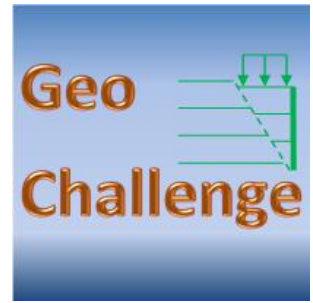




**GEO-  
INSTITUTE**



**The  
Geo-Institute  
of the American Society of Civil Engineers  
Presents  
Competition Rules  
for the National GeoWall  
Held During  
Geo-Congress 2022**

**Important Dates**

**Rules published:** October 4, 2021  
**Design papers due:** January 14, 2022  
**Finalists notified:** February 4, 2022  
**Pre-Competition Captains' Meeting:** March 20, 2022  
**Competition:** March 21, 2022

**Geo-Congress 2022 Information:** <https://www.geocongress.org/>

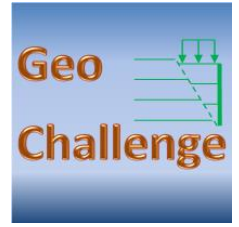
**GeoChallenge Official Information Site:**

<http://www.mygeoworld.info/groups/profile/61033/geochallenge>

Revision 01: August 28, 2021



## GeoWall 2022 Competition Rules Geo-Institute of the ASCE



1. **Objective** – The objective of the GeoWall competition is to design and build a model mechanically stabilized earth (MSE) retaining wall using paper reinforcement taped to a poster board wall facing. The competition objectives for students are to:
  - a) Design a MSE wall using the least amount of reinforcement needed to support the retained soil plus both vertical and horizontal surcharge loads,
  - b) Effectively communicate their analysis and design processes,
  - c) Enjoy a friendly but spirited competition among schools, and
  - d) Attend a world-class professional engineering conference.
2. **Background** – MSE walls have roots to prehistoric builders who used sticks and tree branches to reinforce soil structures. The modern use of reinforced soils dates to the 1960s and French architect Henri Vidal's development of the Reinforced Earth<sup>®</sup> system. In the US, the first MSE wall was built on California SR-39 near Los Angeles in 1971. A more recent application of MSE walls is as support for bridge abutments as shown in Figure 1. This year's competition will model this application of MSE walls by requiring teams to construct a three-sided wall.



Figure 1: Typical use of MSE walls as bridge abutments

3. **Eligibility** – Only one team per school will be allowed to compete. A team consists of a maximum of four (4) students consisting of no more than two (2) graduate students. Each team shall designate a captain who shall be the point of contact for the team. All team members must be enrolled students at the date of the national competition.
4. **Design Report Submittal** – Invitation to the National Competition will be based upon submittal and ranking of the Mechanically Stabilized Earth (MSE) Wall Design Report. The report must include:
  - a) Cover page with name of institution; names and status (graduate, undergraduate) of each team member; identification of team captain with email address; and name, title, and email address of faculty advisor.
  - b) Material properties used in design including methods (lab tests, correlations, assumptions) used to obtain the properties.
  - c) Description of the engineering design and construction procedures including assumptions and equations used.
  - d) A complete description of the geometry and placement of all reinforcing elements. Estimated mass of the reinforcing paper in grams (not including facing material or tape).
  - e) Safety appendix (Appendix E) which outlines the potentially hazardous tasks reasonably expected during the competition and how the team will mitigate these hazards.

f) Completed reimbursement appendix (Appendix A)

Formatting requirements:

- g) Length shall be a maximum of three (3) pages long (not including references, cover page, safety appendix or reimbursement appendix). Over-length design reports will be disqualified.
- h) One-inch margins, single-spaced, and 12 point Times New Roman font.
- i) All pages after the cover page shall contain a header identifying the team and a footer with the page number.
- j) Entire design report must be submitted in a single PDF format file with a filename of <School Abbreviation>2022GeoWall.pdf.

Design reports will be judged by a panel of practicing engineers and professors. Judging will consider reasonableness of design equations, material properties, factors of safety, assumptions, and satisfaction of the objectives of this competition. “Trial and error” designs will be heavily penalized. The judging rubric is presented in Appendix C.

Complete Design Report must be submitted in PDF format via email to Dr. Beena Ajmera ([bajmera@iastate.edu](mailto:bajmera@iastate.edu)) by 6:00 pm PST January 14, 2022. Subject line must include “GeoWall 2022 Submittal.” Sender will receive confirmation of receipt by e-mail. Any changes or corrections made to the design report after this time will incur a penalty.

5. **National Competition Selection** – Up to twenty teams will be selected for the National Finals GeoWall competition based upon scores earned on the design reports.

Teams selected for National Finals must complete Appendices E and F and submit copies to Dr. Ajmera at the email address in section 4.

