

GEO WALL COMPETITION

Competition Dates: Thursday, April 18, 2019
Saturday, April 20, 2019

Competition Location: San Jose State University Campus

Summary:

The objective of the GeoWall competition is to design and build a model wrapped faced mechanically stabilized earth (MSE) retaining wall using paper reinforcement attached to a poster board wall facing. Students are to design a MSE retaining wall using the least amount of facing and reinforcement material needed to support the retained soil and the surcharge loads, and effectively communicate their analysis and design processes.

Contact:

Any questions regarding the GeoWall Competition may be sent to:

Linh Truong

midpac2019geowall@gmail.com

DESIGN REPORT SUBMISSION:

The complete Design Report must be submitted in PDF format via email to the Mid-Pac Geo-Wall Coordinator, midpac2019geowall@gmail.com, by 11:59 pm PST on March 31, 2019. Subject line must include “Geo-Wall 2019 Report Submittal.” The 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 (see Section 11).

DESIGN POSTER SUBMISSION:

The complete Design Poster must be submitted in PDF format via email to the Mid-Pac Geo-Wall Coordinator, midpac2019geowall@gmail.com, by 11:59 pm PST on April 14, 2019. Subject line must include “Geo-Wall 2019 Poster Submittal.” The 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 (see Section 11).

NATIONAL COMPETITION:

Invitation to the National Competition will be based upon submittal and ranking of the Wrapped Face Segmental (MSE) Wall Design Report. Design paper is due January 18, 2019. Please refer to the Geo-Institute Competition Rules for the National GeoWall using the link below:

[National GeoWall Rules](#)

Rules

1. **Objective** – The objective of the GeoWall competition is to design and build a model wrapped faced mechanically stabilized earth (MSE) retaining wall using kraft paper reinforcement. The competition objectives are for students to:
 - a) Design a wrapped face segmental MSE wall using the least amount of facing and reinforcement material needed to support the retained soil plus both vertical and horizontal (static and dynamic) surcharge loads.
 - b) Effectively communicate their analysis and design processes
 - c) Enjoy a friendly but spirited competition among schools
 - d) Attend a world-class professional engineering conference.
2. **Background** – MSE walls have root 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[®] system. In the US, the first MSE wall was built on California SR-39 near Los Angeles in 1971. A more recent development in MSE walls is the wrapped face wall as shown in Figure 1. This year’s competition will model this development of MSE walls by requiring teams to design and construct a wrapped face retaining wall.



Figure 1: Typical wrapped face MSE walls

3. **Eligibility** -- Only one team per school will be allowed to compete. A team consists of a maximum of four (4) students consisting of not 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 Wrapped Face Segmental (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 wrapped face MSE wall elements. Estimated mass of the facing and reinforcing paper in grams and total length of kraft paper required to construct the wrapped face MSE wall.
- e) A safety appendix which outlines the potentially hazardous tasks reasonably expected during the competition and how the team will mitigate these hazards.

Formatting requirements:

- a) Length shall be a maximum of three (3) pages long (not including references, cover page, or safety appendix). Over-length design reports will be disqualified.
- b) One inch margins, single spaced, and 12 point Times New Roman font.
- c) All pages after the cover page shall contain a header identifying the team and a footer with the page number.
- d) Entire design report must be submitted in a single pdf format file with a filename of <School Abbreviation>2019GeoWall.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 objective of this competition. “Trial and error” designs will be heavily penalized. Teams ***not*** submitting designs for a ***wrapped face segmental MSE*** wall ***will be disqualified***. The judging rubric is presented in Appendix B.

Complete Design Report must be submitted in PDF Complete design report must be submitted in PDF format via email to the Mid-Pac GeoWall Coordinator, midpac2019geowall@gmail.com by 11:59 pm PST March 31, 2019. Subject line must include “Geo-Wall 2019 Report 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. **Sandbox** – The wrapped face segmental MSE wall will be constructed within an apparatus hereafter referred to as a sandbox. Each team shall bring their own sandbox to the competition. Painting and 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 will be removable as shown in Figure 2. The removable box panel will be in place during wall construction and removed after construction to expose the ***wrapped face segmental*** MSE wall. The sandbox will also include two PVC piles used to apply the horizontal load. Dimensions of the sandbox and the PVC piles are shown in Figures 2 through 4. The sandbox will meet the following requirements:
 - a) Have exterior walls and base constructed of any grade of plywood not to exceed 3/4-inch (19 mm) thick.
 - b) Have planar inside surfaces with the natural plywood finish.
 - c) Have a removable front 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 3/4 inch (19 mm) beyond the base of the wall once the front panel has 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 they can be transported as flat pieces and reassembled at the competition site.

