

2027 Boomilever Event

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Disclaimer

- This presentation was prepared using draft rules. There may be some changes in the final copy of the Rules.
- The Rules released by the Science Olympiad National Office in September 2026 will be the official Rules and should be used for all competitions.

Why is this a STEM Event?

Design Fundamentals:

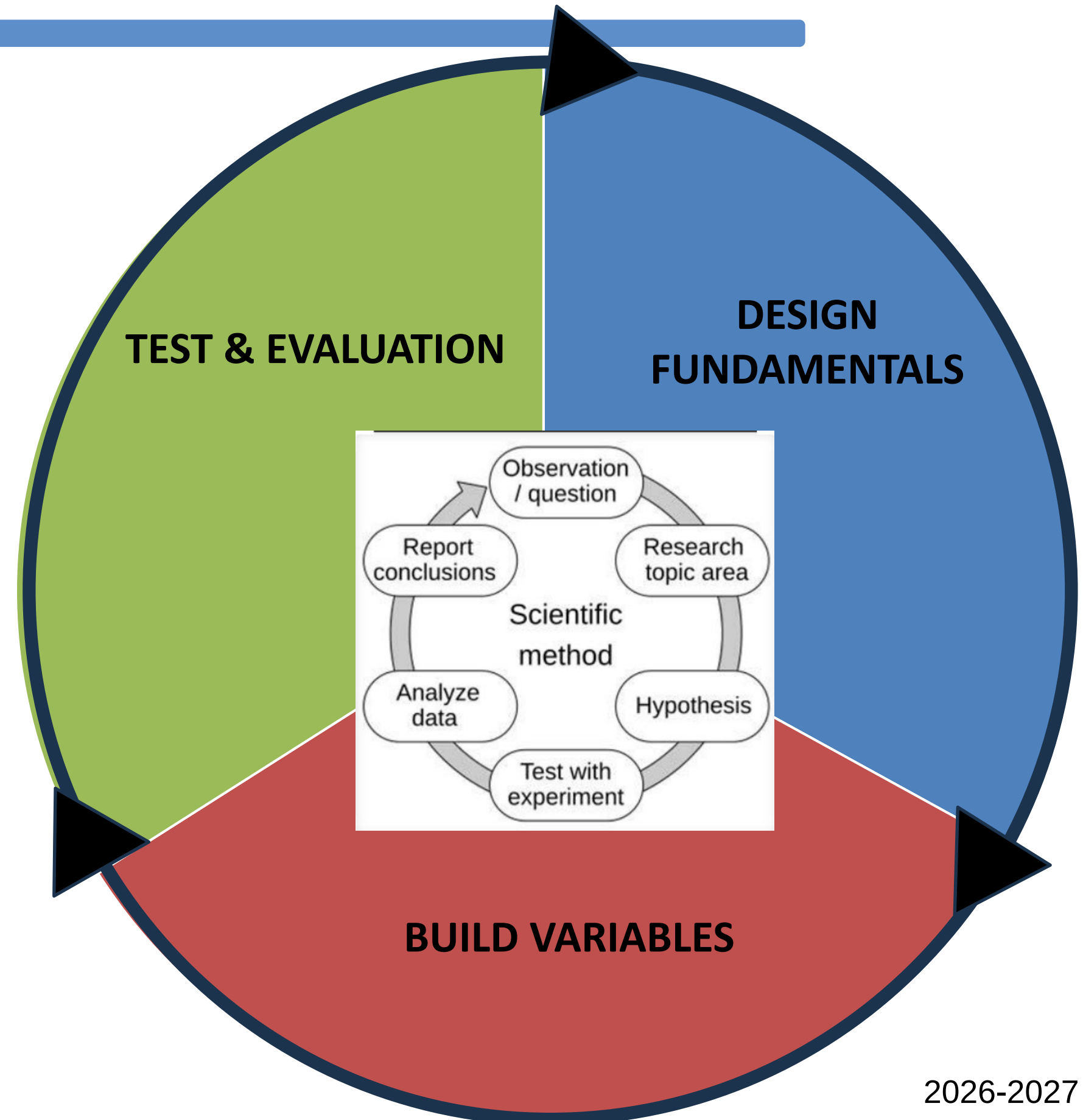
- Teaches Requirements Traceability
- Material Properties & Modeling
- Euler's Formula for Buckling (Density, Cross-section, Length)
- Statics (Force Vectors; Compression/Tension)
- Design Optimization & Trade-offs

Build Variables:

- Material Inspection & Screening
- Bonding Techniques
- Tools & Assembly Aides
- Attention to Detail
- Process Improvements

Test & Evaluation:

- Compliance Verification
- Forensics
- Process Details & Repeatability
- Root Cause / Corrective Action
- Design of Experiments



Structure – Scoring (Strength Calculation)

Structural Efficiency (SE) is a normalized measure of a structure's design/construction in relationship to its mass

Weightlifters' ratio: ~2:1

Ants' ratio: >100:1;

These structures can have a Ratio up to 4000:1

Calculation:

Pre-weigh & record Structure **MASS**,

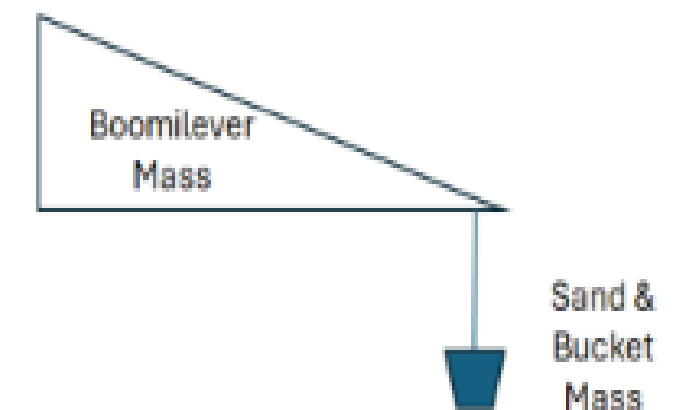
LOAD test Structure to a maximum **LOAD** or test to Failure. Record the actual Test **LOAD** held

Calculate Ratio: Test Load held ÷ Structure Mass

HOWEVER: There is a **MAXIMUM LOAD**, ... and a potential for a **BONUS**, ... and there are **3 TIERS** of scoring!

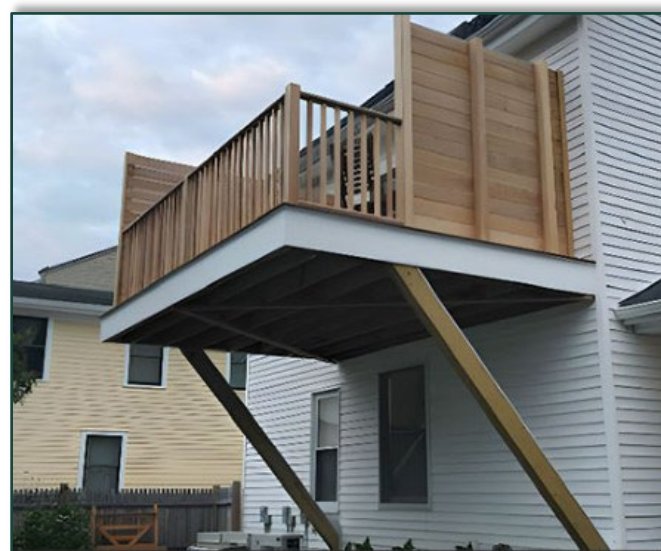
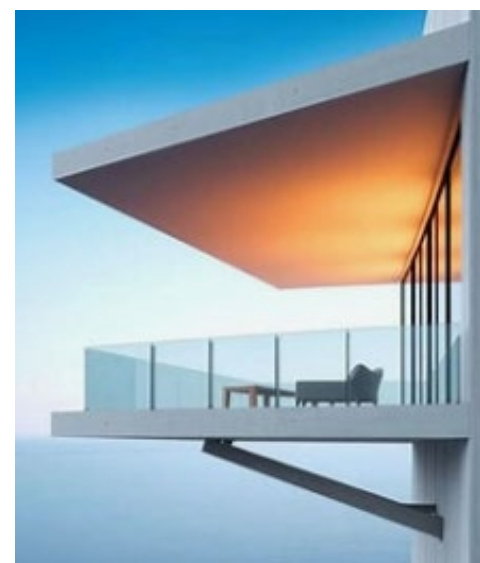
Structural Efficiency (SE) = Load ÷ Mass of Structure

Bonus points are applied to Score where appropriate



What is a Boomilever?

- Boomilever is a Cantilever device



5

Cantilever

[Article](#) [Talk](#)

From Wikipedia, the free encyclopedia

For the figure skating element, see [Cantilever \(figure skating\)](#).

A **cantilever** is a rigid [structural element](#) that extends horizontally and is unsupported at one end. Typically it extends from a flat vertical surface such as a wall, to which it must be firmly attached. Like other structural elements, a cantilever can be formed as a [beam](#), plate, [truss](#), or [slab](#).

When subjected to a [structural load](#) at its far, unsupported end, the cantilever carries the load to the support where it applies a [shear stress](#) and a [bending moment](#).^[1]

Cantilever construction allows overhanging structures without additional support.

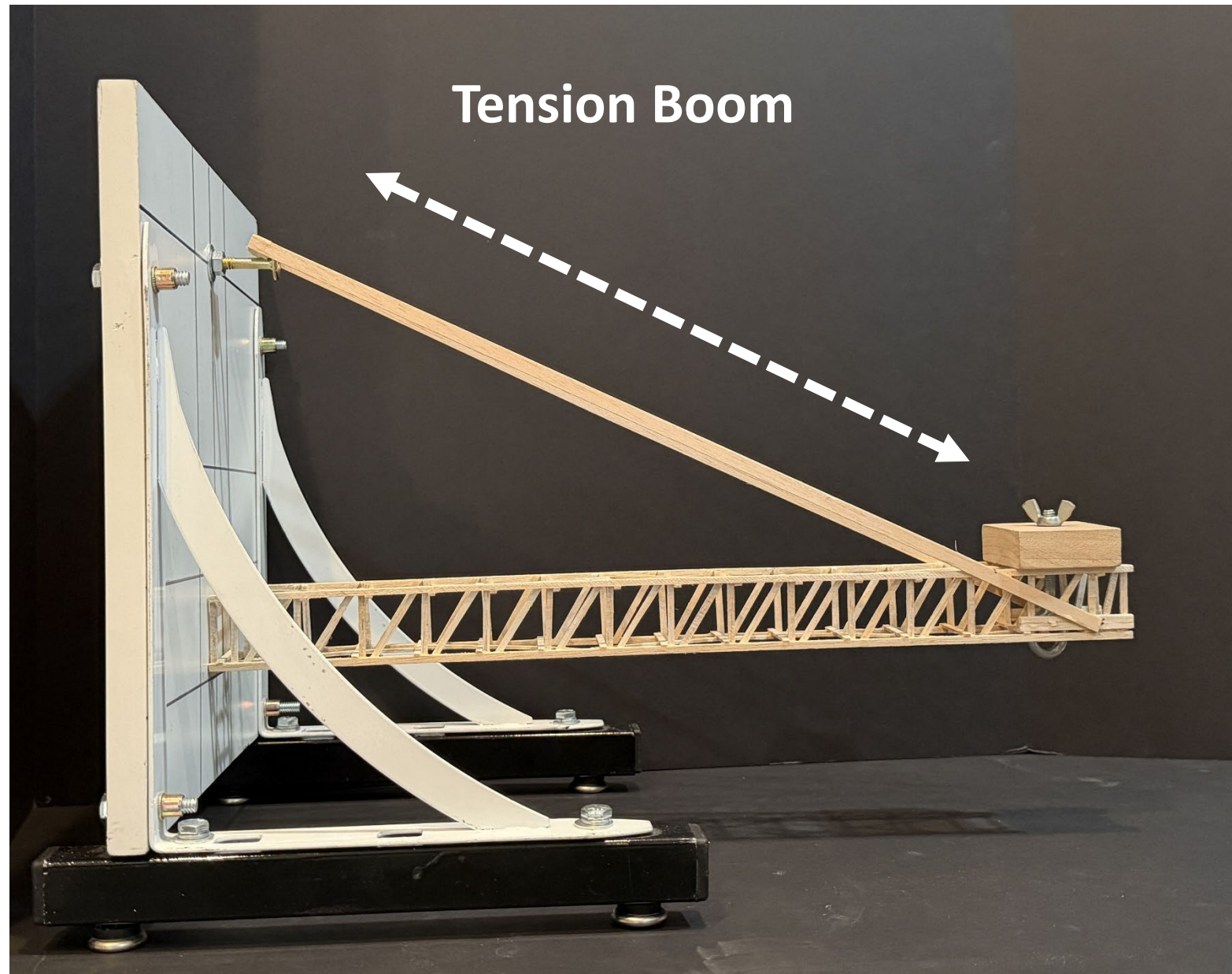
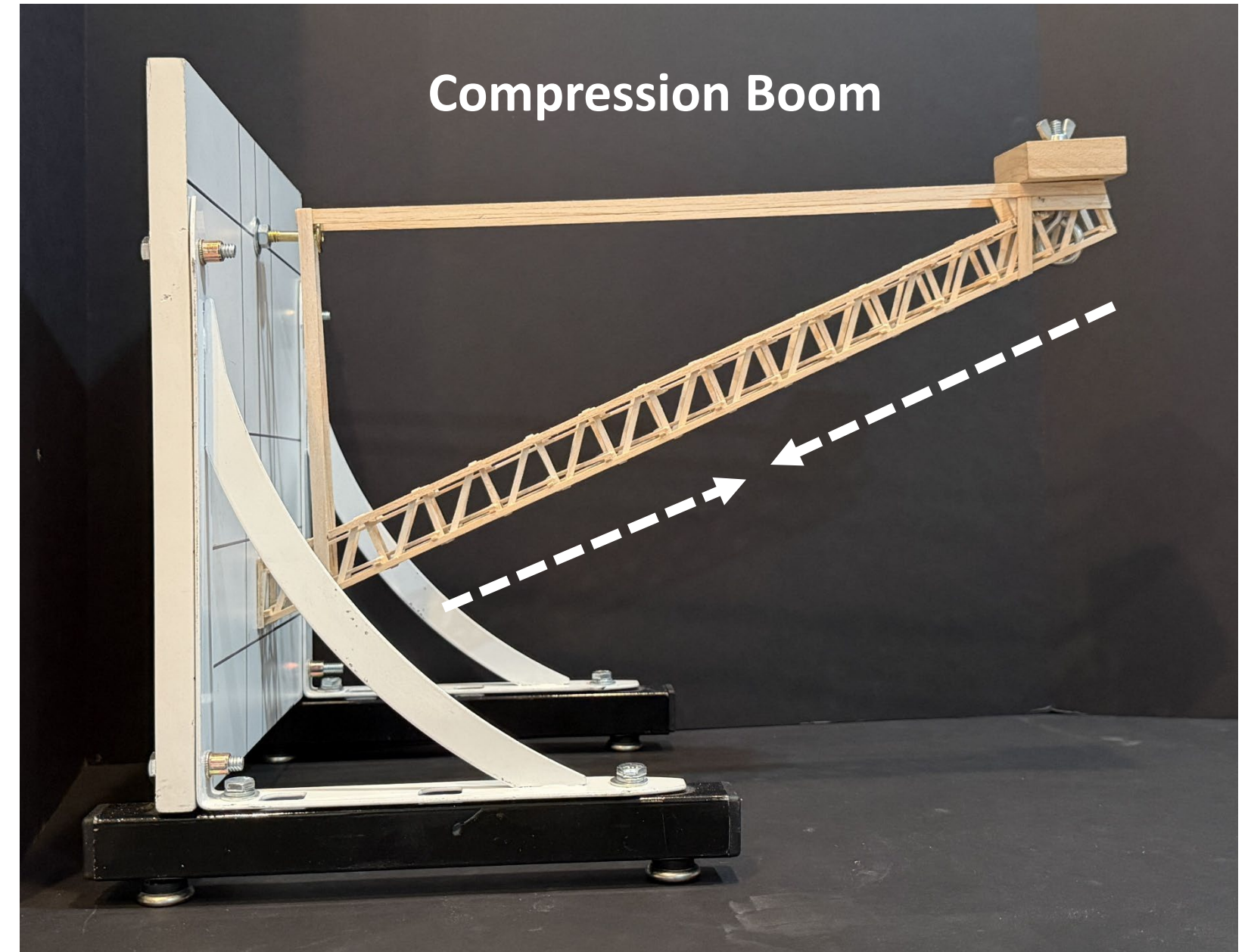


One of World's Most Famous Cantilever Bridge – Firth of Forth Scotland

Roadmap of Learning & Objectives

Objective	Bridge	Tower	Boomilever
Understanding & applying event rules	X	X	X
Understanding wood properties in Compression & Tension	X	X	X
Wood Screening & Pairing	X	X	X
Understanding adhesive & bonding properties & practices	X	X	X
Design Principles: Loading & Distributions. Trade-offs for Bonus	X	X	X
Construction Awareness & Attention to Details: Symmetry; Perpendicularity	X	X	X
More complicated Structures: Logistics; Considerations for Large Structures		X	X
Scientific Factors with Compression Loading *i.e. Euler's "Oiler's" Formula for Buckling)		X	X
Extreme Tension & Compression Loading			X

Boomilever Types (Tension vs Compression)