6. **Sandbox** – The MSE wall is to be constructed within an apparatus hereafter referred to as a sandbox. Each team shall bring their own sandbox to the competition. Painting and the addition of school or sponsor logos and other decorations to the exterior of the sandbox is highly encouraged. The sandbox shall be made up of a bottom and four vertical sides with no top. The front panel and part of the two side panels are removable as shown in Figure 2. The removable box panels will be in place during wall construction and removed after construction to expose the MSE wall. The sandbox will also include two PCV piles as shown in Figures 2 through 4. The sandbox shall meet the following requirements:

- a) Have exterior walls and base constructed of any grade of plywood not to exceed  $\frac{3}{4}$  inch (19 mm) thick.
- b) Have planar inside surfaces with the natural plywood finish.
- c) Have removable front and side panels as shown in Figure 2. Panels must be flush with the base of the box and held in place with threaded inserts, screws, hinges or other easily removable fasteners.
- d) Have a full-sized base such that it extends no more than  $\frac{3}{4}$  inch (19 mm) beyond the base of the wall once the front and side panels have been removed.
- e) Include a steel tie rod designed to keep the two fixed sides of the box parallel after removal of the facing panel.
- f) Include circular guides to ensure bases of the PVC piles are held in the correct location. A temporary template may be used to control alignment at the top of the piles.
- g) Any templates used must be removed after wall construction and before testing.
- h) All dimensions of the sandbox shall be as shown in Figures 2 and 3.

For convenience, sandboxes may be designed so that they can transported as flat pieces and reassembled at the competition site.