Sandboxes and PVC piles will be checked for compliance at the pre-competition captains' meeting. Teams will have until 9:45 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 competition will be penalized.

- 6. **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 1-½” schedule 40 PVC pipe. Please see Figure 2 for the pile locations and length requirements.
- 7. **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 captains' 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.

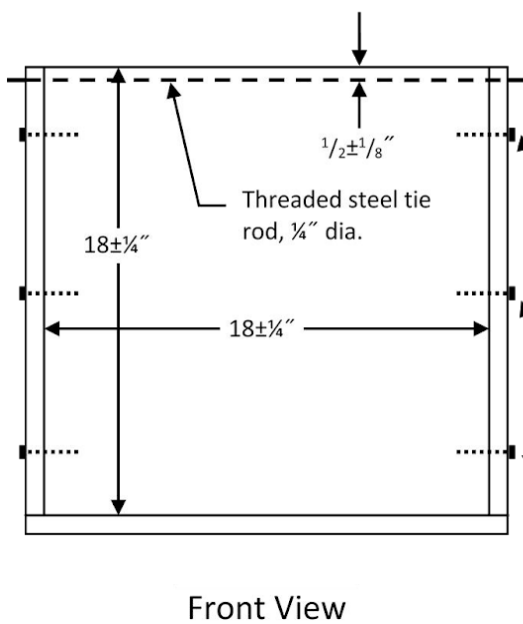
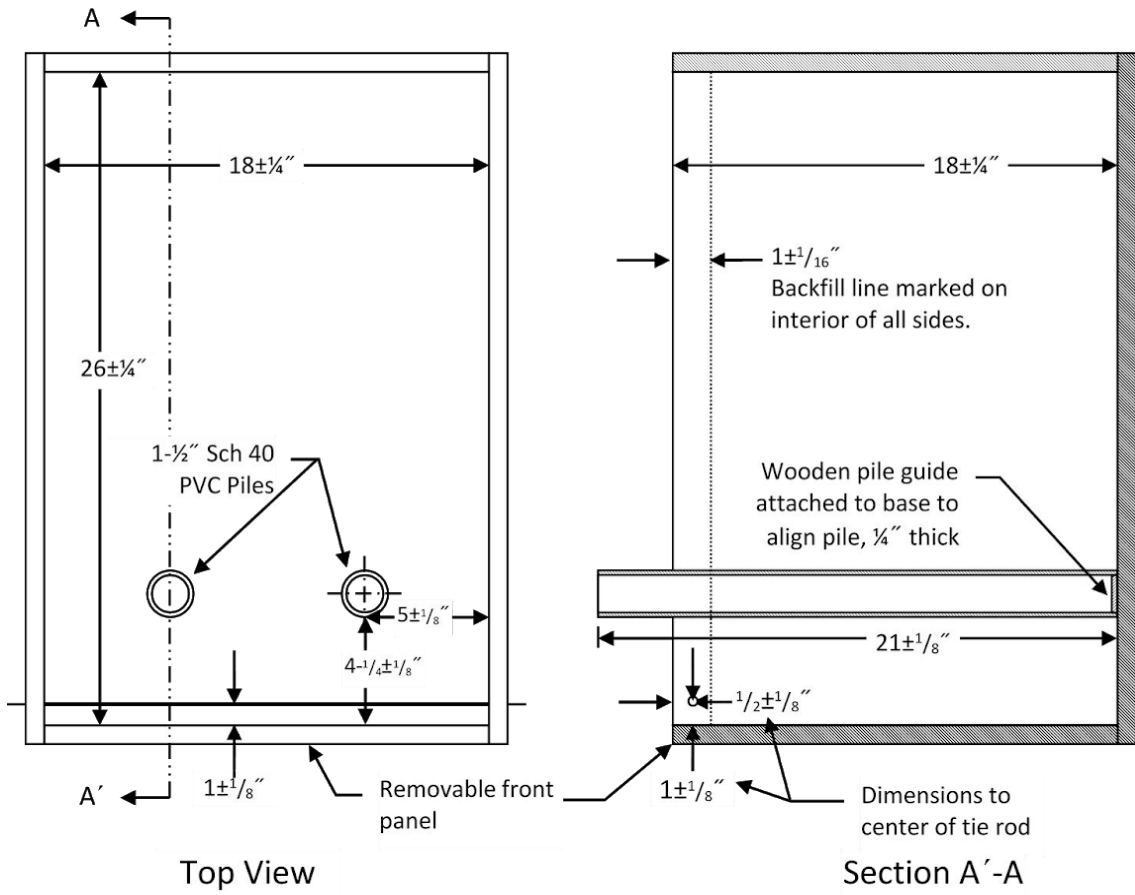
Table 1: Representative anticipated grain-size distribution for GeoChallenge competition sand.