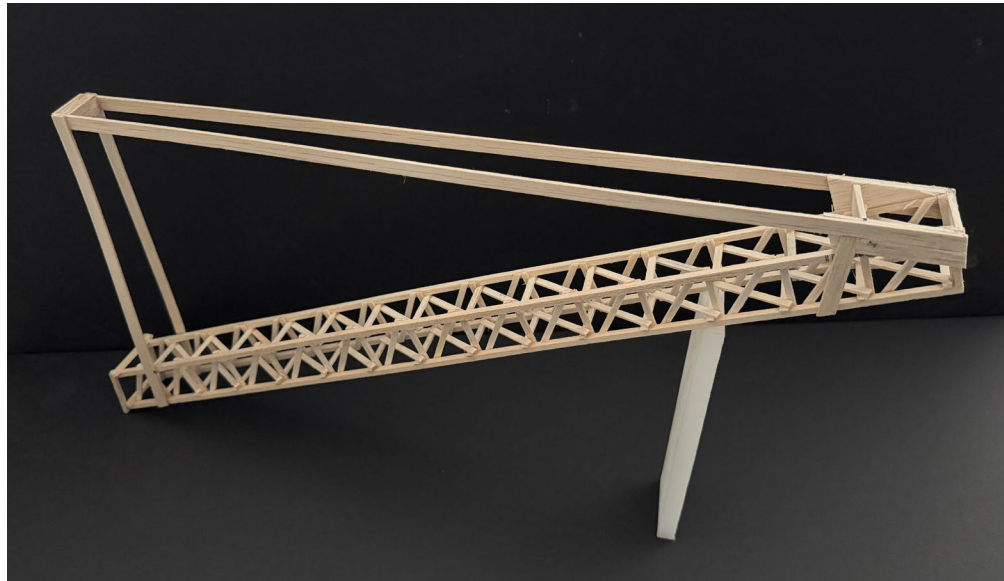
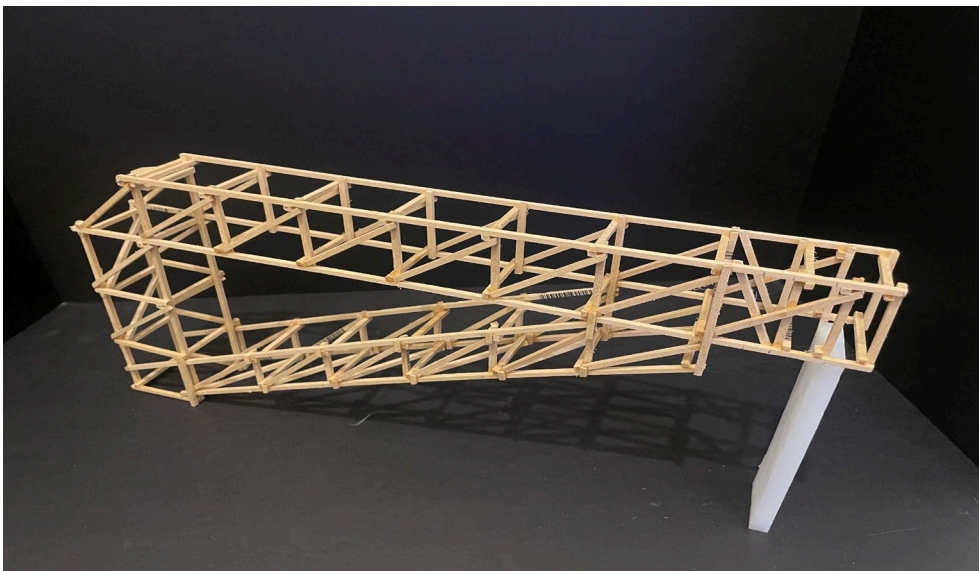
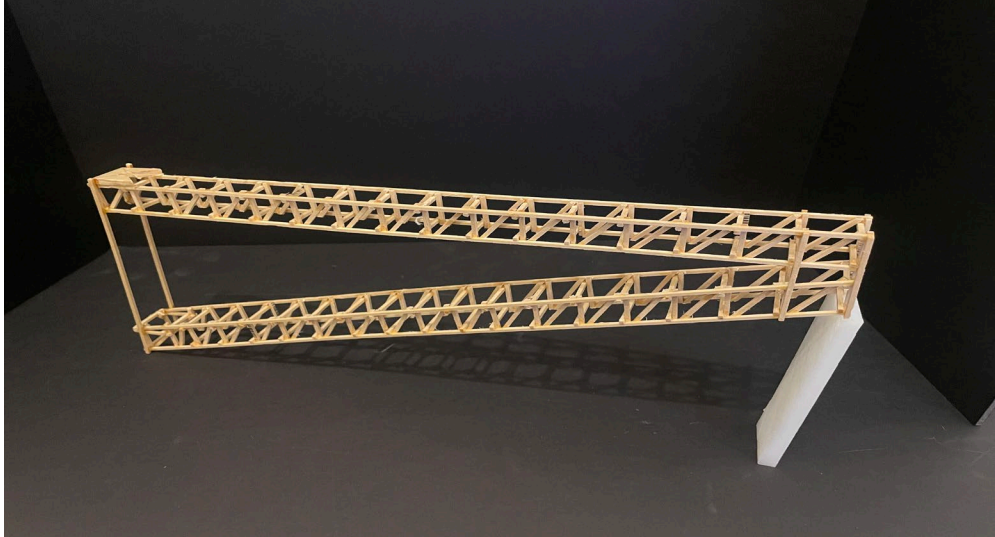
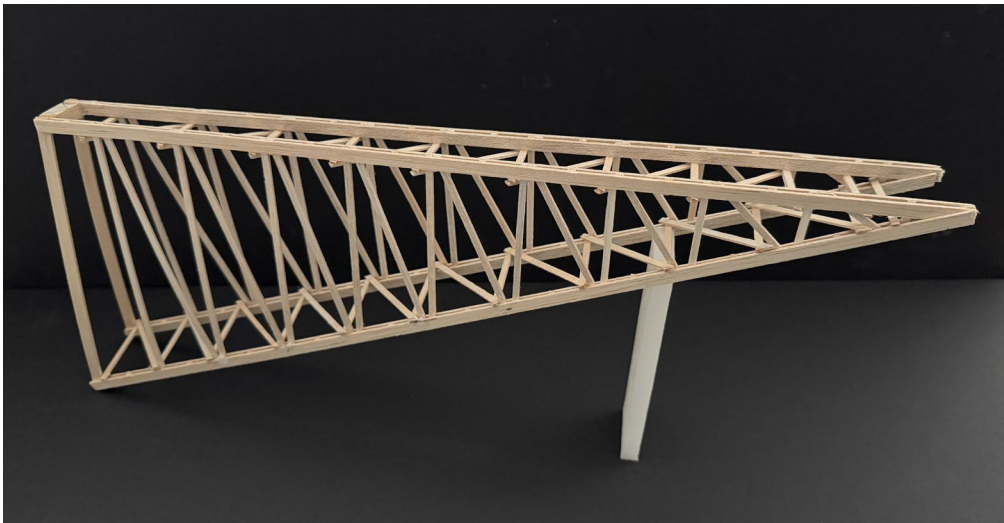
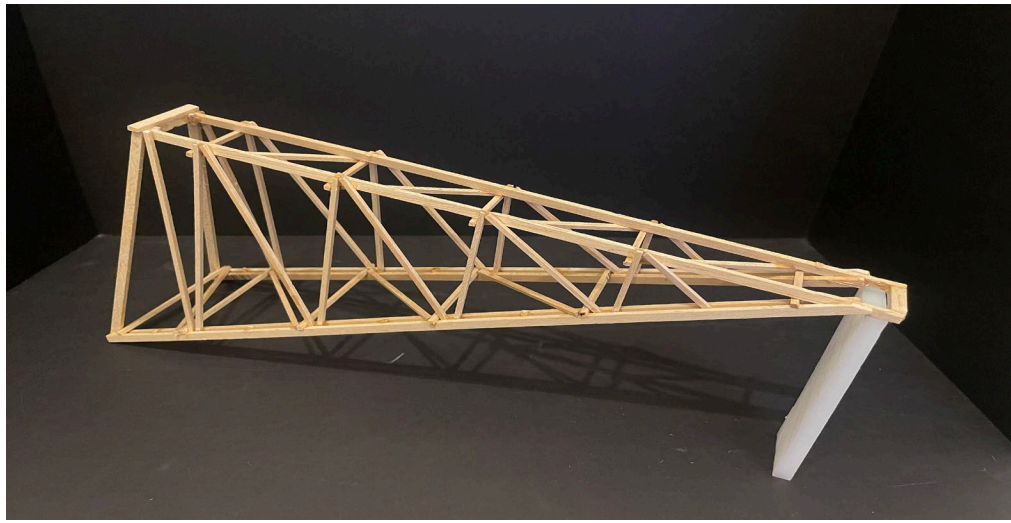
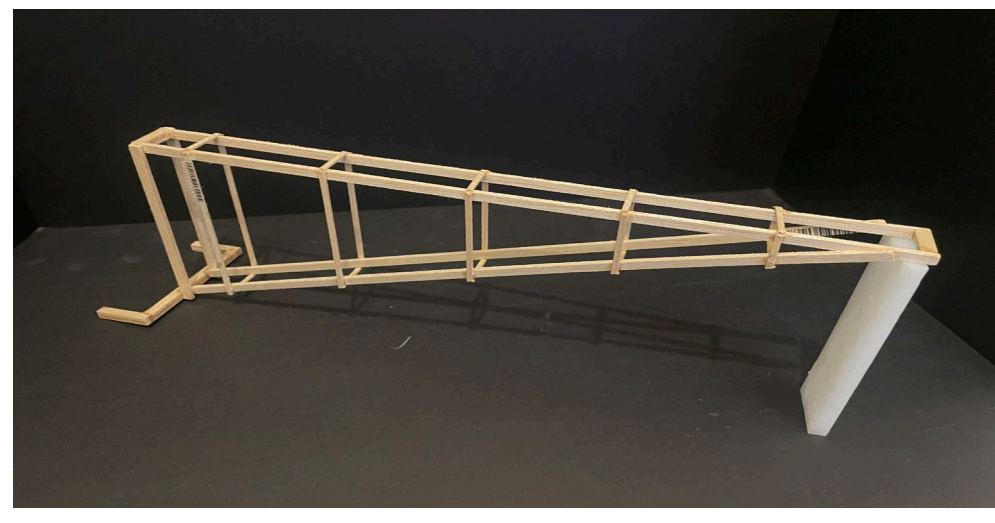


Given name by the type of force exhibited by its longest member (i.e. Hypotenuse of the Triangle Shape)

NOTE: 2026 NSO Entries were Tension Type Boomilevers

NOTE: 2027 Rule Change will be Compression Type Boomilevers

What does a “Compression” Boomilever Look Like?



2027 Boomilever – Bottom Line Up Front

CONSTRUCTION PARAMETERS

- Single structure, wood bonded by glue
- Mounting & Dimensional requirements

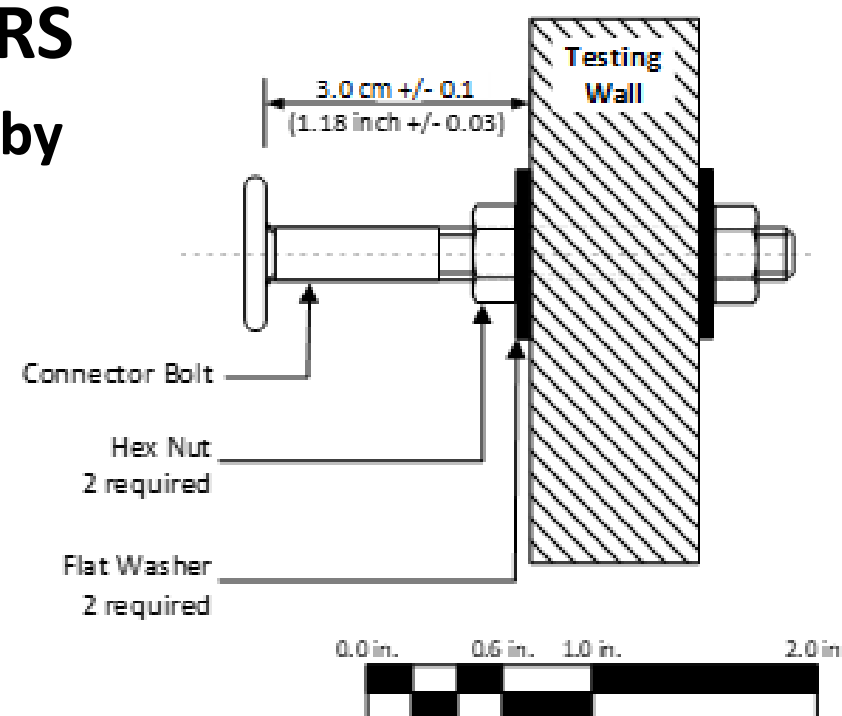


Figure 4 – Mounting Bolt Assembly in Testing Wall

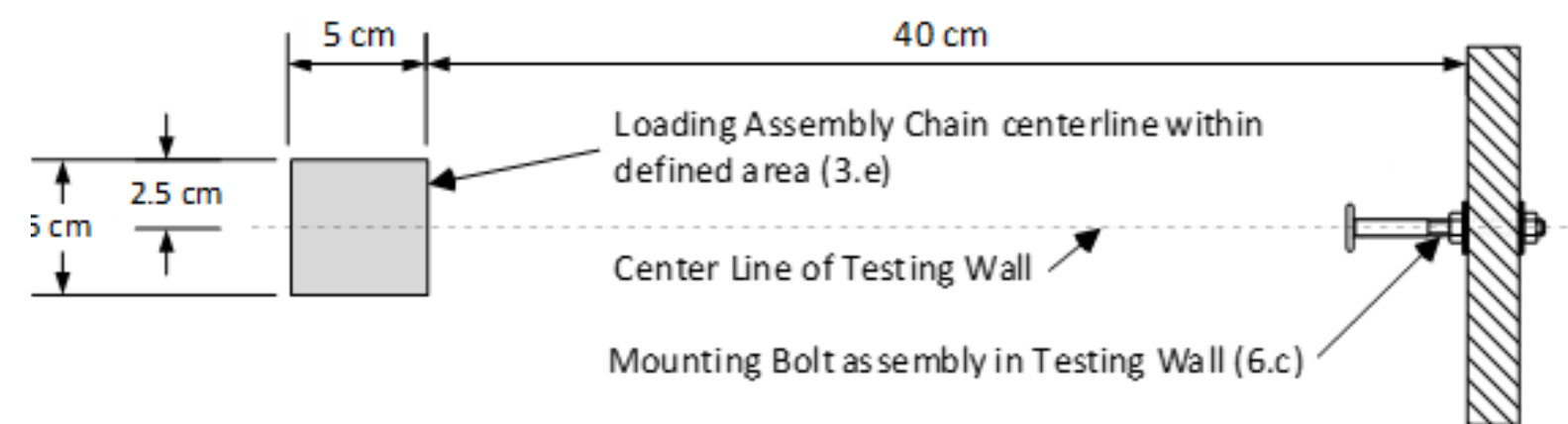


Figure 1: Top view of Testing Wall (not to scale)

Dimensional Requirements	Div. B	Div. C	Comments
Length	40 - 45 cm		9
Contact Width (CW)	< 8 cm	> 8 cm	entire test
Load Block (bottom)	Above CL of Mounting Bolt Assembly		prior to loading sand
Contact depth (CD)	< 20 cm	< 15 cm	entire test
BONUS CD & must hold 15 Kg	< 15 cm	< 10 cm	entire test

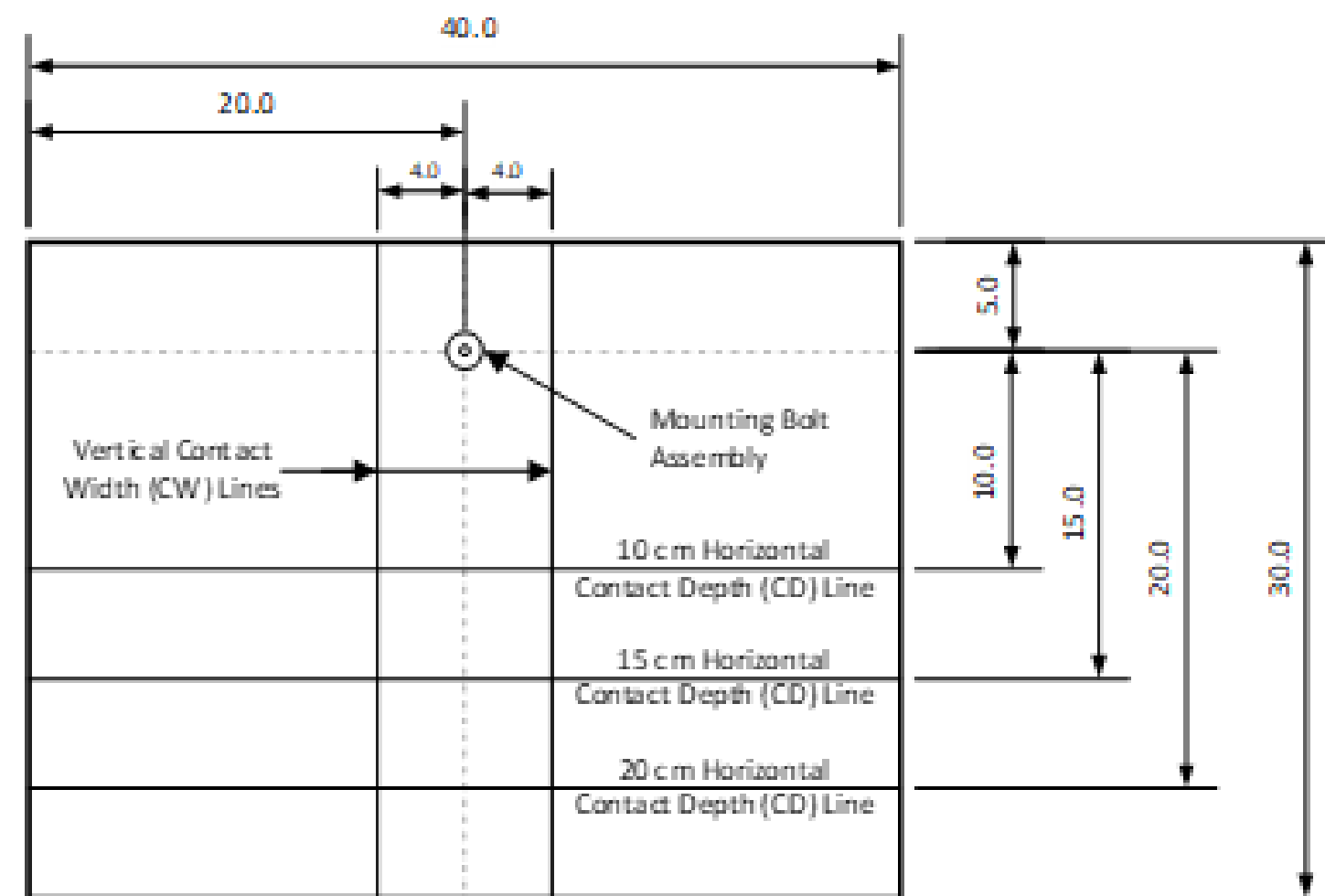


Figure 2 – Testing Wall (not to scale, dimensions in cm)

Summary of Changes from 2026 Rules

- CHALLENGE: Whole new structural dynamics and critical areas with requirements driving a “Compression Type” Boomilever
- NEW (ref 3.g Rule): Load Block Positioned higher than the Center Line plane of the Connector Bolt
 - Most 2026 designs will not meet this new requirement
- CHANGE: Load Scored Bonus (5.b) – Meeting the Load Scored BONUS construction parameters (3.i.ii). Bonus = 5000g Div B; Bonus = 7,500g Div C
- Slight change in Tie Breaker Logic
- No Change to:
 - Materials & Adhesives
 - Test Wall (Size, Markings, Connector Bolt)
 - Structure Length & Contact Width
 - Load Block Assembly
 - Load Test Process & Bonus

3.g Prior to loading sand, the bottom of the Loading Block must be supported ABOVE the horizontal plane extending from the centerline of the Mounting Bolt. During loading, the bottom of the loading block may go below the horizontal plane extending from the centerline of the Mounting Bolt.