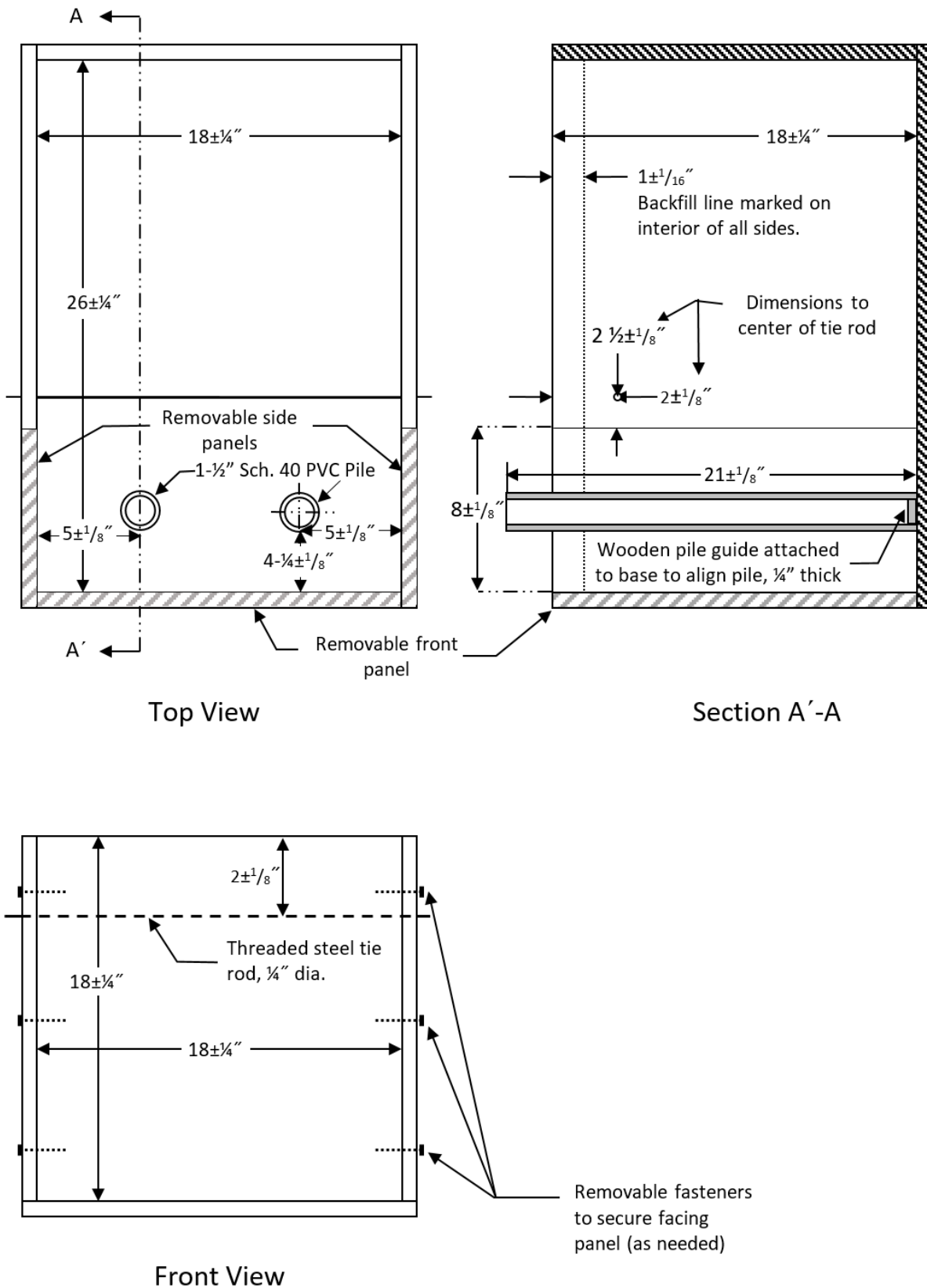


Figure 2: Sandbox dimensions (not to scale)

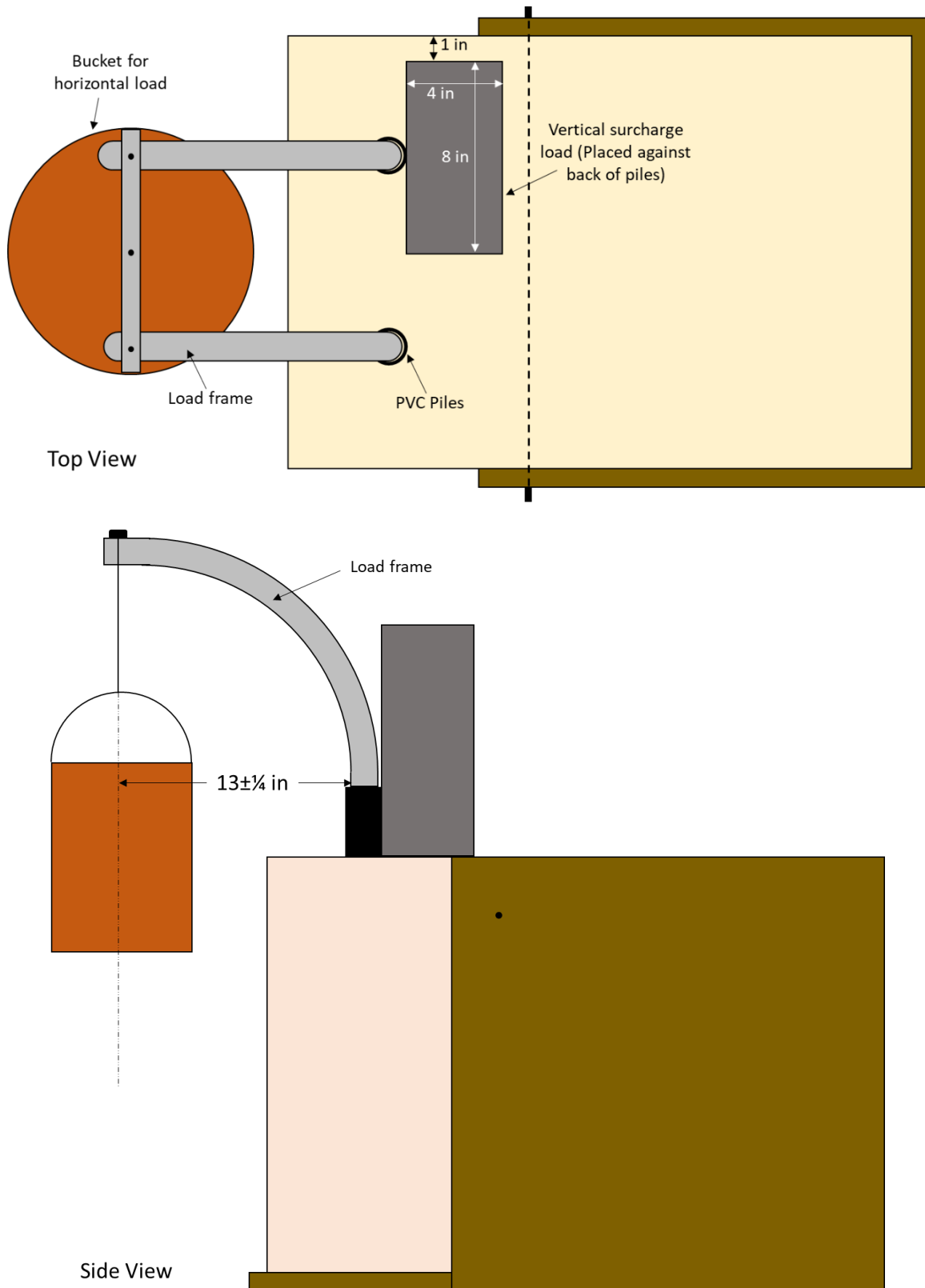


Figure 3: Load Placement (not to scale)