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

- 8. **Wall Materials** – Materials will be provided by competition organizers on site. See Appendix A for detailed specifications. Facing and reinforcement for the wrapped faced segmental MSE wall will be prepared from 60 lb kraft paper. Quantity of kraft paper will be measured by mass to the nearest 0.01g. There are no restrictions on the shape or geometry of reinforcing elements, except that all reinforcement must be cut from kraft paper. Furthermore, each lift of the wrapped faced MSE wall must be segmental at the start of construction. Designs that do not contain segmental lifts at the start of construction will be disqualified. The teams must specify in their report the length of the 24” wide kraft paper required for their design during the competition.

Competition organizers will make reasonable efforts to ensure the wall materials meet the specifications in Appendix A. Teams will be allowed to examine small samples of the reinforcing material at the

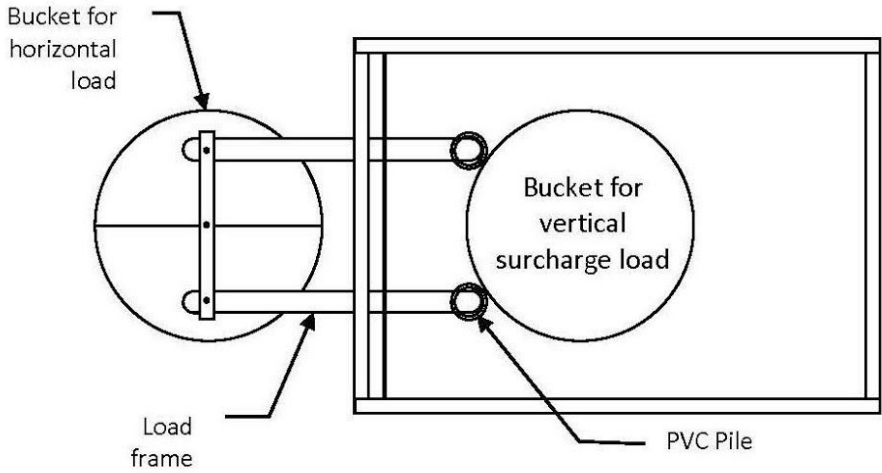
captains' meeting. No reinforcing material samples may be removed from the meeting room. Teams may modify their wall design at this time if they desire. See section 11 below.



