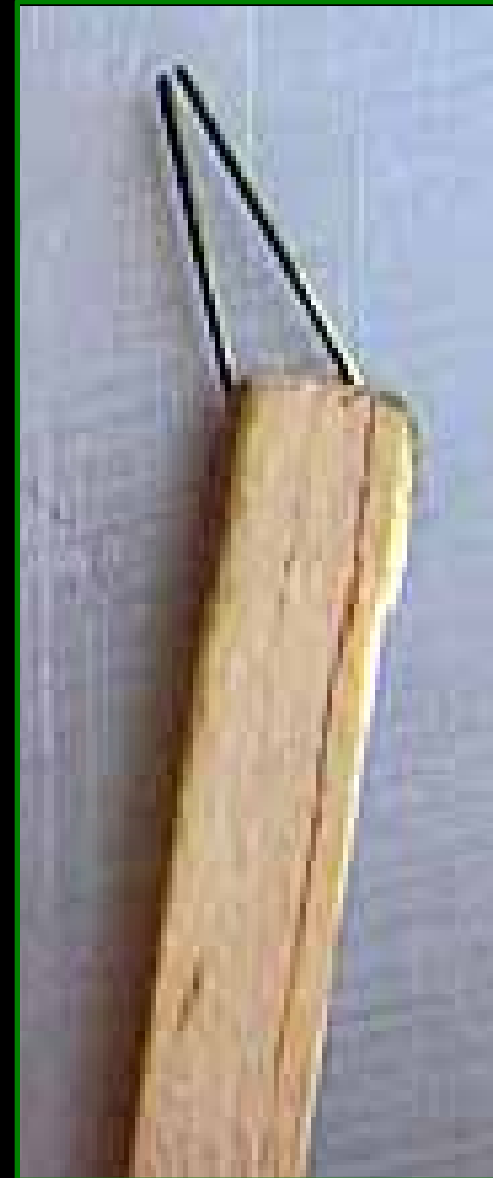
**MI SO Wright Stuff Event Supervisor**

**Livonia, MI**

Warning, LONG dissertation on how to minimize weight gain while maximizing strength when gluing balsa. But, it's MUCH harder to explain in writing than to actually do in practice. Plus, I'm an engineer, not a teacher.

# Construction suggestions (con't)

- Draw design on graph paper.
- Back it with corrugated cardboard.
- Place wax paper over drawing.
- Cut balsa with a *very* sharp knife (not scissors).
- Use pins to hold balsa pieces in place while gluing.
- Maximize glue joint surface area.
- Minimize glue volume (It is much heavier than balsa).
- Use Anderson's glue applicator and use glue accelerator.



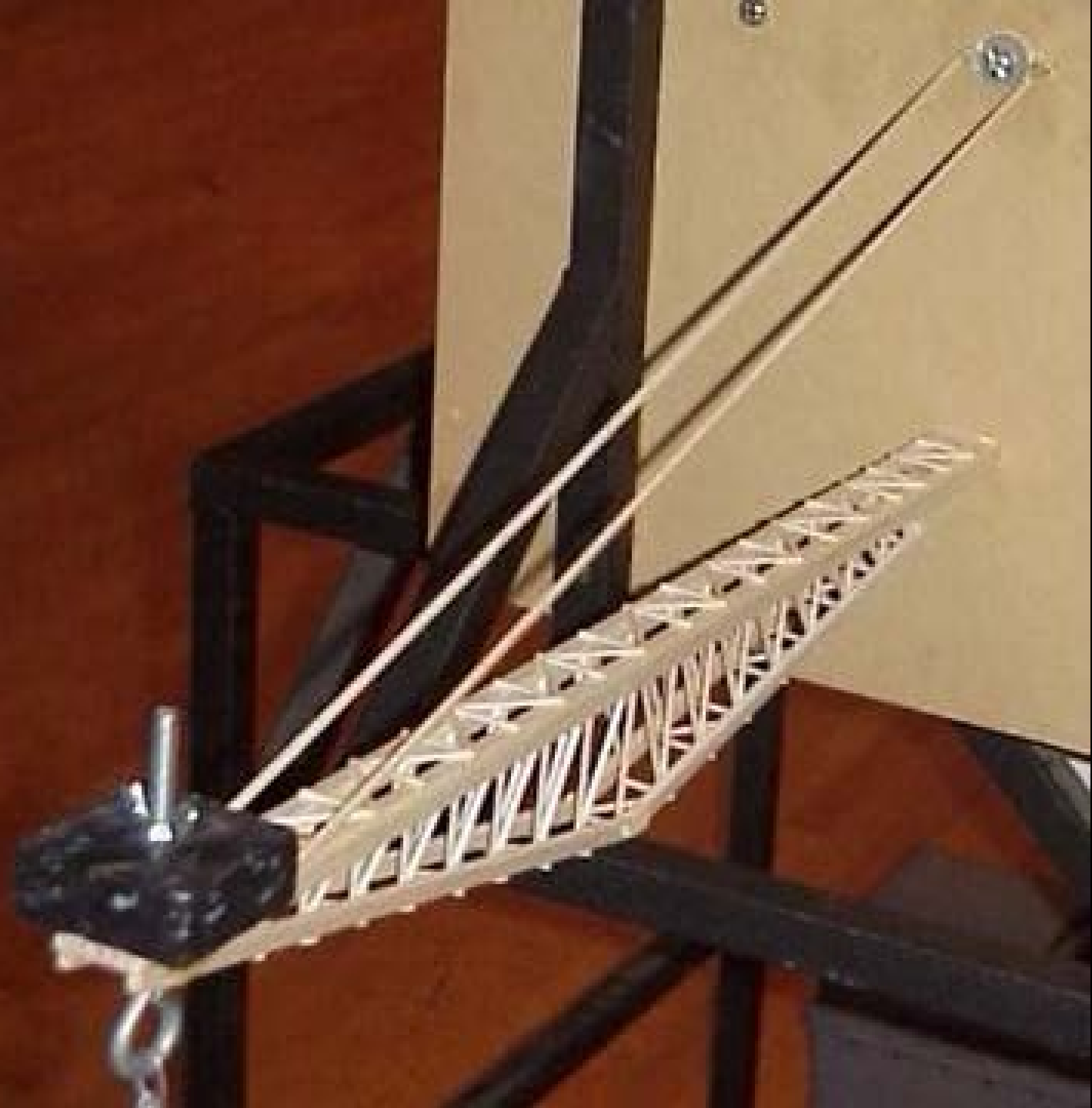
# Construction suggestions (Old tower close-ups)