Structure Length (Top View) - Unchanged

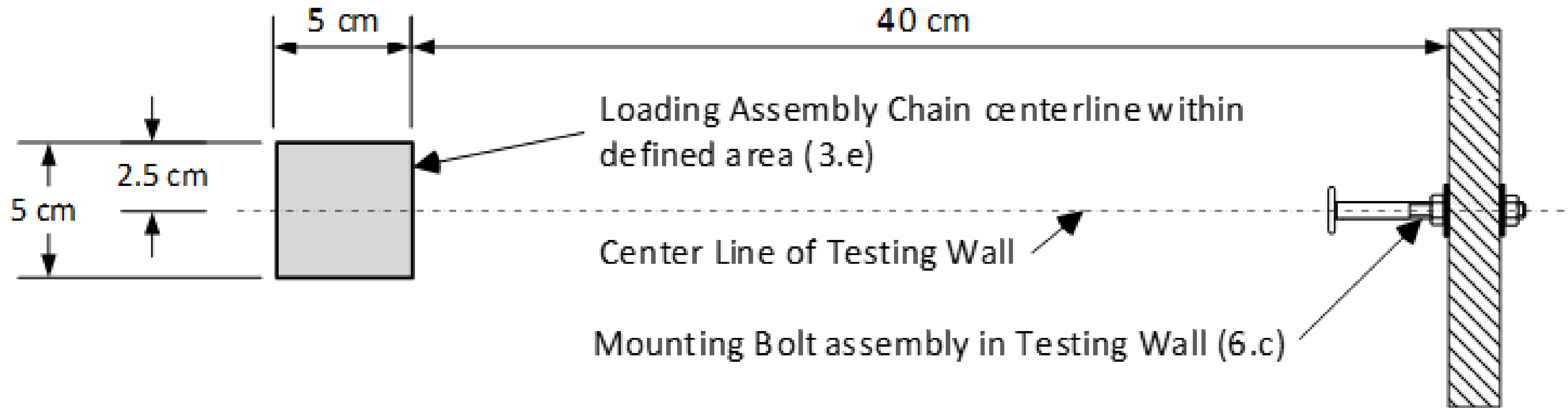
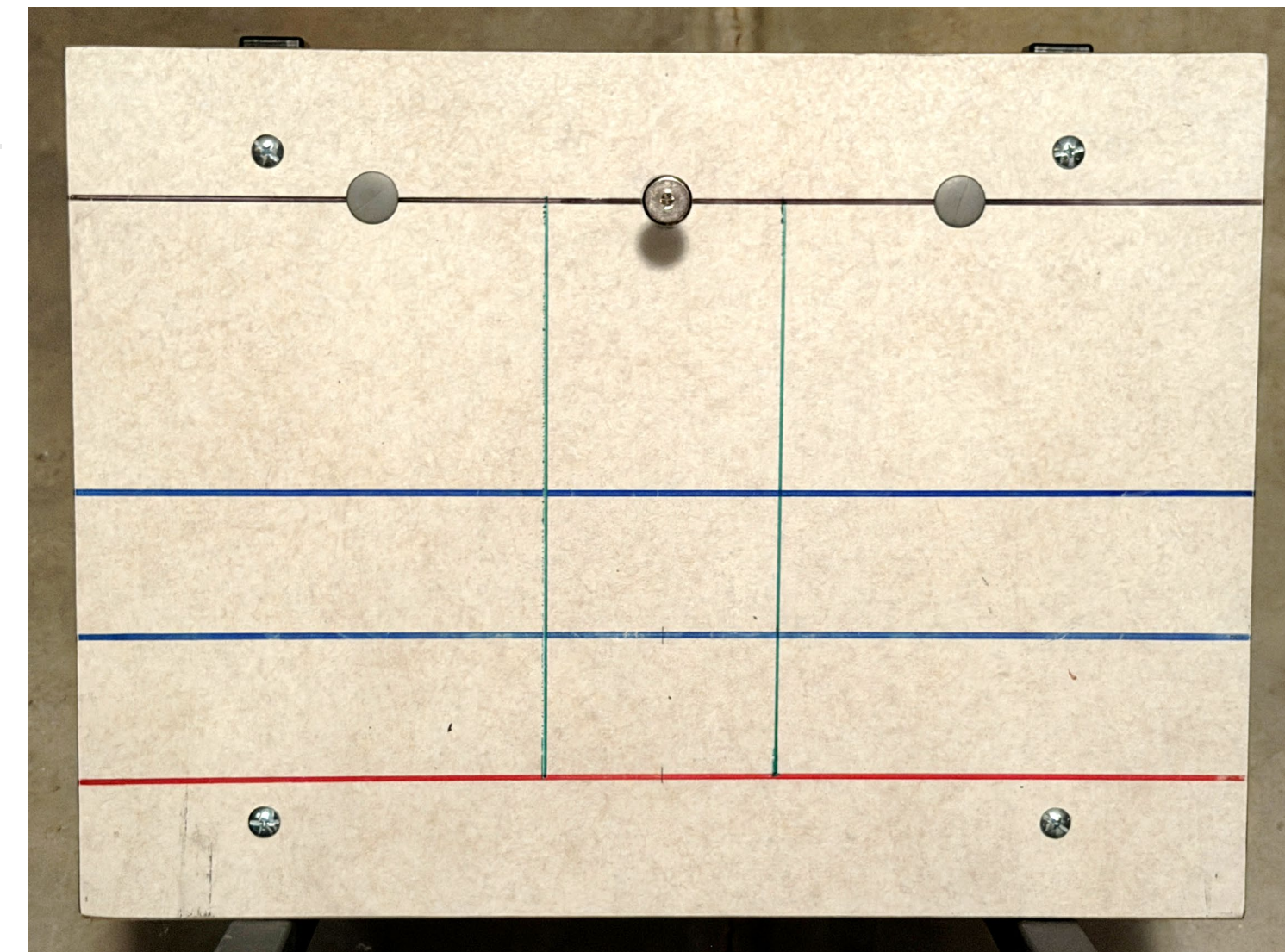


Figure 1: Top view of Testing Wall (not to scale)



2026-2027 Season

Connector Bolt - Unchanged

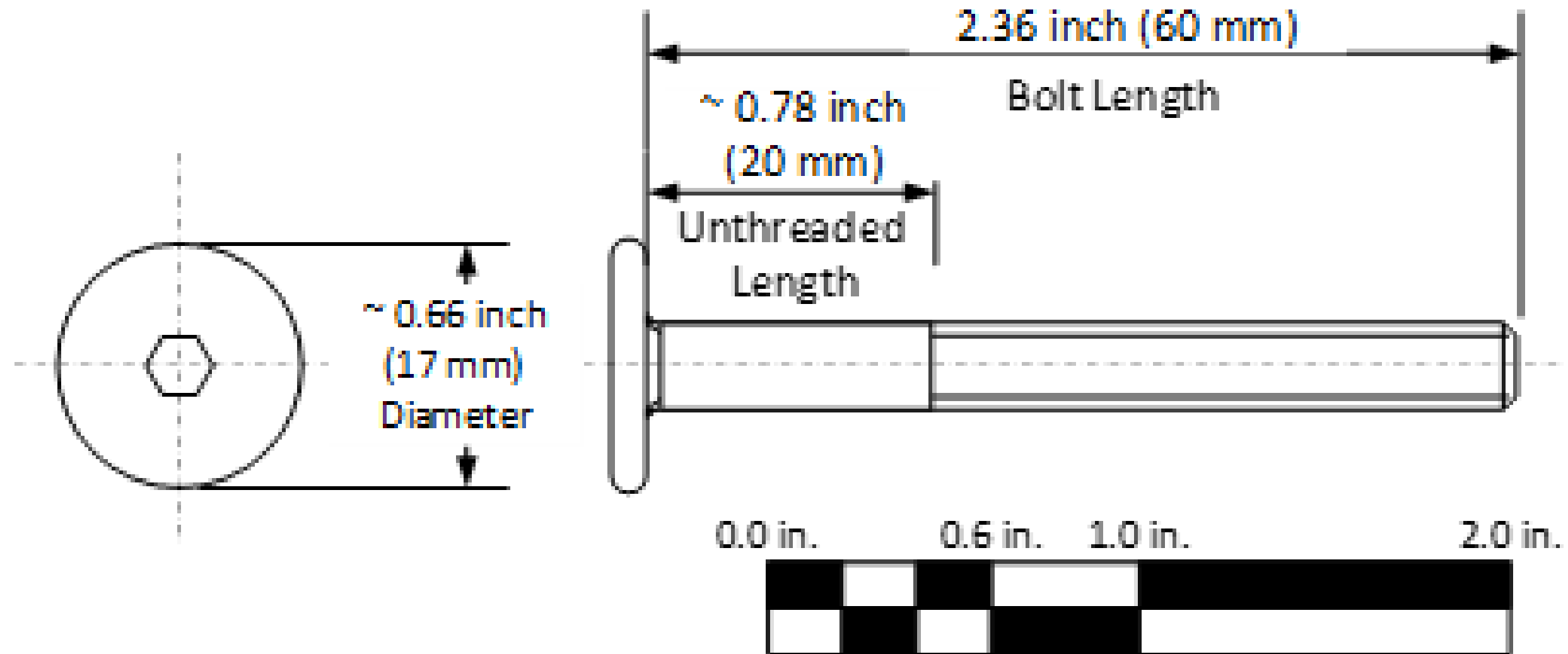
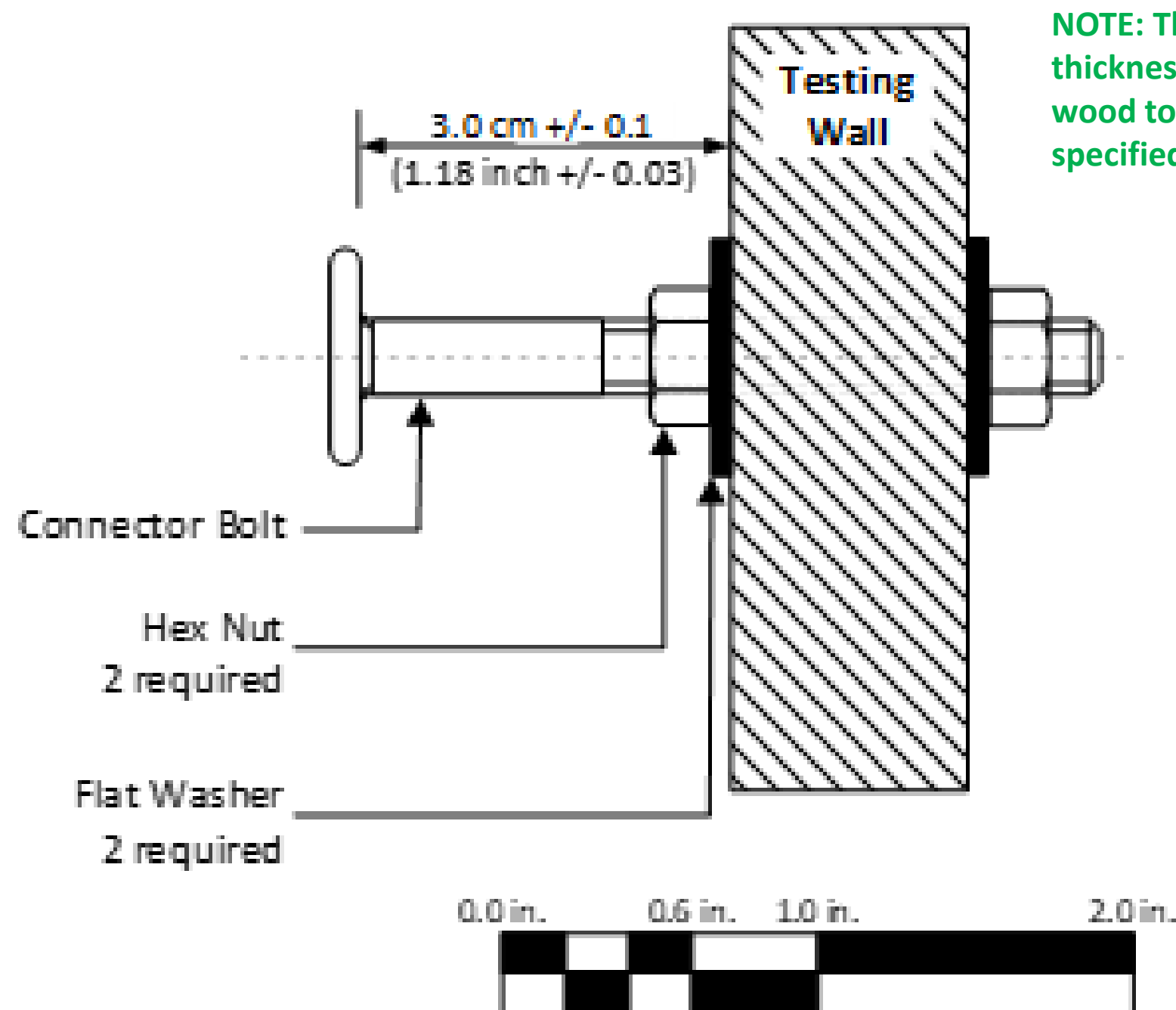


Figure 3 - Connector Bolt, $\frac{1}{4}$ -20 x 2.36 inches (60 mm) long



Mounting Bolt Assembly - Unchanged



NOTE: The Test Wall thickness should be $\frac{3}{4}$ " wood to accommodate the specified Connector Bolt.



Figure 4 – Mounting Bolt Assembly in Testing Wall

Load Block - Unchanged

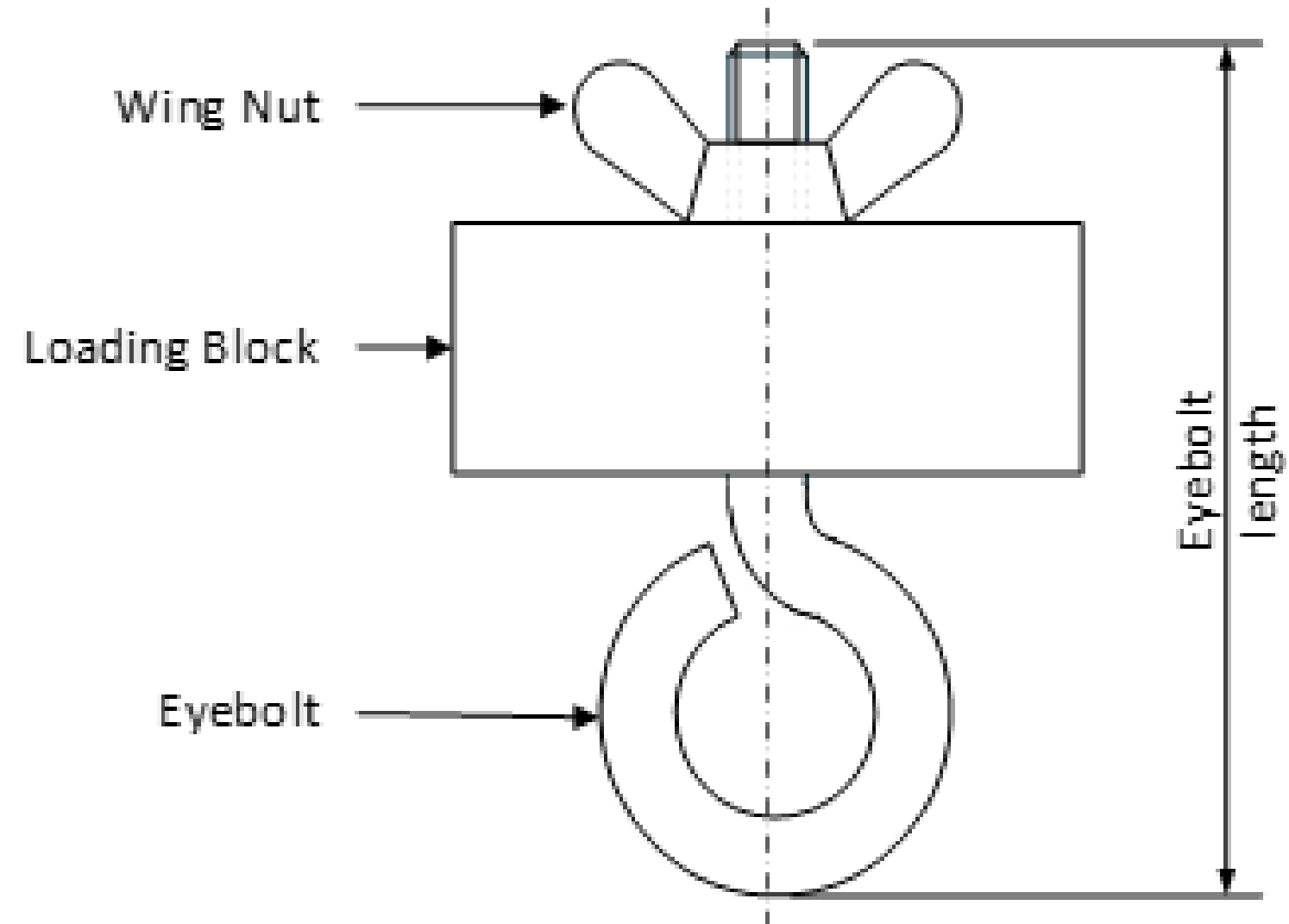


Figure 5 – Loading Block with eyebolt and wing nut (not to scale)