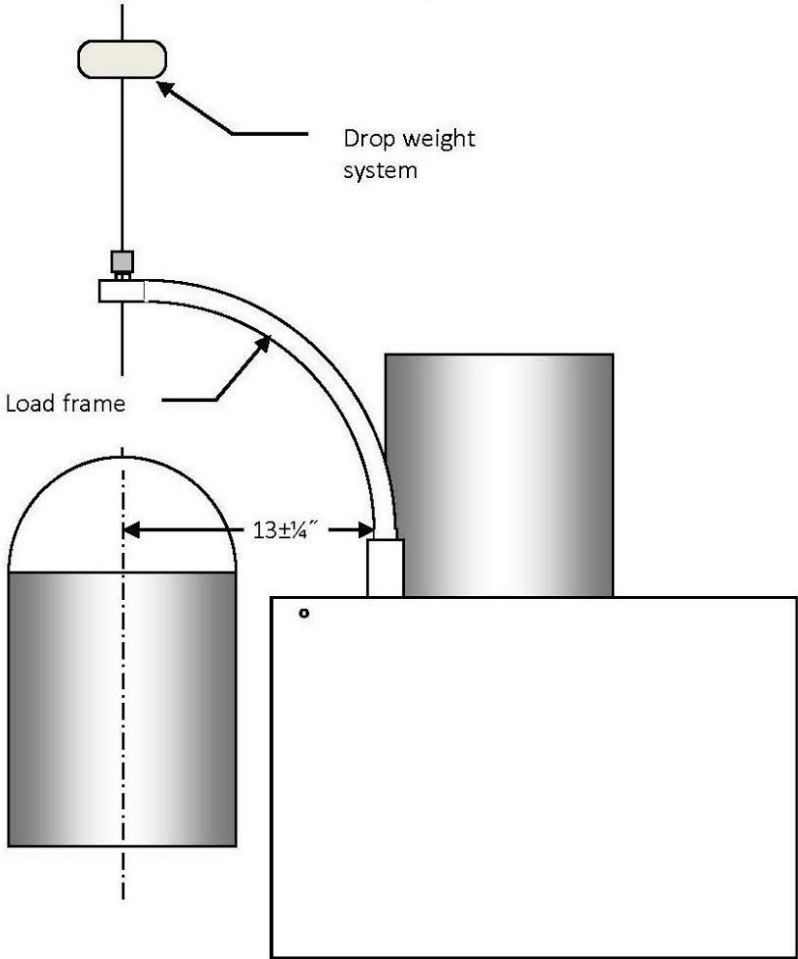
- Notes:
- Box to be fabricated of 23/32" or 3/4" plywood except as noted
 - Tie rod must be 1/4" threaded steel rod with washers and nuts as needed
 - Piles must be 1-1/2" Schedule 40 PVC and must slide over wooden guides; piles may not be attached to guides or box
 - Handles or knobs may be attached to outside of front panel to aid in removal
 - Interior surface of box must be natural wood and unmodified
 - Exterior of box may be painted and decorated with school logos etc.

Removable fasteners to secure facing panel (as needed)

Figure 2: Sandbox dimensions (not to scale)



Top View



Side View

Figure 3: Load Placement (not to scale)