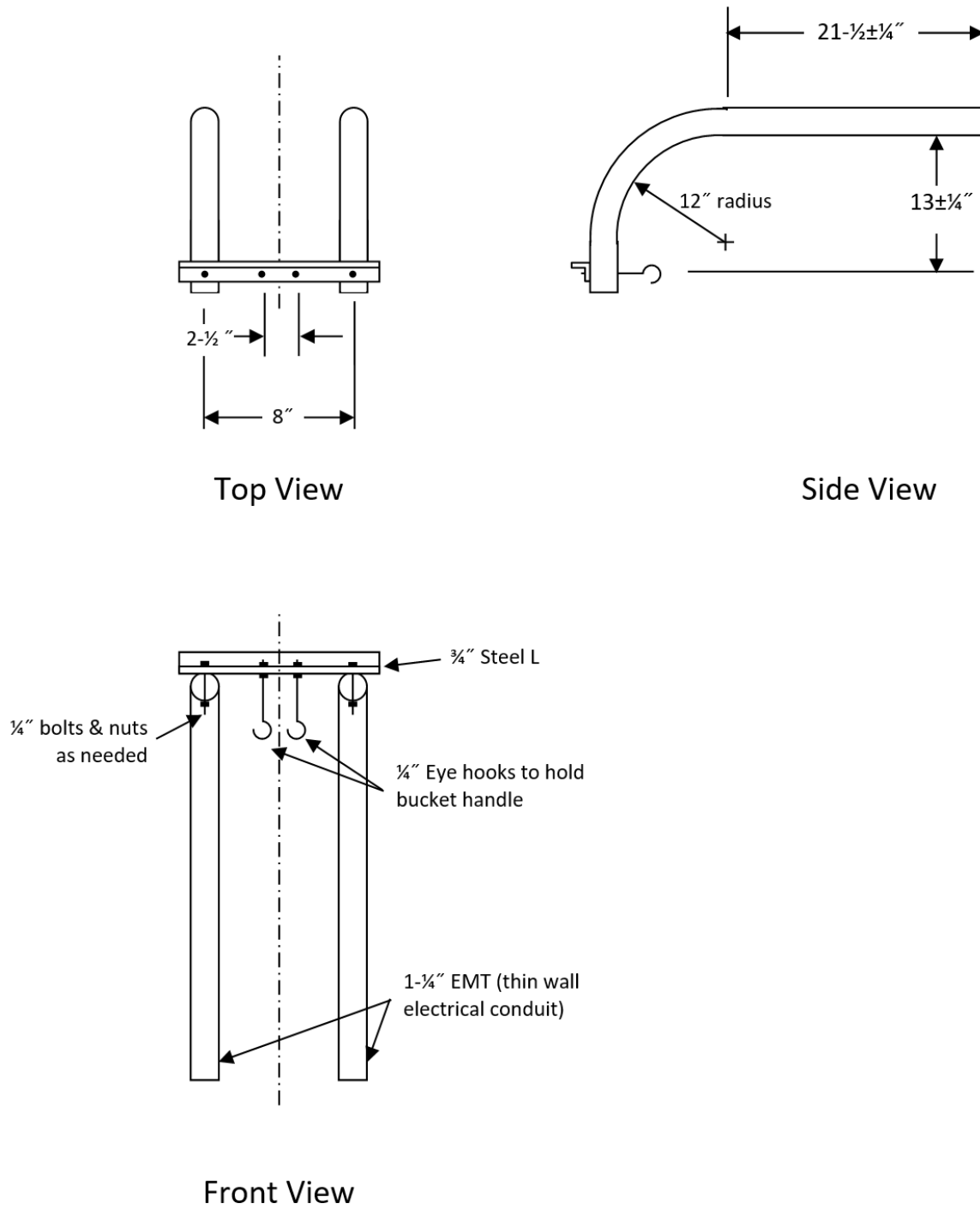


Figure 4: Dimensions of Horizontal Load Frame (not to scale)

Sandboxes and PVC piles will be checked for compliance at the pre-competition captain's meeting. Teams will have until 8:45 am local time the day of the competition to correct any compliance issues. Any team with a sandbox and/or PVC piles out of compliance at the start of the competition will be penalized.

7. **Piles** – Two vertical piles will be used to apply the horizontal load to the backfill behind the wall. Each team will provide their own piles. Piles will be fabricated out of 1½ in schedule 40 PVC pipe. Please see Figure 2 for the pile locations and length requirements.
8. **Backfill Material** – The backfill material will be sand provided by competition organizers on site. The sand will be a clean, dry, rounded to subrounded sand with grain size as specified in Table 1 and Figure 5. The backfill material must be used as-is; no water, additives, or chemical stabilizers may be placed in the backfill material.