Loading Assembly - Unchanged

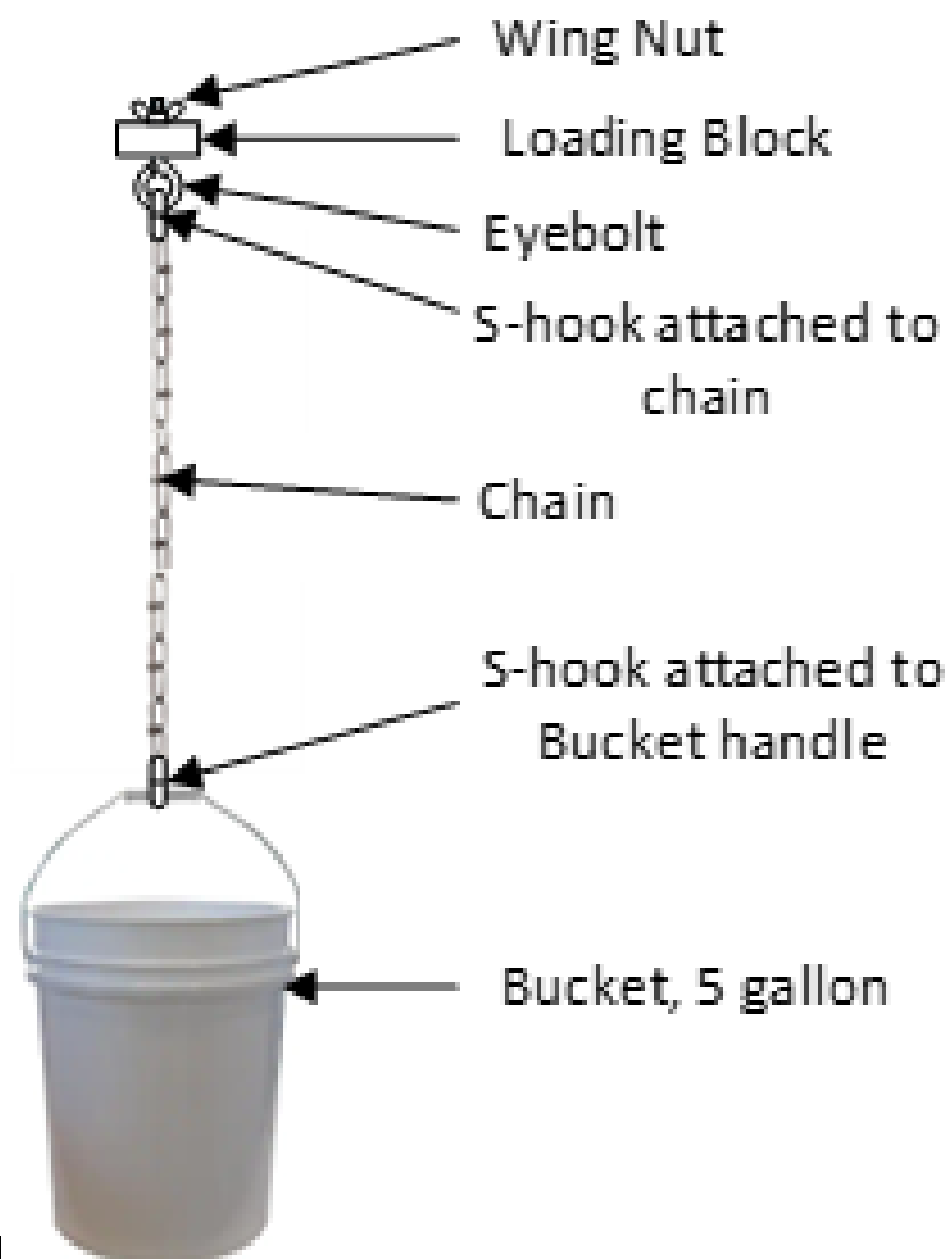
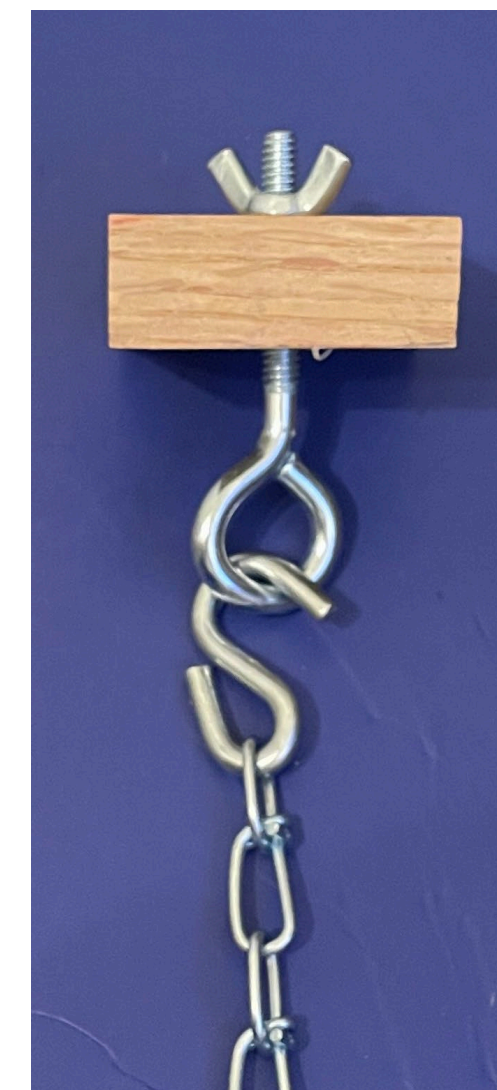


Figure 6 – Loading Assembly (not to scale)



Boomilever – Requirements Recap

➤ TEST APPARATUS: UNCHANGED

- Smooth/level/stable Test Wall (40cm x 30cm min); Mounting Bolt Assembly; Vertical and horizontal lines drawn;
- Load Block Assembly (5x5x2cm block, Eye-Bolt; Wing Nut; S-hooks, Chain, Bucket, Sand)
- Stabilization Sticks
- Measurement Devices (Structure Scale 0-200gms range w 0.01 resolution or better; 0-15Kg Sand/bucket scale 0-<15Kg range w 10 gm resolution or better)

➤ THE COMPETITION: UNCHANGED

- Check In:
 - ES: construction compliance
 - Students: weigh structure, submit estimated load supported, eye protection
- Test: Stand: ES Confirms test set-up; Loading Assembly mass: <1.5Kg Maximum; 15.1Kg – 15.2Kg Load

Test:

Students: Mount Boomilever, placement of load assembly, load until failure, full load or 6 minutes expires

ES: visual verification of Construction and Competition parameters

➤ SCORING: UNCHANGED

- $\text{Score} = \text{Load}_{\text{gms}} \div \text{Mass}_{\text{gms}}$ or $\text{Score}_{\text{Bonus}} = (\text{Load}_{\text{gms}} + \text{Bonus}_{\text{grams}}) \div \text{Mass}_{\text{gms}}$
- Tiers: Tier1 - Fully Compliant; Tier2 - Construction Violations; Tier3 - Cannot Load (cannot hold min load)

Boomilever – Key Parameters

Length = Structure's Length (in reference from Wall Contact Surface to Load Block Assembly)

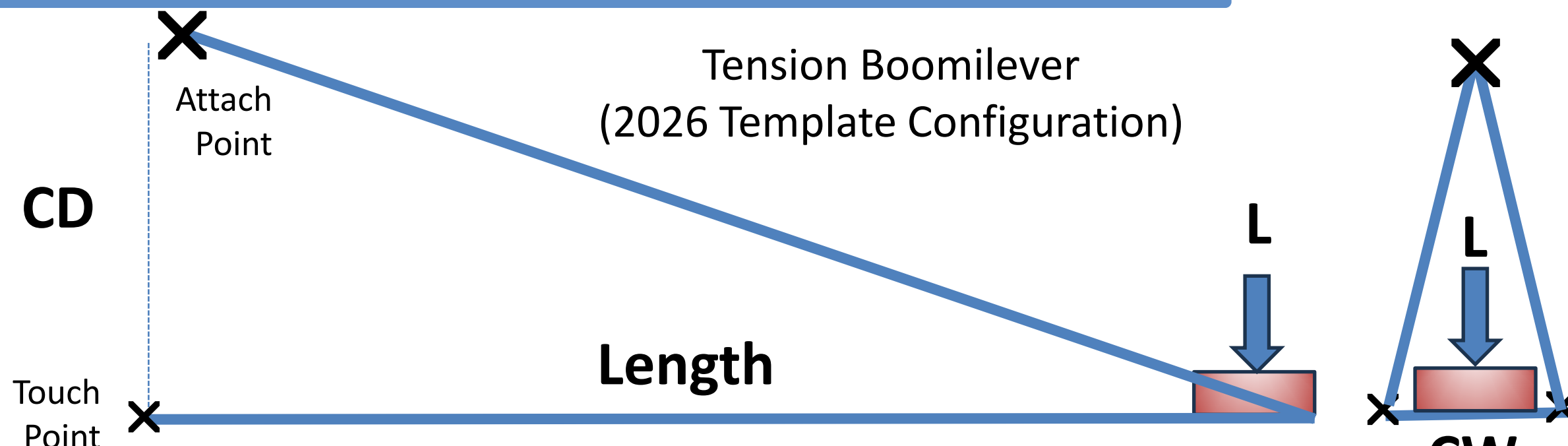
CD = Contact Depth (<20cm for Div B; <15cm for Div C). Bonus for Aggressive CD

- **NOTE:** Div B CD is longer than the Div C requirements!

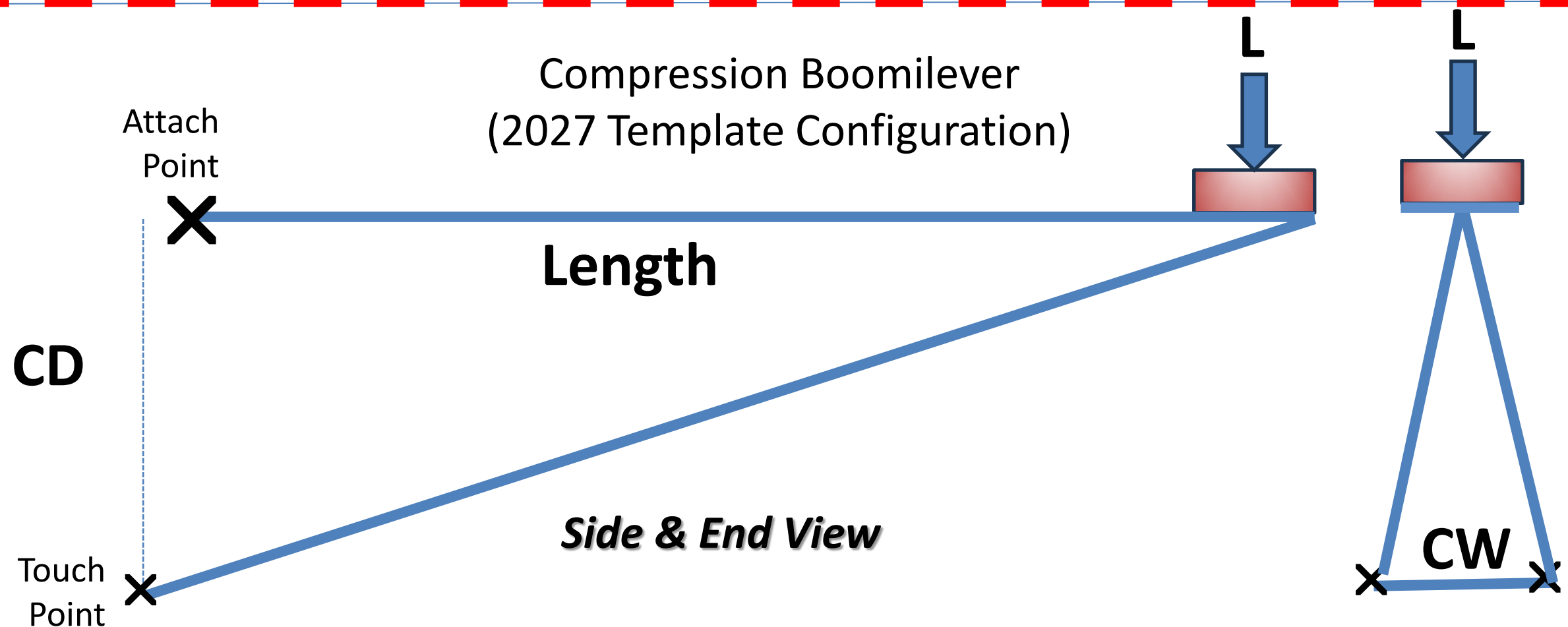
L = Load (Tier 1 "ability to load": 1kg min, 15Kg max)

CW = Contract Width (in reference to its Touch points on the Surface Wall)

- **NOTE:** Div B CW is narrower than the Div C requirements!

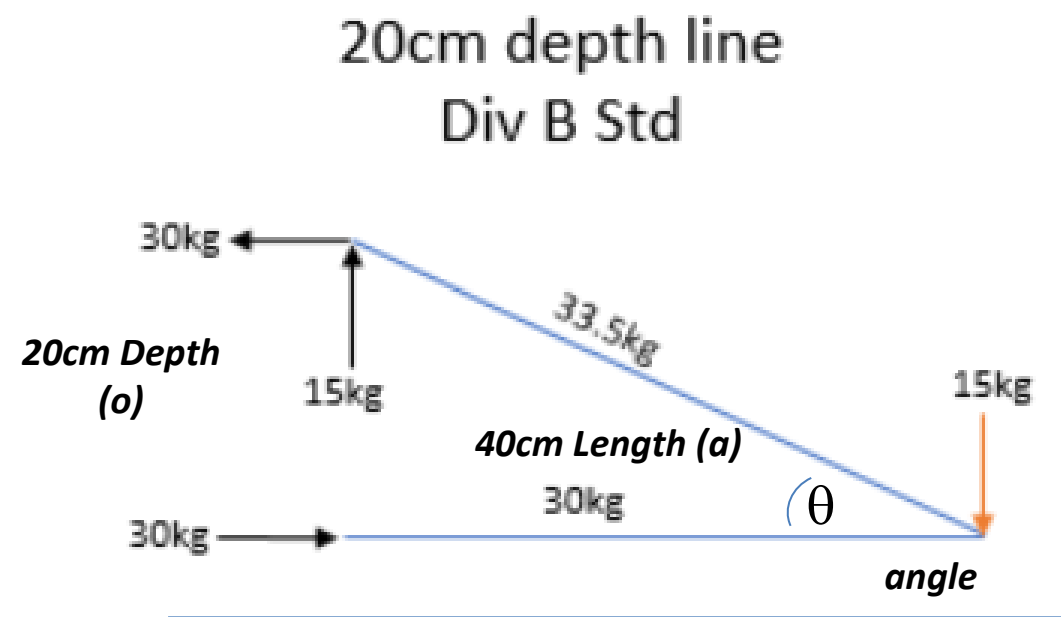


Side & End View



Side & End View

Boomilever – Force Calculations (from 2026)



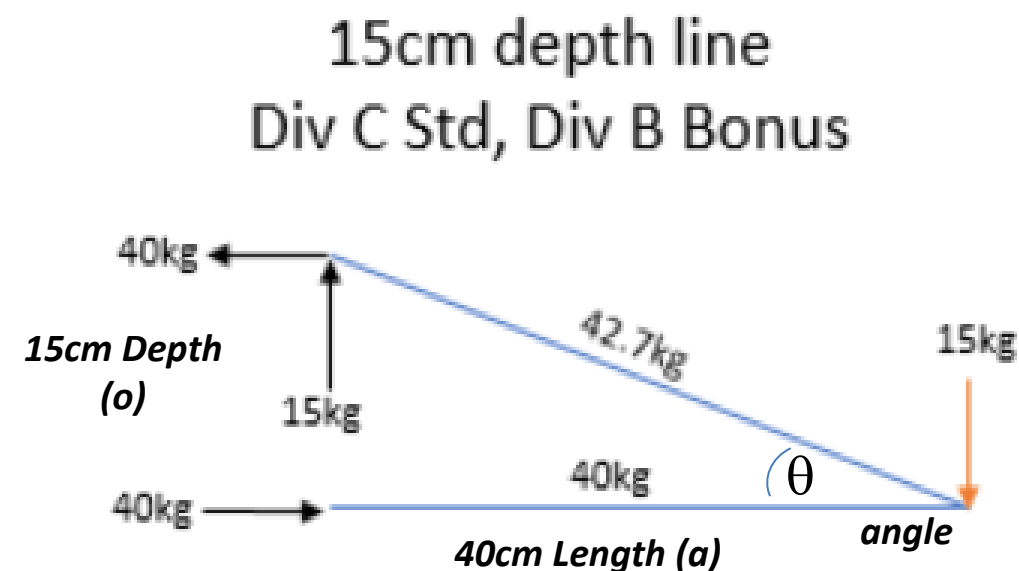
$$\left. \begin{array}{l} \text{Angle} \\ \tan \theta = \frac{o}{a} \end{array} \right\} = 20\text{cm} / 40\text{cm} \\ \tan \theta = 0.5000 \\ \theta = 26.56^\circ$$

Compression Force

$$\tan \theta = \frac{o}{a} \\ = 15\text{Kg} / \text{XKg} \\ \text{XKg} = 15\text{Kg} / \tan \theta \\ = 15 / 0.5000 \\ \text{Force} = 30\text{Kg}$$

Tension Force

$$a^2 + b^2 = c^2 \\ (15\text{Kg})^2 + (30\text{Kg})^2 = c^2 \\ 225\text{Kg}^2 + 900\text{Kg}^2 = c^2 \\ 1155\text{Kg}^2 = c^2 \\ (1155\text{Kg}^2)^{-2} = 33.54\text{Kg} = c \\ \text{Force} = 33.54\text{Kg}$$