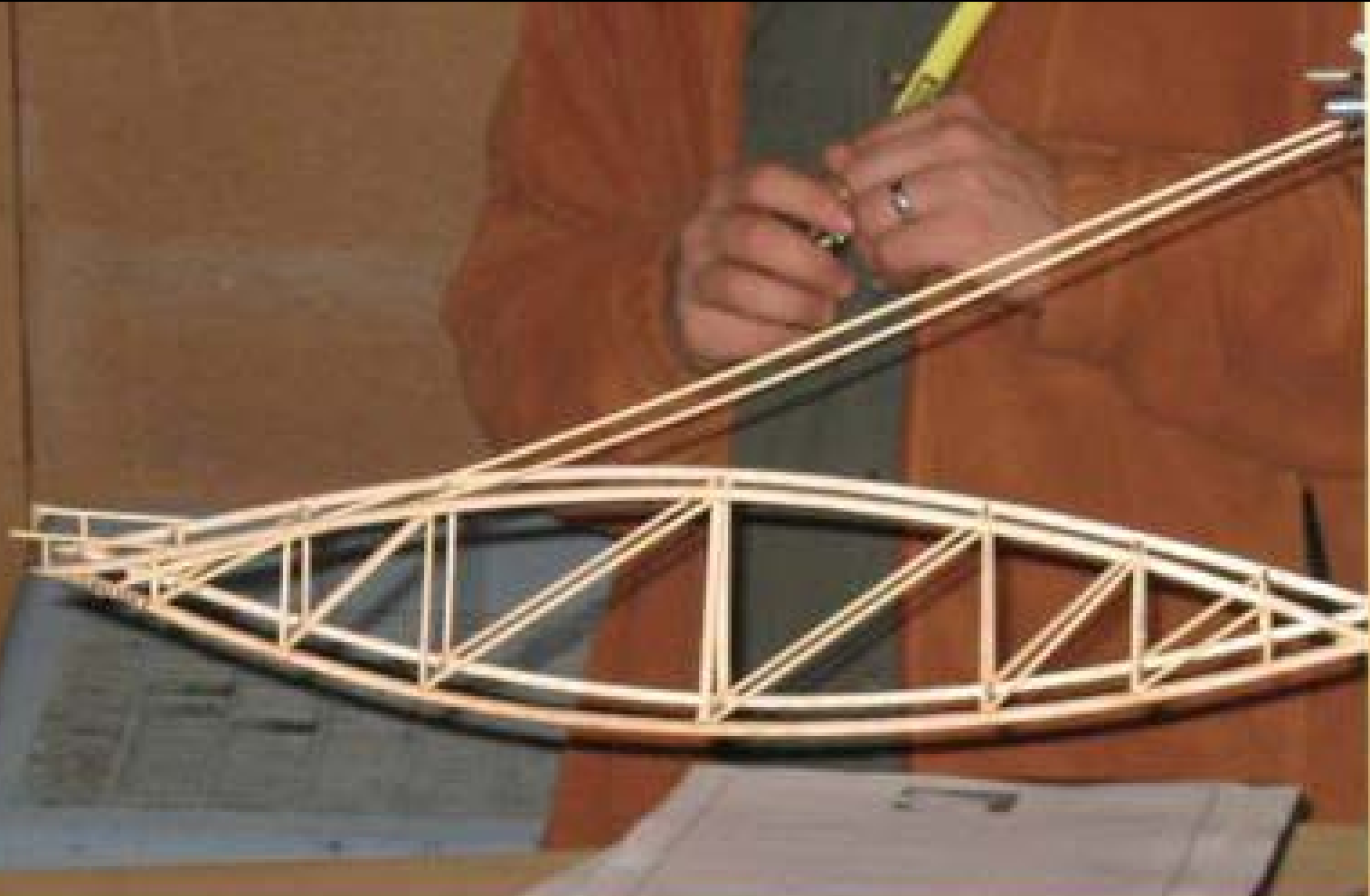


Note: verticals are 4 pc 1/16" balsa  
All cross pieces glued on both sides

# Some variations from web













# Resources

- <https://www.soinc.org/>
- <https://scioly.org/wiki/index.php/Booilever>
- <https://www.youtube.com/>

**(Hundreds of examples and construction hints)**

- **SkyCiv (\$40 software to simulate forces and stresses) tutorial at**  
<https://www.youtube.com/watch?v=PE9Qa5o3WUI>

# Strategy to win:

- **Start NOW.**
- **Read resources.**
- **Build a Boomilever.**
- **Check rules and test it.**
- **Build another Boomilever but stronger and lighter.**
- **Test again.**
- **Build another ....**

# The laws for competitive boomilever building:

**You need less wood than you think.**

**You need less glue than you think.**

**Repeat**

**The End**

**How it goes on a bad day:**







# Objective of the Competition

**Design and build the most efficient Boomilever = The *lightest* Boomilever that will support the largest load up to 15 kg**