Competition organizers will make reasonable efforts to ensure the competition backfill materials meet the specifications in Table 1 and Figure 5. Teams will be allowed to examine a sample of the competition backfill at the captain's meeting. No backfill samples may be removed from the meeting room. Teams may modify their wall design at this time if they desire. See section 12 below.

Table 1: Representative anticipated grain-size distribution for GeoWall competition sand.

Typical Distribution		Lower Bound		Upper Bound	
Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing
2.00	100.0	1.30	100.0	2.50	100.0
1.70	96.8	1.20	96.9	2.30	96.9
1.18	41.8	1.15	93.7	2.10	93.7
1.00	15.8	0.80	38.7	1.60	38.7
0.85	3.3	0.60	12.7	1.30	12.7
		0.50	2.0	1.10	2.0

9. **Wall Materials** – Materials will be provided by competition organizers on site. See Appendix A for detailed specifications
  - a) Facing – Two pieces of poster board must be joined with a lap splice. See Figure 6 for dimensions.
  - b) Reinforcement – 60 lb kraft paper. Quantity of reinforcement will be measured by mass to the nearest 0.01g. There are no restrictions on the shape or geometry of reinforcing elements, but all reinforcement must be cut from a single sheet 24" × 24" kraft paper.
  - c) Reinforcement Attachment to Facing – Heavy-duty polypropylene packaging tape that is 2" wide.

Competition organizers will make reasonable efforts to ensure the wall materials meet the specifications in Appendix B. Teams will be allowed to examine small samples of the reinforcing material at the captain's meeting. No reinforcing material samples may be removed from the meeting room. Teams may modify their wall design at this time if they desire. See section 12 below.