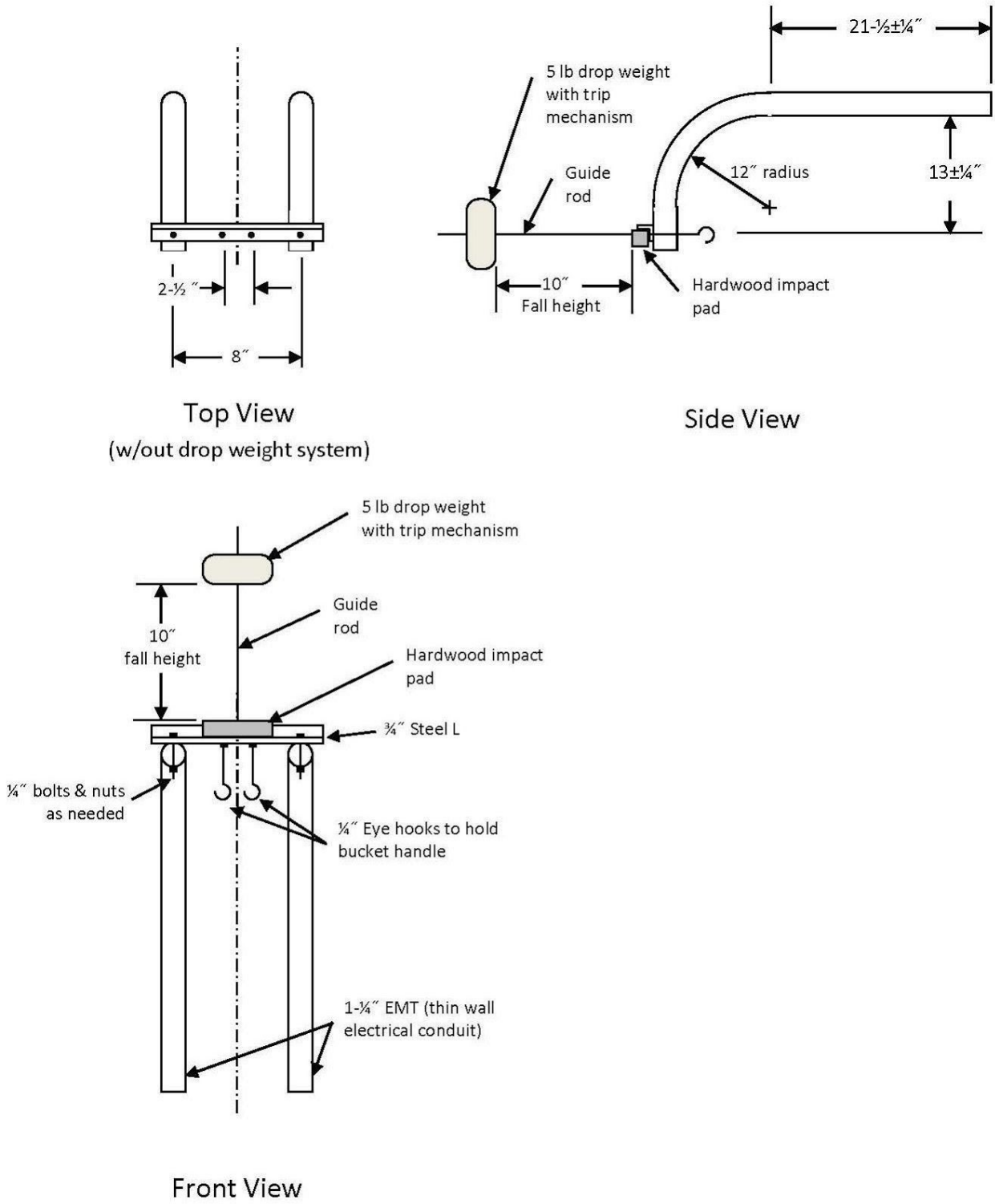


Figure 4: Dimensions of Horizontal Load Frame (not to scale)

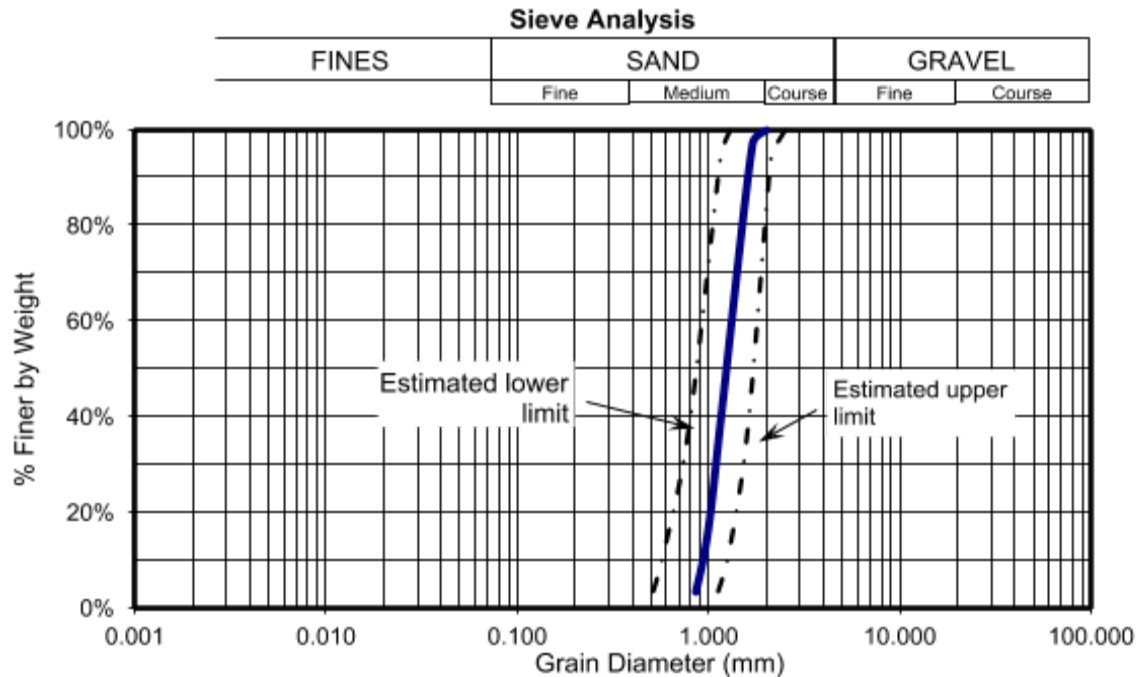


Figure 5: Estimated grain size distribution of backfill sand

9. **Construction Tools** - 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 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.

10. **Execution** – Construction and testing of the wall will be done in the following stages:
- a) **Reinforcement Fabrication Stage** – Each team will be provided with 60 lb kraft paper (as mentioned in their design report). The team must fabricate all their wrapped face segmental MSE wall elements from those sheets using authorized construction tools. Twenty (20)

minutes will be allotted for this stage. Teams will be penalized for time exceeding the time limit. After all wrapped face segmental MSE wall elements are fabricated, excess material will be disposed of and the judges will weigh the reinforcing elements to the nearest 0.01 grams.