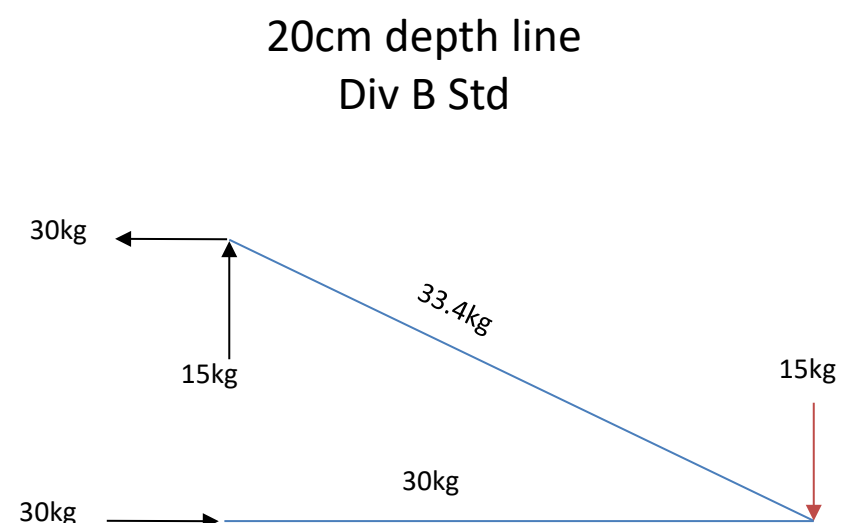
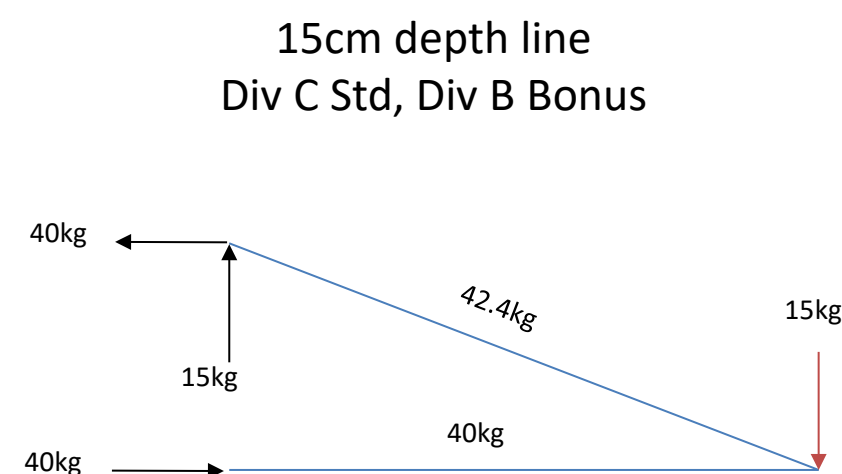
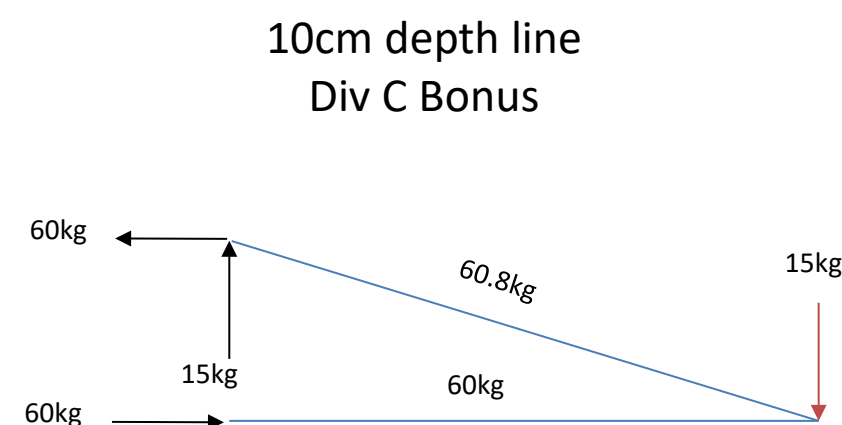
Same Calculations, but with Div C Contact Depth

- $\theta = 20.55^\circ$; Compression Force = 40Kg; Tension Force = 43Kg
- BONUS: $\theta = 14.04^\circ$; Compression Force = 60Kg; Tension Force = 61.84Kg

Force Vector Analysis Summary:

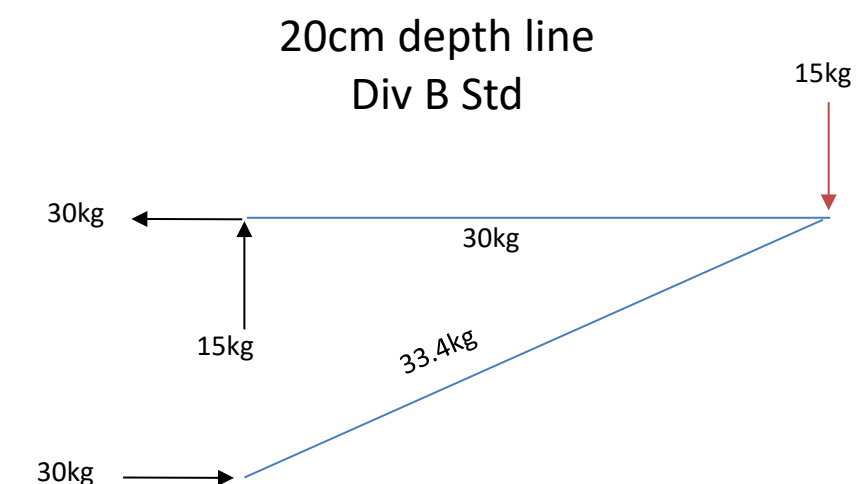
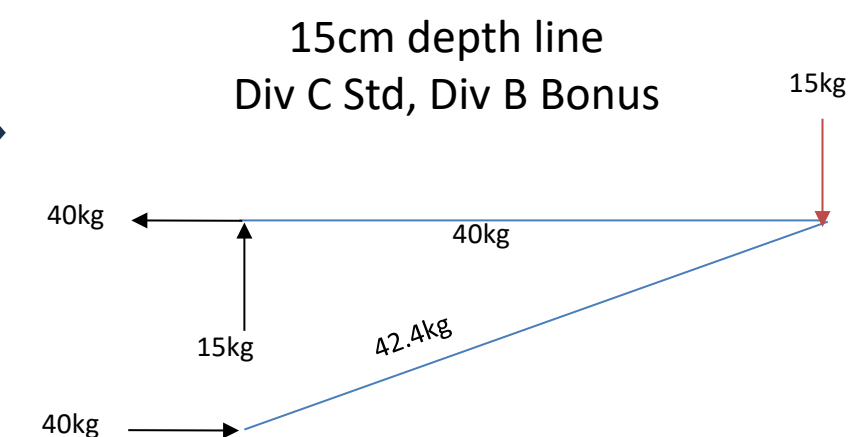
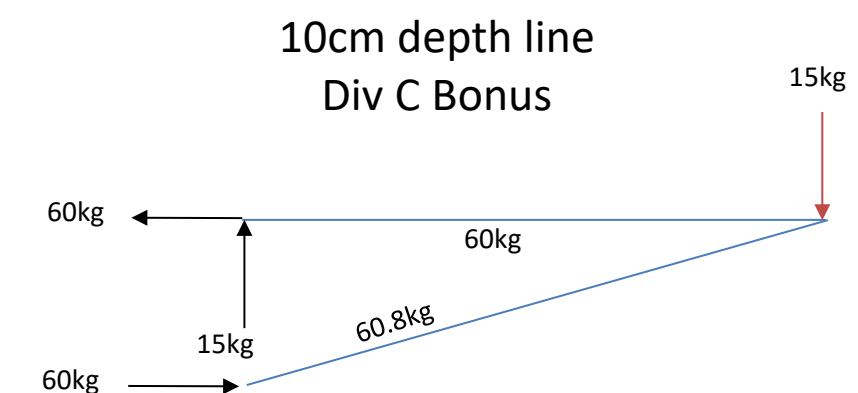
- Tension and compression forces experienced by the structure's members are significantly higher than the 15Kg max Load applied to the Load Block point
- The longer the length from wall surface to the center of the Load Block bolt, the smaller the θ angle of the structure, then the larger the forces are applied to its members.
 - GUIDANCE: Make the Boomilever just long enough to satisfy the length requirement
- The smaller the θ angle of the Boomilever (or the shorter the Depth), then the larger the forces are applied to its members.
- Forces change from Tension-Compression, and Compression to Tension when design is flipped-over to create a "Compression Design" Boomilever

Boomilever – Force Changes (to 2027)



Change in Boomilever Forces

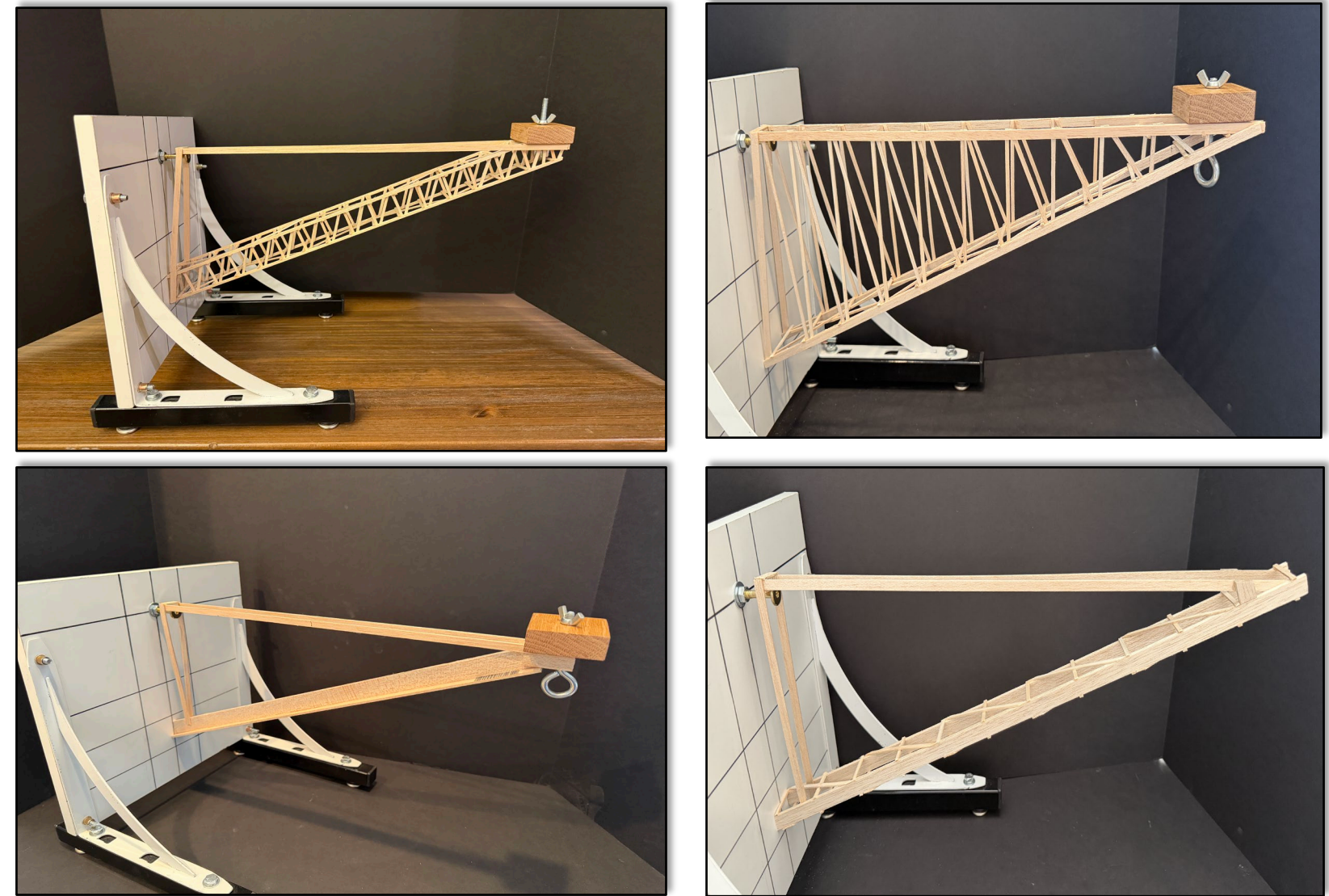
- Horizontal Member Force Becomes Tension
- Diagonal Member Force Becomes Increased Compression



2026-2027 Season

Build Clinic Learning & Objectives

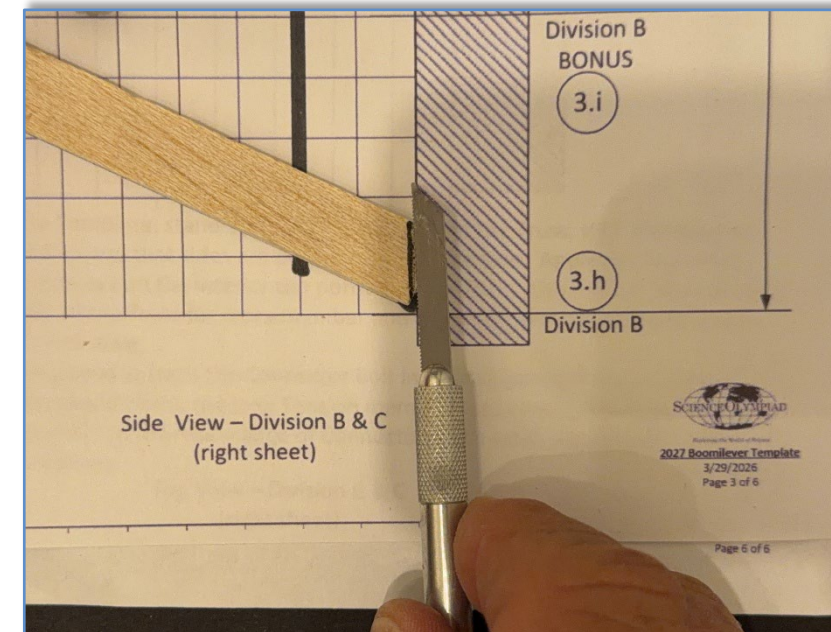
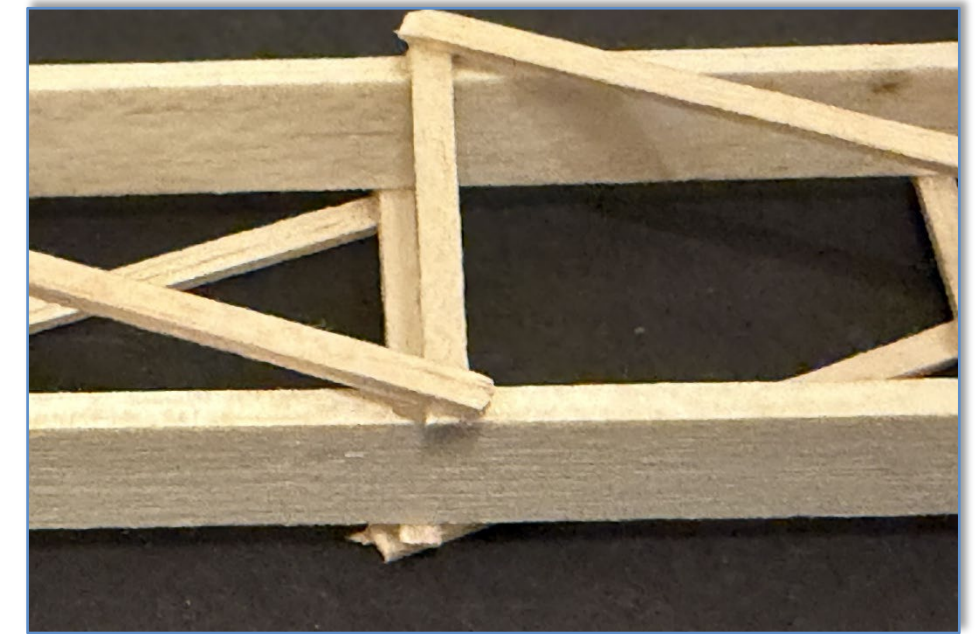
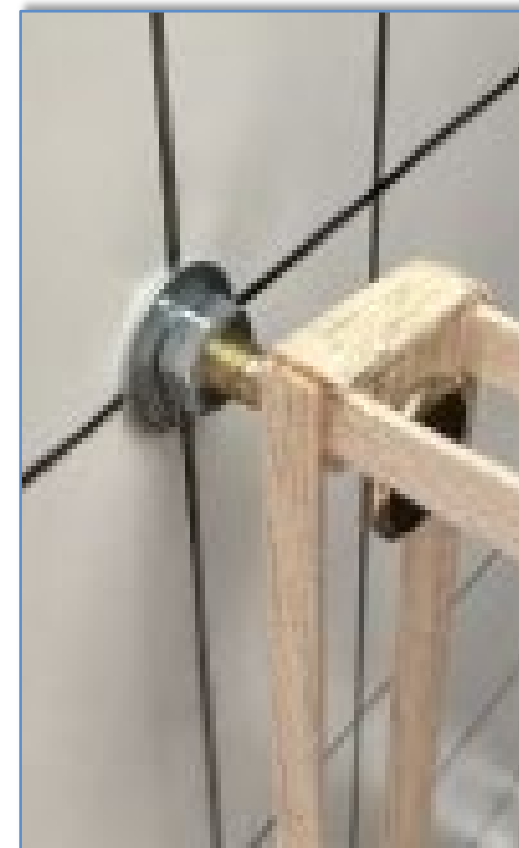
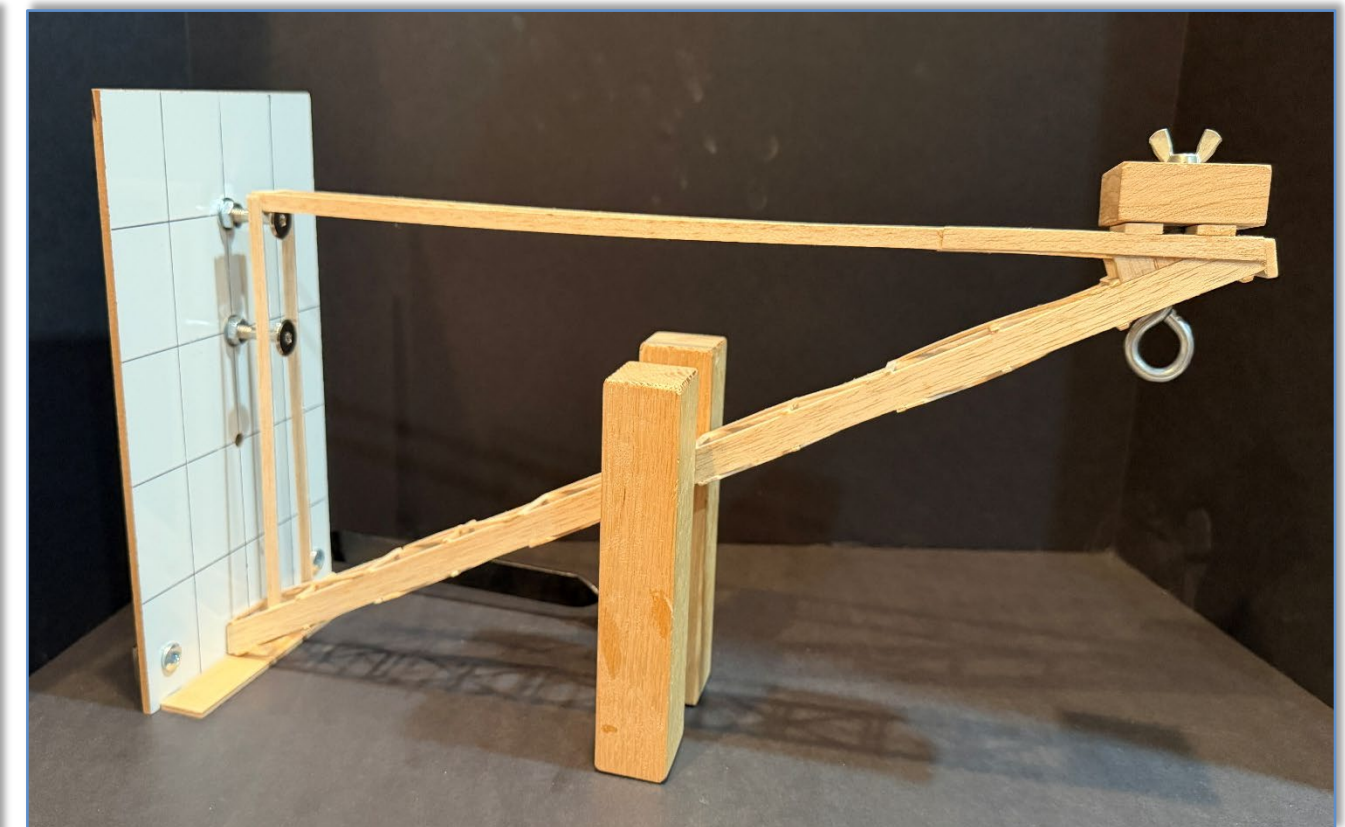
- Templates for New Div B & C Builders construction methods and techniques (1st Usage of Intended YouTube Video Release – 2027 Boomilever Template Build & Test)
- Accessibility to Event Supervisors
- Sharing of Past Experiences, Tips, & Tricks
- Learning of Use of limited and low-cost hard tooling
- Use of typical materials & Glues, and a variety of low-cost tools
- Ability for Structure's construction within <3 hours
- Successfully tested as a compliant Tier 1 entry
- Load tested to entry level scoring (~600:1 Structural Efficiency)