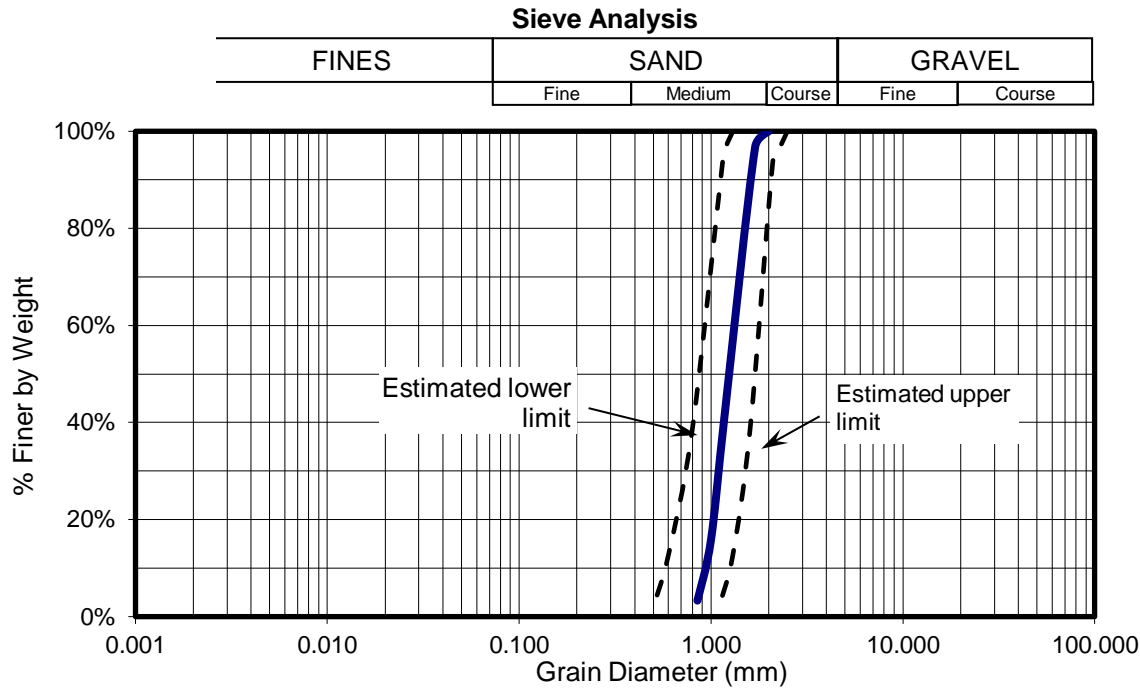


Figure 5: Estimated grain size distribution of backfill sand

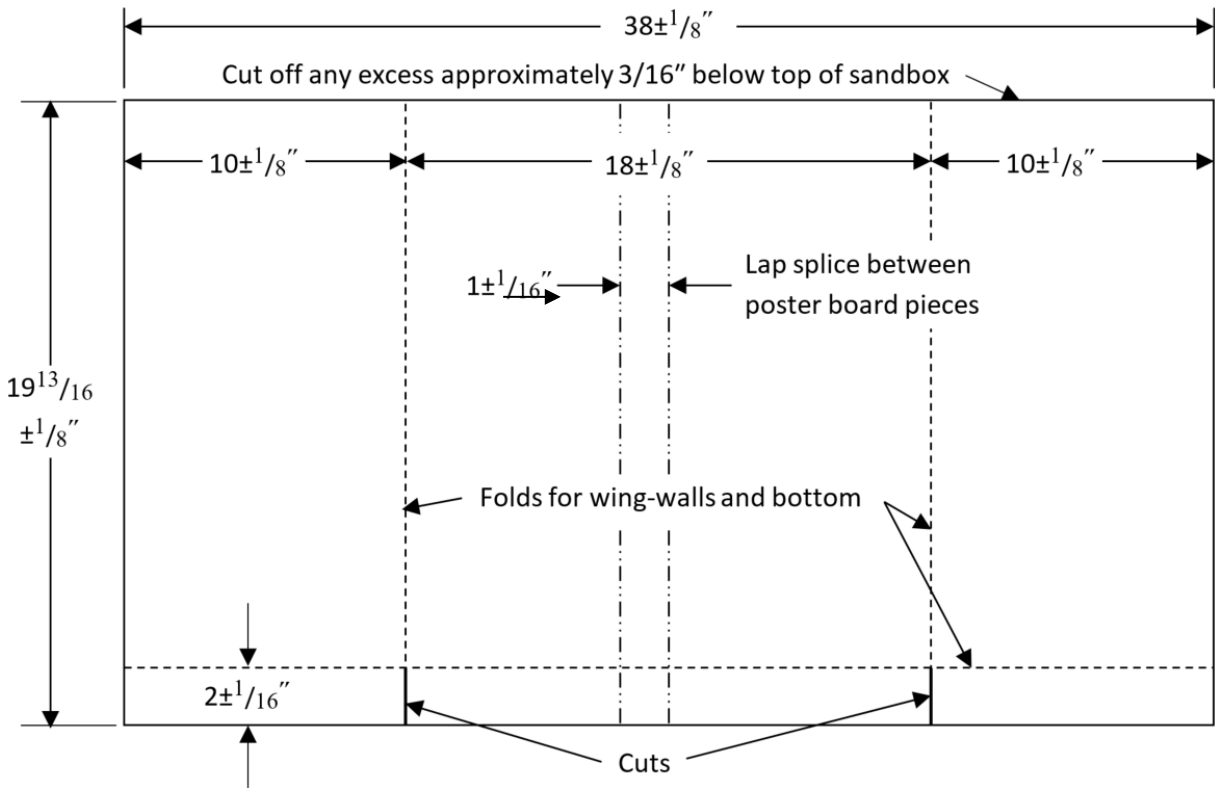


Figure 6: Dimensions of the poster board wall facing (not to scale)



10. **Construction** – The following construction tools may be used and must be provided by the competing team (quantities of these items shall not be restricted):

- a) Pencils, pens and markers
- b) Rulers and straight edges
- c) Levels
- d) Manually operated cutting instruments (e.g., scissors, utility knives, safety razor blades, hole punch)
- e) Cutting boards or mats
- f) Design notes, calculations, and drawings
- g) Material handling and compaction tools consisting of any hand operated devices
- h) Screwdrivers (battery operated drills or screwdrivers may be used, but only to remove fasteners when removing the facing panels)
- i) Temporary templates for use in any stage of competition. These templates may be made of any material, must not have any moving parts, and must be removed at the end of the any stage in which they are used.

Buckets and shovels will be provided by the competition organizers. It may be necessary for teams to haul backfill a distance up to 20 feet.

11. **Execution** – Construction and testing of the wall will be done in the following stages:

- a) **Reinforcement Fabrication Stage** – Each team will be provided with a single sheet of 60 lb kraft paper approximately 24 in × 24 in. The team must fabricate all their reinforcing elements from this sheet using authorized construction tools. Fifteen (15) minutes will be allocated for this stage. Teams will be penalized for time exceeding the time limit. After all reinforcing element are fabricated, excess material will be disposed of and the judges will weigh the reinforcing elements to the nearest 0.01g.
- b) **Wall Assembly Stage** – After each team's reinforcing elements have been fabricated and weighed, the team will be provided with two sheets of poster-board (22 in × 28 in) and a roll of packing tape. The team must assemble their wall using these materials and authorized construction tools. Dimensions for the wall facing are shown in Figure 5.
  - i) Tape may be used for only two purposes: 1) to join the two poster-board sheets along the lap splice (Figure 5) to form the wall facing and 2) to attach reinforcement to wall facing. The poster-board sheets must be joined using a single lap splice on each side not exceeding 1" to form the wall facing. A single continuous strip of tape may be used on each side of the poster-board to join the poster-board sheets. The tape must be in contact with only the two poster-board sheets. No other adhesives may be used to join the poster-boards.
  - ii) Tape used to attach reinforcement to the wall facing must be used in individual pieces no larger than 2 in × 2 in. The adhesive side of each piece of tape must be in contact with both the wall facing and a reinforcing element. Tape pieces may not overlap one another, although they may overlap the tape forming the poster-board lap splice. All tape pieces must be placed on the vertical planes forming the wall facing. No tape piece may be applied to more than one vertical plane simultaneously.
  - iii) Tape may not be used for any other purpose, including but not limited to: sealing corners of facing material, joining two or more reinforcing elements, anchoring facing material or reinforcement to the box. This is the only stage in which the team is allowed to use tape.

The wall should be trial-fitted to the sandbox during this stage. Any portion of the wall that rises above an imaginary line that is 3/16 in below the top of the sandbox must be trimmed off. The assembly stage is complete when the facing material is properly folded and trimmed, all the reinforcing elements are attached to the facing, and the wall is placed in the sandbox. No sand is added to the box in this stage. Fifteen (15) minutes will be allocated for this stage. Teams will be penalized for time exceeding the time limit. Judges will check to ensure the wall is properly assembled.

- c) **Construction Stage** – After the wall is assembled and checked by the judges, the judges will instruct the team to start construction. During this stage, the team fills the box with sand so that the sand fill line (see Figure 2) is covered and the backfill is level, and places the empty rectangular vertical surcharge bucket on top of the sand. The facing material must be in direct contact with the inside of the sandbox at all times during this stage. The tie rod may be removed from the box at the start of this stage, but it must be in place before any sand is placed in the box. Temporary templates or guides may be used during this stage so long as they are removed before the end of the stage.

The construction stage is complete when the wall is in place, the sand backfill covers the sand fill line and is level, any temporary templates or guides have been removed, and the empty vertical surcharge loading bucket is in place. Twenty (20) minutes will be allotted for this stage. Teams will be penalized for time exceeding the time limit. At the end of this stage, judges will check fill placement and the placement of the empty vertical surcharge load bucket to ensure they meet requirements.

- d) **Loading Stage** – Details of the load placement are shown in Figure 3. This stage occurs in three steps: 1) removal of front and side panels, 2) placement of 50 lb vertical surcharge, and 3) placement of the 20 lb static horizontal surcharge load in an empty 5 gallon bucket on the loading frame. During each step, the wall will be checked for the following three criteria: 1) excessive deformation (any portion of the wall extending outside imaginary planes extending vertically from the base of sandbox), 2) excessive soil leakage (more than 30 cm<sup>3</sup> of sand passing out of the sandbox), and 3) catastrophic failure. The team will be penalized for excessive soil loss and excessive deformation, but will be disqualified for a catastrophic failure.
- i) When directed by the judge, the team shall remove the front and side panels of the sandbox. After the panels are removed, the judge will wait one (1) minute and then check the three criteria.
  - ii) If the wall does not fail catastrophically, the team will then place 50 lbs of sand in the vertical surcharge platform (see Appendix B for the platform details). The team will have one (1) minute to place the load. After the load is placed, the judge will wait one (1) minute and then check the three criteria.
  - iii) If the wall does not fail catastrophically, the team will hang an empty 5 gallon bucket on the loading frame and place 20 lbs of sand in the bucket (see Figure 4). The team will have one (1) minute to complete this loading sequence. After the sequence is complete, the judge will wait one (1) minute and then check the three criteria. The horizontal load frame will be provided by the competition organizers. Teams should not bring their own load frames to the competition.

12. **Design Changes** – Teams may change their design between the time the design report is submitted and the wall is tested. The adjusted mass of the reinforcing material used for scoring,  $M$ , will be computed as

$$\begin{aligned} \text{if } |m_D - m_A| \leq 0.25 & \quad M = m_A \\ \text{if } |m_D - m_A| > 0.25 & \quad M = \max \left[ \begin{aligned} & (m_D - 0.25) - \frac{(m_D - m_A - 0.25)}{2} \\ & m_A + \frac{(m_A - m_D - 0.25)}{2} \end{aligned} \right] \end{aligned} \quad (1)$$

Where,

$m_D$  = reinforcing mass (g) reported in design report;

$m_A$  = reinforcing mass (g) used during competition; and

$M$  = adjusted mass (g) rounded to two decimal places

13. **Scoring** – After completion of the loading stage, the score for each team will be computed using the following formula:

$$Score = R + 15(20 - M) - 10N_{min} - 40N_{maj} - 2T - 20D \quad (2)$$

Where,

$R$  = report score out of 60 points

$M$  = adjusted mass of the reinforcement material in grams from Equation 1

$N_{min}$  = number of minor rules violations

$N_{maj}$  = number of major rules violations

$T$  = total number of minutes over time limit for all phases rounded up to the nearest minute

$D$  = deflection rating

8 if wall fails deflection criteria during initial loading without surcharge

6 if wall fails deflection criteria during vertical surcharge loading

4 if wall fails deflection criteria during horizontal surcharge loading

0 if wall passes deflection criteria for all loading phases

If the wall fails catastrophically during any loading stage, the team will be disqualified.

a) Minor Penalties

i) Box dimension out of spec

ii) Pile location out of spec

iii) Minor safety mishaps

iv) Any addendum to the design report required by judges which simply clarifies content but does not change the design

v) Any other rule violation that in the opinion of the judges that has the potential to provide the team with a measurable, but minor advantage

b) Major Penalties

i) Soil leakage greater than 30 cm<sup>3</sup> (volume of standard 1 oz plastic medicine cup)

ii) Improper use of adhesive tape

iii) Major safety mishaps include any mishap that results in bleeding

iv) Any addendum to the design report required by judges which results in a significant change to the design

- v) Any other rule violation that in the opinion of the judges has the potential to provide the team with a significant advantage, but does not warrant disqualification
- c) Disqualification – Teams may be disqualified for the following:
  - i) Failure to send a representative to the pre-competition captains' meeting
  - ii) Unsafe practices
  - iii) Design or construction techniques which violate the spirit of the competition and provide a large and unfair advantage
  - iv) Catastrophic wall failure at any point during the loading
  - v) Any other rule violation that in the opinion of the judges has the potential to provide the team with a significant advantage and warrants disqualification

Scores will be recorded to the nearest tenth of a point. In the event of a tie, the following criteria will be used, in order, to break the tie: 1) lowest actual reinforcement mass, 2) higher report score, 3) lowest deflection rating, and 4) judges' consensus of best-decorated sandbox.

The judges will follow the rules as published using reasonable judgment and interpretation. The head judge will be the arbiter of any disputes, which are to be brought forth solely by the Team Captain. Decisions of the head judge are final. Results posted at the competition are not subject to review after the competition.

**Scoring Example:** Assume a team constructs a wall with following characteristics

- Report Score: 48/60,  $R = 48$
- Design report specifics 8.57 g of reinforcement. Reinforced used is 8.25 g. From Equation 1,
 
$$M = \max \left\{ \begin{array}{l} (8.57 - 0.25) - \frac{8.57 - 8.25 - 0.25}{2} = 8.29g \\ 8.25 + \frac{8.25 - 8.57 - 0.25}{2} = 7.97g \end{array} \right. = 8.29g$$
- Minor deduction for tape overlapping on wall,  $N_{min} = 1$
- Execution times were
  - Reinforcement fabrication: 15:18 (18 sec over allotted time, round up to 1 min)
  - Wall assembly: 16:05 (1:05 over allotted time, round up to 2 min)
  - Construction: 18:27 min (under allotted time)
  - Total time over: 1+2=3 min,  $T = 3$

Note: Only times over limit during each stage are counted. Teams get no benefit for times under the limit of any individual stage.
- Wall passed deflection test in first loading phase, but failed deflection test during the horizontal surcharge loading phase,  $D = 4$

Using Equation 2, the final score would be

$$Score = 48 + 15(20 - 8.29) - 10(1) - 40(0) - 2(3) - 20(4) = 127.7$$

See Appendix D for scoring checklists.

14. **Pre-Competition Team Captains' Meeting** – A team captains' meeting will be held prior to the competition for the purposes of: checking sandboxes and PVC piles for compliance, examining construction tools and any temporary templates, establishing competition order, gathering team biographical information, and disseminating any logistical or administrative information. This is a MANDATORY meeting. Each team must have the team captain (or designee) present. All team members are encouraged to attend. Specific meeting time and location will be announced on the GeoWall website before the conference. Teams without a representative at the captains' meeting will be disqualified.

Teams should bring their sandboxes, PVC piles, and any hardware or tools needed for assembly during the competition. Sandboxes and piles should be assembled and will be checked for compliance at the meeting. Teams will have until 8:45 am local time of the day of the competition to correct any compliance issues identified during the captains' meeting. Any sandboxes or piles found out of compliance at the captains' meeting will be rechecked at this time.

Teams shall complete Appendices F and G and bring copies to the captains' meeting. The information on these forms will be used by the emcee during the competition.