Example 2027 Boomilever (Div B) using Template

2027 Boomilever – Template

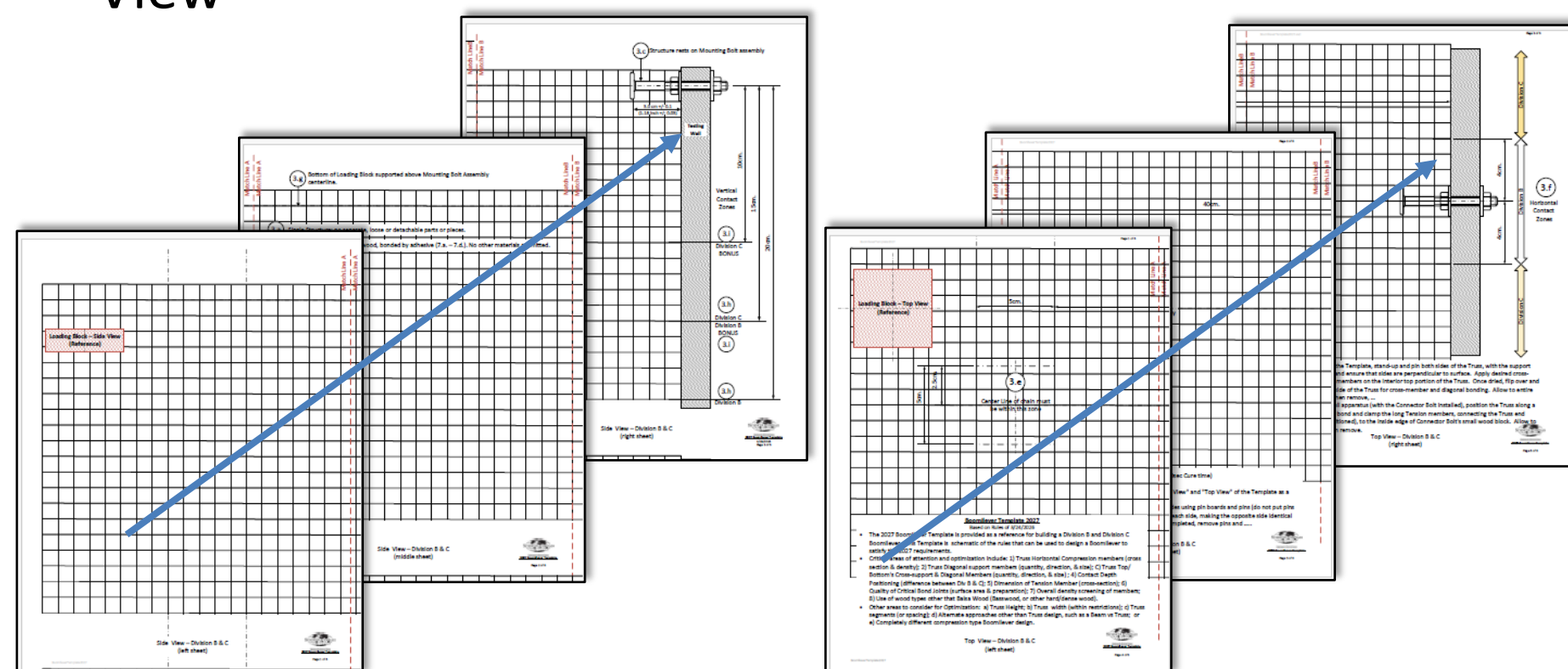
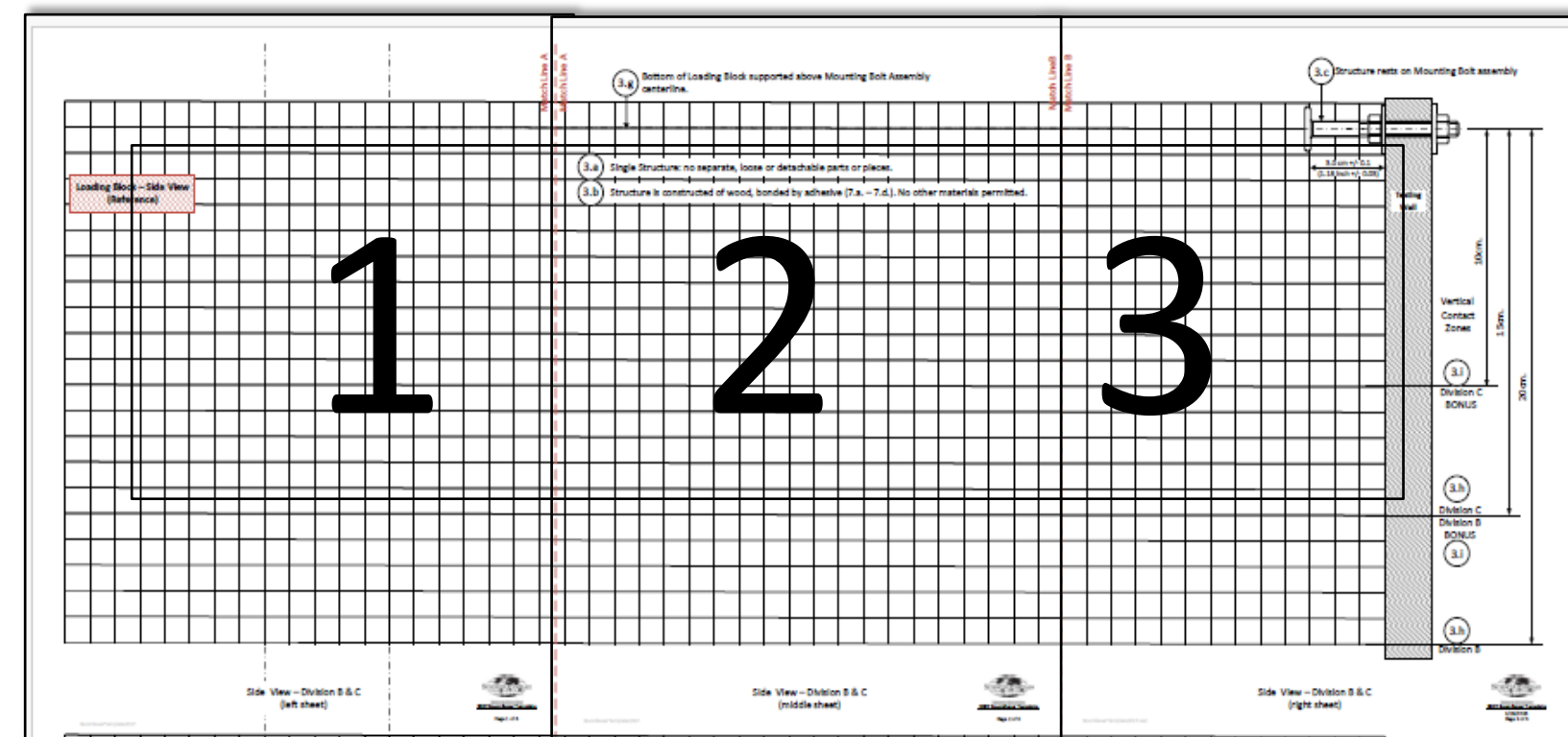
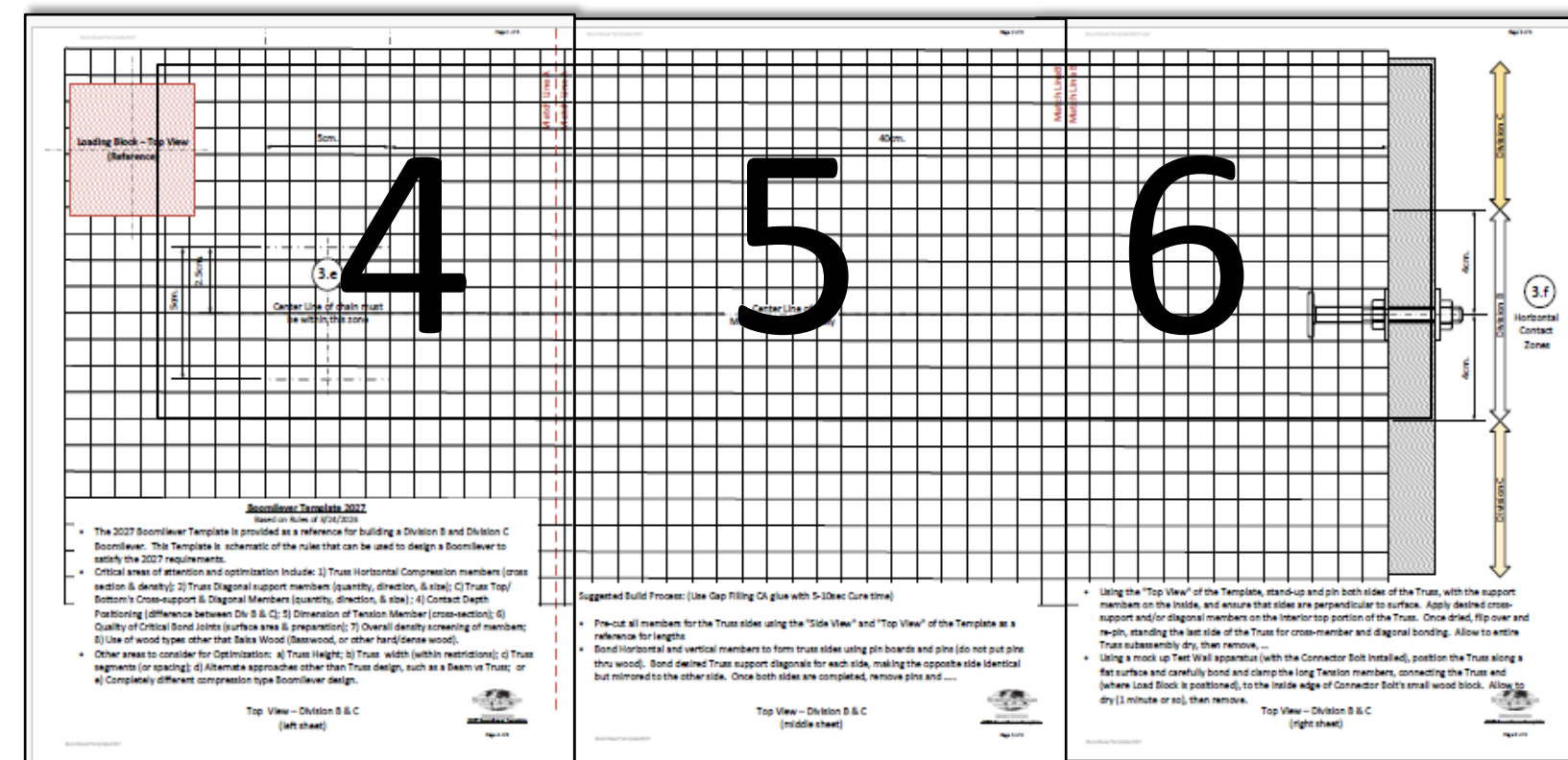
- Available on SO Website in ~Sept'26
- 6-page Common Template for Div B & C
- Contains verbiage on design decisions and challenges
- Provides scale schematic of Truss and Tension Member
- Illustrates challenge for BONUS pursuits
- Official 2027 SO Template Video to be Posted



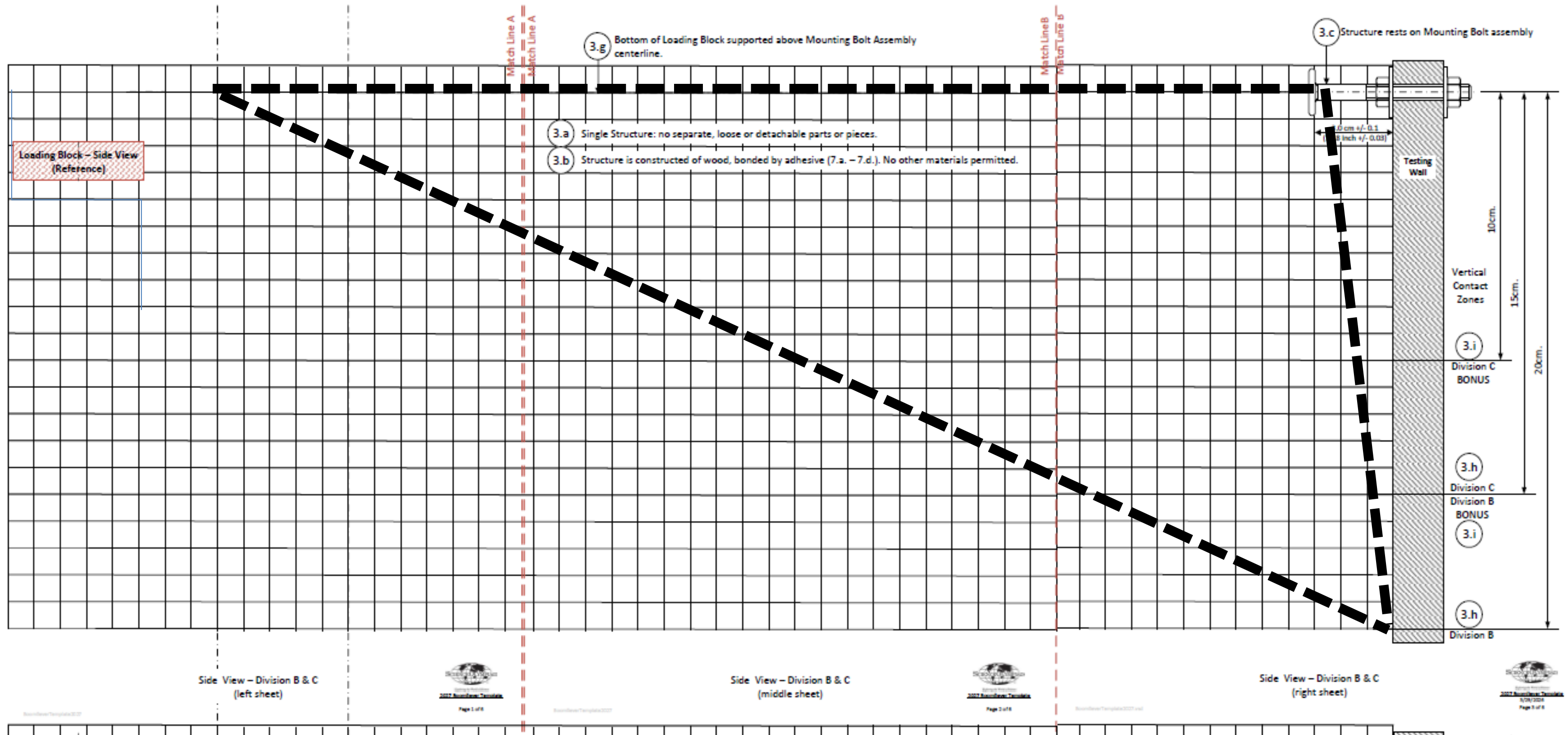
2027 Boomilever Template (Div B & C)

Using the Template:

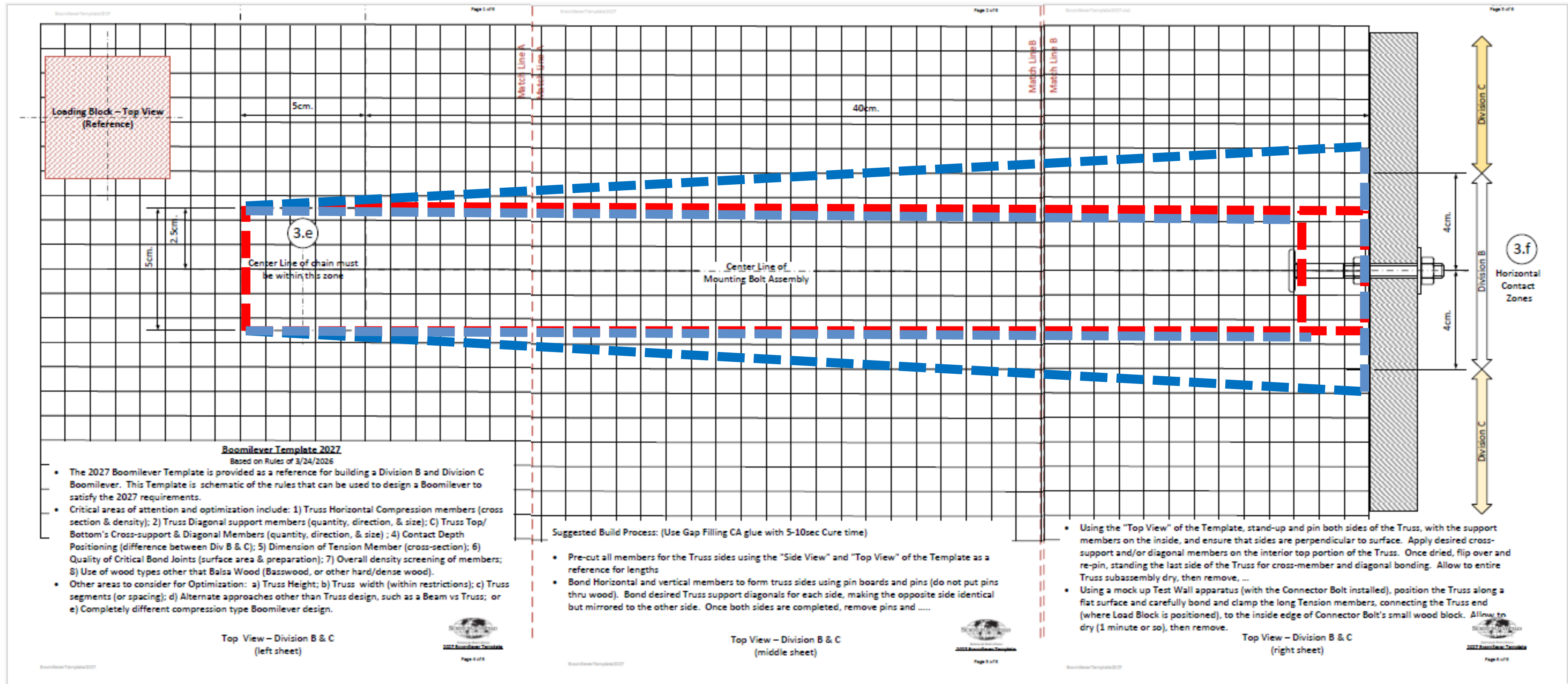
- Obtain official SO 2027 Templates from the NSO Website, and print PDF File (6 pages) at “Actual Size” (or 100%)
- Verify correct printout dimensions by measuring the “Reference Scale” on the center of page 2
- Position & Tape pages 1, 2, & 3 to create Side View
- Position & Tape pages 4, 5, & 6 to create Top View



2027 Boomilever Template – Side View Layout



2027 Boomilever Template – Top View Layout



Red Lines = Div B Width; Blue Lines = Div C Width

2026-2027 Season

Build Clinic – Assembly Aides

2027 Boomilever
Div B Aide



2026 Boomilever
Div B Aide

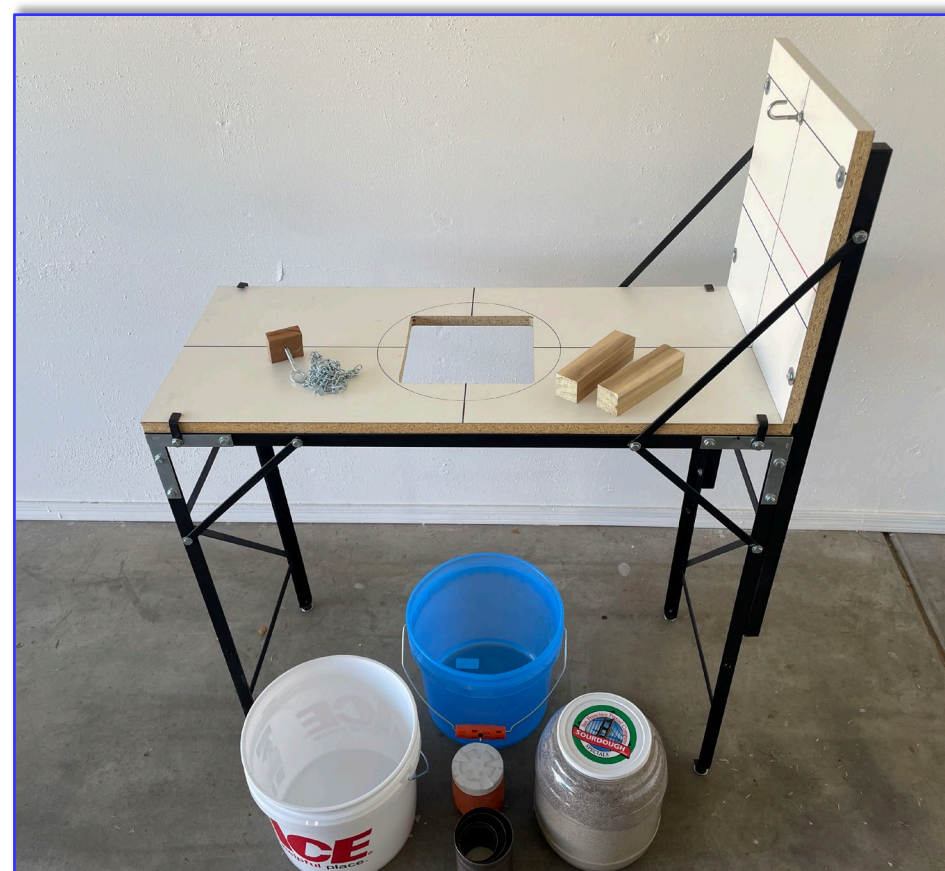


Example Test Stands

**Typical Boomilever
Hopper System**



**Universal Manual Table
Stand**



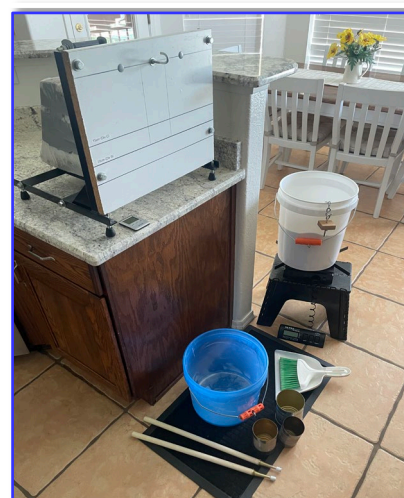
**Vertical Manual
Boomilever w
Counterweight Test Stand**



**Hybrid Universal
Hopper System**

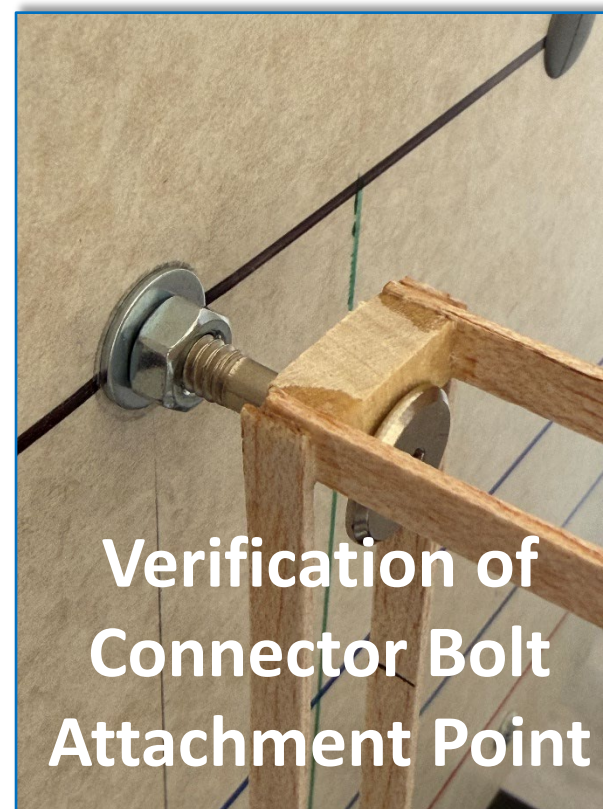
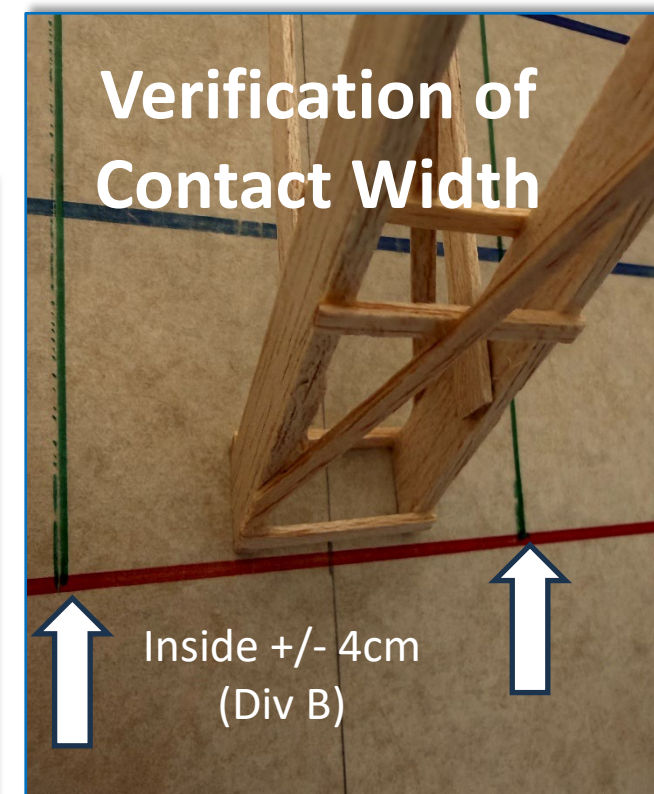
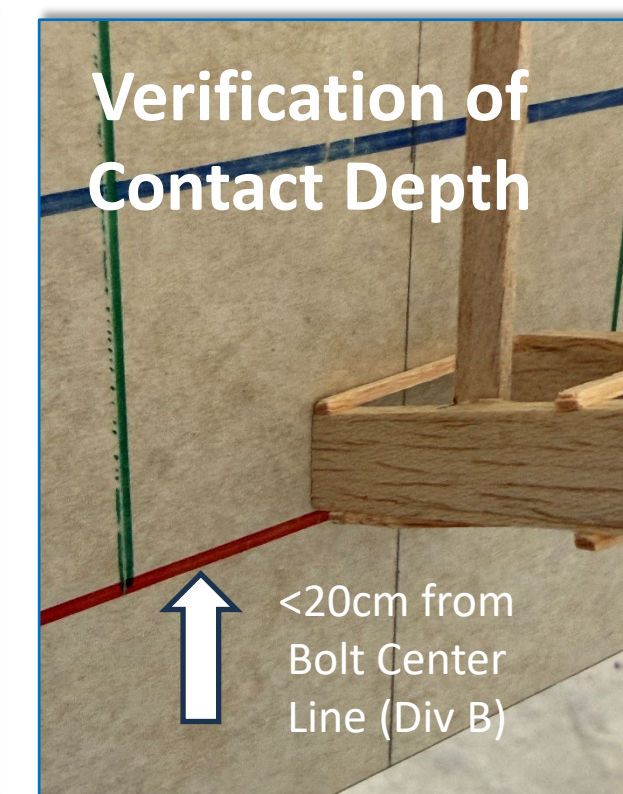
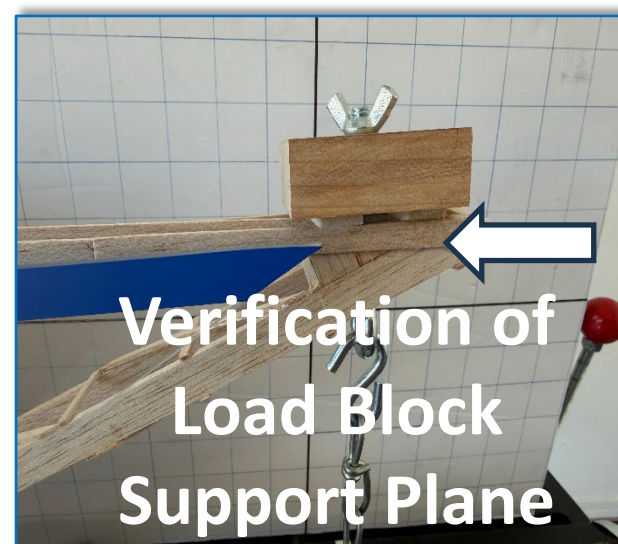
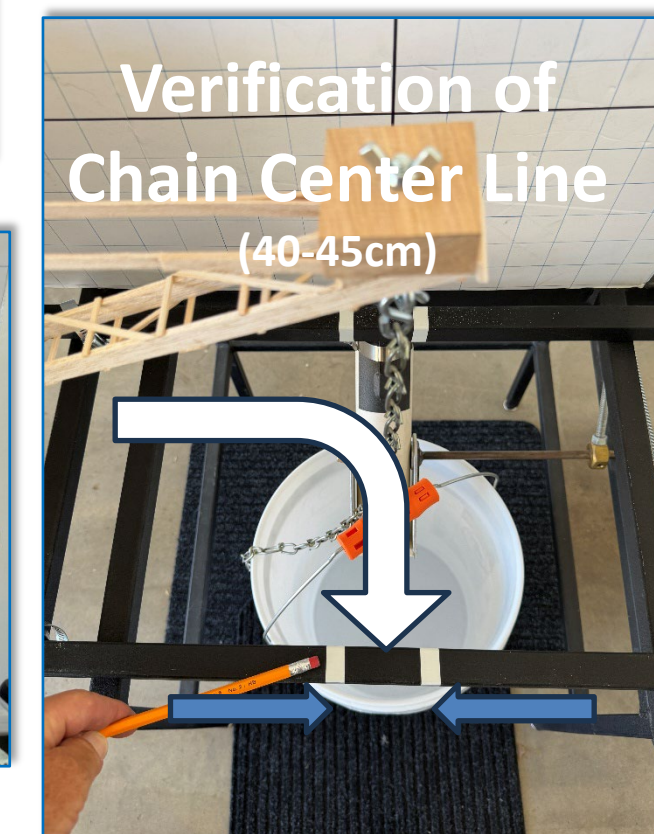
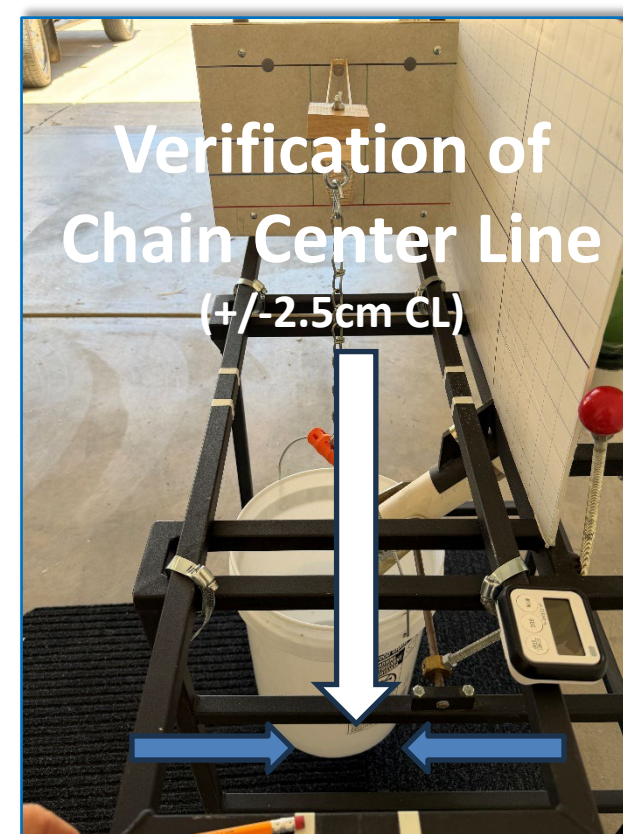


**Tabletop Manual
Boomilever Test
Stand w
Counterweight**



Boomilever – Verification Methods

Requirement	Rule	Verification Method
Test Apparatus	6.0	Levels, rulers, or a variety of instruments for Event Supervisor to ensure a compliant Test Platform
Materials	3a - 3.d	Visual inspection by Event Supervisor
Structure Mass	4.b.iii.4 & 6.f	Measured by Structure Scale
Contact Depth	3.h	Visual Indicators (lines) on Test Wall (Figure 2)
Contact Width (CW)	3.f	Visual Indicators (lines) on Test Wall (Figure 2)
Chain Center Line (CL)	3.e.1 3.e.ii	Measured by Ruler, or Visual Indicators (lines) on the Test Stand
Load Block Support Plane	3.g	Visual Aids (such as Drafting Triangles)
Load Supported	4.c.v & 6.g	Measured by Sand Scale (Figure 6 Load Assembly Components & Sand)



Boomilever - Other Event Equipment

Load Block (5x5x2cm block with 8mm hole in center)

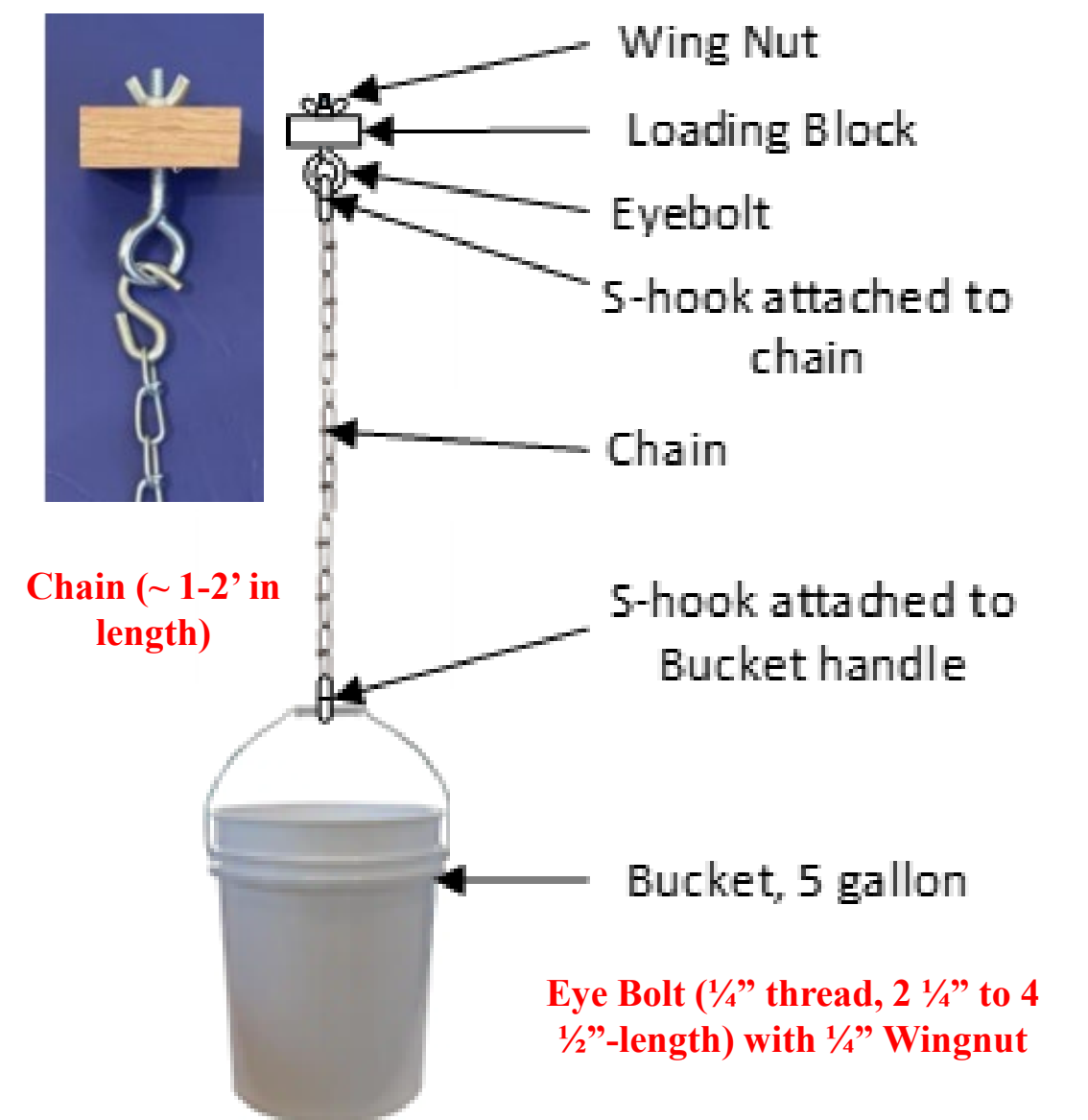
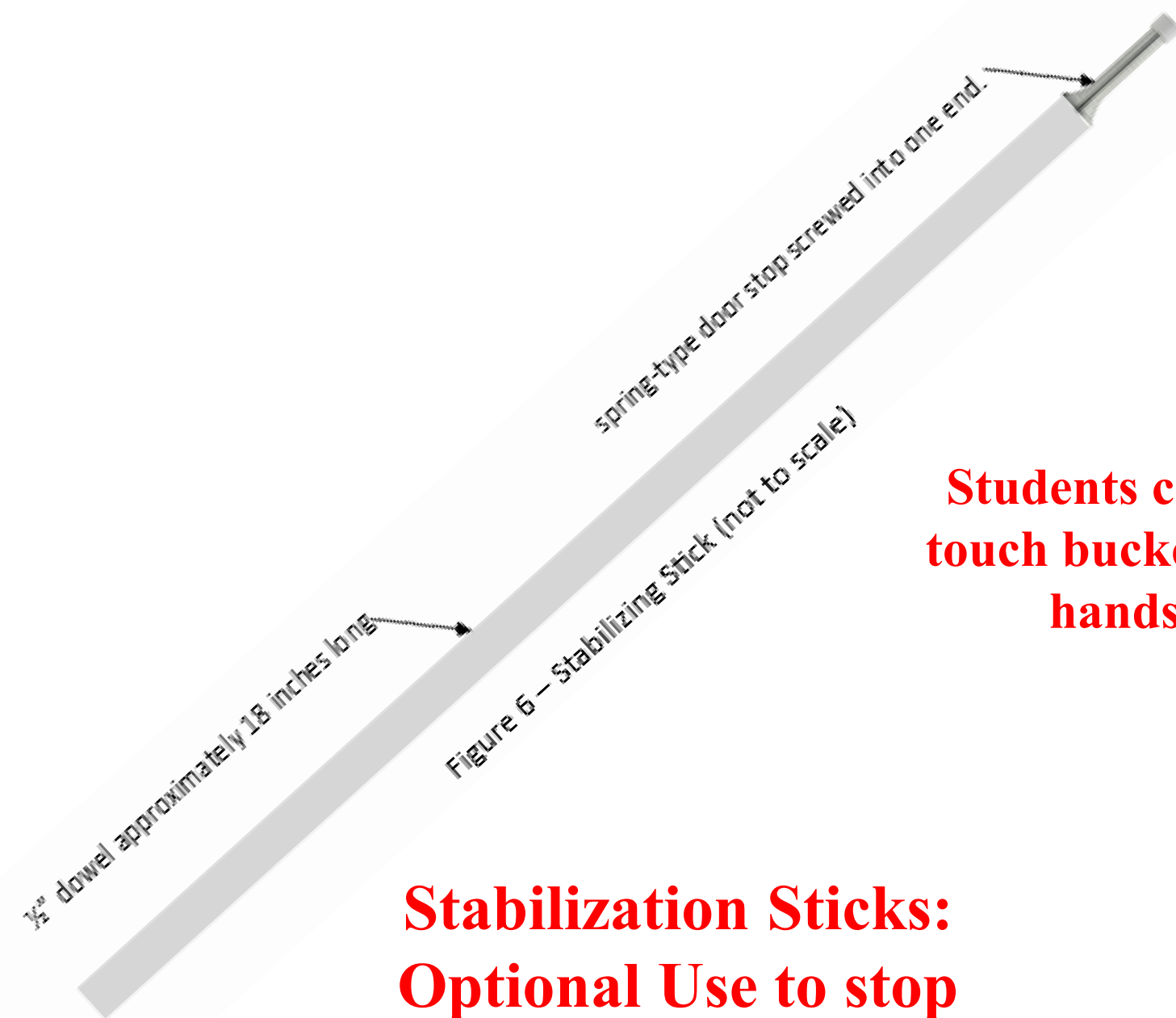


Figure 5 – Loading Assembly (not to scale)



**Stabilization Sticks:
Optional Use to stop
bucket from swaying**

**Students cannot
touch bucket with
hands!**



**Mandatory Eye
Protection
(ANSI Z87+)**

Thoroughly Read & Understand Each Requirement

Affordable & Available Scale Options

Amazon Searches in 2023

- **Structure Scale:** Search Amazon.com for “Jeweler's Scales”
 - Fusion Digital Scale 0-200g/0.01g @ ~\$9
 - Gram Scale 220g/0.01g @ ~\$12
 - Weigh Gram Pocket Scale 0-200g/0.01g @ ~\$8

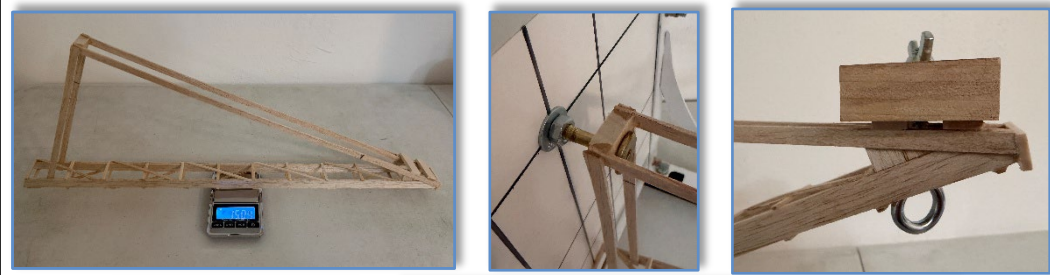
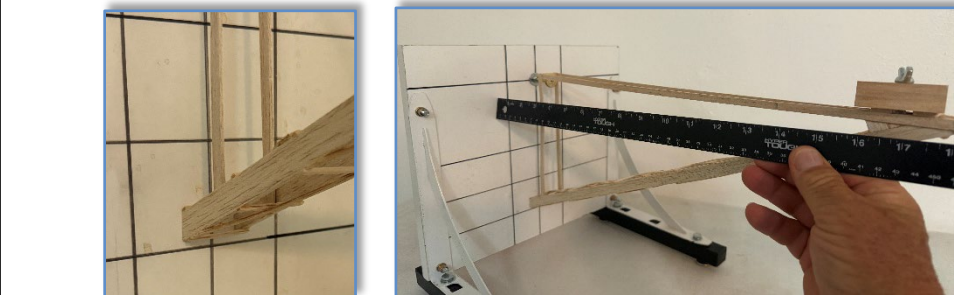


- **Load Scales:** Search Amazon.com for “Postal Scales”
 - Fusion Shipping Scale 86lb (or 39Kg/0.000Kg) @ ~\$24
 - Amiloe Digital Postal Scale 66lb (or 30Kg/00.0Kg) @ ~\$30
 - MyWeigh Ultra Ship Ultra 35/55/75 lb Scale display in grams @ <\$55

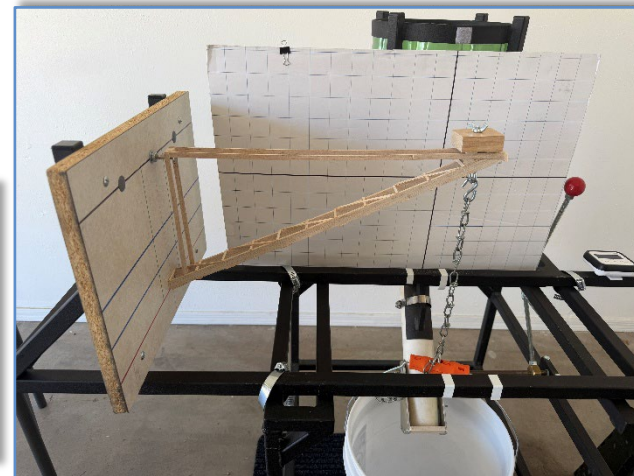
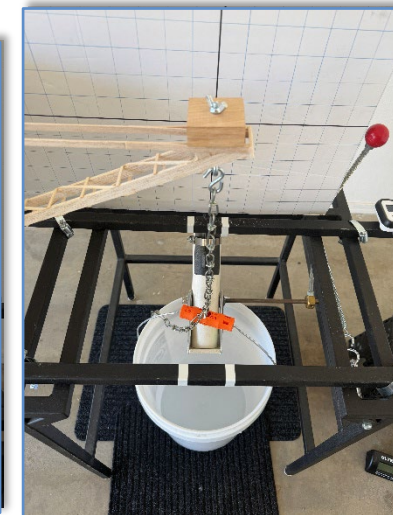


DO NOT USE: Triple Balance Beam, Bathroom Scales, In-Line Fishing Scales, or Luggage Scales!

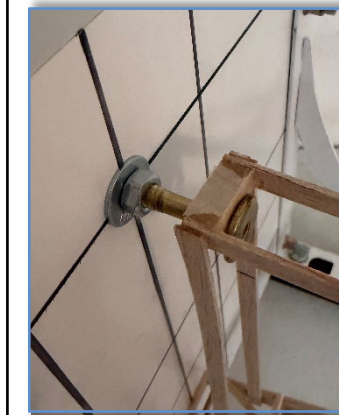
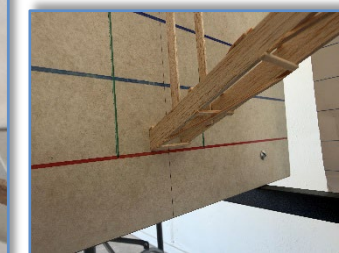
Boomilever - Hopper Load Testing Sequence



1) Check-in by Student: a) Discusses design/construction & estimated Load; b) Structure Weighed; c) INITIAL visual compliance checks; d) Determine if Bonus is pursued



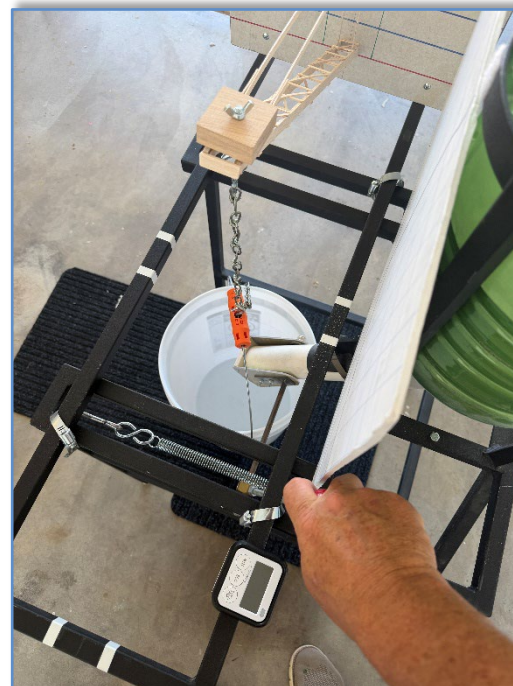
2) 6min Timer Starts: a) Mount Structure to Stand, then b) Mount Load Block Assembly; then c) Attach Empty Bucket



3) Supervisor Visually Verifies FINAL Mounting setup compliance & that Structure holds Minimum Load



4) Ready to Start Loading the Structure



5) **CAREFULLY** Pull Lever with RED BALL to start pouring Sand into the bucket. **STOP** at 6 minutes, or at Full Load, or When ... **STRUCTURE BREAKS !**

6) Confirm Load Held (15kg max: Bucket, Load Block Assembly; Chain, & Sand); Sand is returned to Hopper



Boomilever - Example Scoring

TEAM	A	B	C	D	E	F	G	H
MASS (grams)	20.00	15.00	40.00	11.00	12.00	25.00	10.00	7.00
LOAD (grams)	5,000	14,000	15,000	12,000	15,000	15,000	15,000	0
BONUS (grams to LOAD)	0	0	5,000	0	0	5,000	5,000	0
TOTAL LOAD	5,000	14,000	20,000	12,000	15,000	20,000	20,000	0
STRUCTURAL EFFICIENCY (SE)	250	933	500	1,091	1,250	800	2,000	0
TIER (1, 2, or 3)	1	2	1	1	1	2	2	3

Team A: Compliant 20g design that broke at ~third of Load, that didn't attempt the BONUS

Team B: Non-Compliant 15g design (too short) that broke at near full Load

Team C: Compliant 40g design for BONUS that held the full Load and received the BONUS

Team D: Compliant 11g design for BONUS, but broke at majority of Load (no BONUS)

Team E: Compliant 12g design for BONUS that held the full Load, but no BONUS (touches lower than BONUS line)

Team F: Non-Compliant 25g design (too short) that held the full Load and received the BONUS

Team G: Non-Compliant 10g design (too short) that held the full Load and received the BONUS

Team H: 7g Structure that could not be tested due to design deficiencies (could not accommodate the Load Block, or broke before min load)

RANK = E, D, C, A, G, B, F, H

Team E Wins with highest score in Tier 1

Boomilever - Fault Diagnosis Capabilities

- 2027 Boomilever Construction & Test Video to be posted on the Science Olympiad YouTube channel. Gives an overview of building to the 2027 requirements, but also provides relevant information for Data capture and Diagnosis of Failures
- Use Smart Phones to record “slow motion” video for entire loading of Structure
 - Edit video duration to extract video just prior to break (from second before break, to second after break)
- View frame-by-frame edited video till 1st failure member is identified
 - Pause video and “frame grab” to get photo of 1st break
 - NOTE: May want to re-save edited video into MP4 format by using App for the conversion (usually captured in MOV format)
- Failure diagnosis is a critical skill in identifying weak points in design during load testing, to determining design improvements for better structures

2027 Div B Template Testing

TYPE	MASS	LOAD	SCORE	NOTES
Truss	13.95g	9460g	678	LB Carriage FM
Ladder	13.25g	11720g	885	Tension FM
Beam	12.68g	6600g	520	Compression FM
Triangle Truss	13.19g	7290g	553	LB Carriage FM

Diagnosis: Observed Boomilever warping during loading. Observed Load Block Carriage failure. Problematic Tension Member performance



NOTE: Subsequent failures are collateral damage from the initial failure mode (such as Tension Member failure)

Past Lessons Learned – Construction & Prep

1. Thoroughly read and understand each requirement to ensure a compliant design
2. Research: Watch all the posted official SO Boomilever videos; Watch YouTube videos on Boomilever (some are very good; other not so much)
3. Consider using the Template to start the Learning process
4. Practice cutting and bonding skills for better construction and glue management skills (Glue is heavy!)
5. For faster and better builds: Consider pre-cutting selected members into piles before start of construction
6. For faster build times: Consider all types of construction tools and aides
7. Pre-screen wood for consistent density (dark color = higher density); screen out wood with imperfections in grains. Balsa wood has a wide range of performance so have Students pay attention to wood quality and grains (uniformity), and density screening for pairing purposes. Competition Wood can be used, but not necessary and may not be worth the costs
8. Use Scientific Method for tracking improvements in Design vs Scores

Past Lessons Learned – Testing @ Events

9. Verify that your built structure meets all requirements (no surprises at Check-in!)
10. Protecting your Structure during transportation to Event
11. Pre-Check-in Limitations (area for storage containers & queuing)
12. 6-minute Time Management @ Load Testing (Structure positioning & Sand Pouring)
13. Stabilization Sticks Pros & Cons (Can prevent interference with bucket handle swings; No lifting; No Pushing; Consider not Using?)
14. Event Supervisor is an “Observer”
15. If time available after load testing, take the time to discuss possible root causes and corrective actions with Event Supervisors. Have Students & Coaches come prepared to ask Event Supervisors for guidance at Invitationals and Regionals, ... to help with the learning and suggestions for next steps.

Boomilever - Closing Comments

- A. Recommend that School builds a “compliant” Test Stand and have the “proper” Scales for Student’s use
- B. Encourage the Student’s self-learning with plans for many build/test activities throughout the season. Highly competitive schools will build/test several structures throughout the season.
- C. Learn the Slo-Mo video capture feature on Smart Phones for data capture/editing and determination of Root Cause for failures
- D. HAVE FUN!

Next Year will be Bridges!

Hope this was informative, ...and Thank You!