- b) **Construction Stage** – After each team’s wrapped face segmental MSE wall elements have been fabricated and weighed, the judges will instruct the team to start construction. At the start of this stage, the wall elements for each lift must be segmental. During this stage the team constructs the wrapped face segmental MSE wall filling the box with sand so that the backfill line (see Figure 2) is covered and the backfill is level, and places the empty 5 gallon 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-five (25) minutes will be allotted for this stage. At the end of the phase, judges will check fill placement and the placement of the empty vertical surcharge to ensure that they meet the meets requirements.

- c) **Loading Stage** – Details of the load placement are shown in Figure 3. This stage occurs in three steps: 1) removal of front panel, 2) placement of vertical surcharge, and 3) placement of the static horizontal surcharge followed by a single application of the dynamic horizontal load. 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 base of sandbox), 2) excessive soil leakage (more than 30 cm³ of sand passing out of the sandbox), and 3) catastrophic failure. The team will be penalized for excessive soil loss and excessive deformation. The team will be disqualified for a catastrophic failure.
- i. When directed by judge, the team shall remove the front panel 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 bucket. 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 place the 5 lb drop weight on top of the load frame, hang an empty 5 gallon bucket on the loading frame and place 20 lb of sand in the bucket, and then trip the drop weight for a single application of the 5 lb weight falling 10 in. and impacting the top of the loading arm (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 with vertical drop weight will be provided by the competition organizers. Teams should not bring their own load frames to the competition.

11. **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

$$M = m_A + (m_D - m_A + 0.50)^2 \quad (1)$$

Where,

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

m_A = reinforcing mass (g) used during competition;

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

Teams may also change the requested length of the 60 lb kraft paper between the time the design report is submitted until 9:45 am local time the day of the competition. The official length of the kraft paper used for the scoring will be computed as the greater of (a) the average of the length requested in the design report and the length requested at any point after the submission of the design report until 9:45 am local time the day of the competition or (b) the length requested at any point later after the submission of the design until 9:45 am local time the day of the competition. The official length will be rounded up to the next half foot (6 inches). The deadlines for the changes in the mass and length of the kraft paper may be altered by the head judge.

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

$$Score = R + 15(60 - M) + 5(10 - L) - 10N_{min} - 40N_{maj} - 2T - 20D \quad (2)$$

Where,

R = report score out of 50 points

M = adjusted mass of the wrapped face MSE elements in grams from Equation 1

L = official length of 60 lb kraft paper requested in feet as described in section 12

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 each rounded up to nearest minute

D = deflection rating

8 if wall fails deflection criterion during initial loading without surcharge

6 if wall fails deflection criterion during vertical surcharge loading

4 if wall fails deflection criterion during horizontal surcharge loading

0 if wall passes deflection criterion for all loading phases

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

a) **Minor Penalties**

i. Box dimension out of spec ii) Pile location out of spec

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

- iv) 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 cm³ (volume of standard 1 oz plastic medicine cup) ii) Any addendum to the design report required by judges which results in a significant change to the design
 iii) 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 design ***a wrapped face segmental MSE wall.***
 ii. Failure to send a representative to the pre-competition captains’ meeting
 iii. Unsafe practices
 iv. Design or construction techniques which violate the spirit of the competition and provide a large and/or unfair advantage
 v) Catastrophic wall failure at any point during the loading

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, 4) lowest length of reinforcement paper, and 5) judges’ consensus of best decorated box.

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: 48/50, $R = 48$
- Design report specifies 46.23 g. Reinforcement used is 47.01 g. From Equation 1,

$$M = 47.01 + (46.23 - 47.01 + 0.50)^2 = 47.53 \text{ g}$$

- Requested length in the design report was 6 feet. The requested length at the captain’s meeting was 7.2 feet. Official length, $L = 7.5$ feet from section 12.
- Minor deduction for two box dimensions out of spec, $N_{min} = 2$
- Execution times were
 - Reinforcement fabrication: 20:18 (18 sec over allotted time, round up to 1 min)
 - Construction: 26:05 (1:05 over allotted time, round up to 2 min)
 - Total time over: 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 initial loading without surcharge and during vertical surcharge loading phase, but failed deflection test during horizontal surcharge loading phase, $D = 4$

Using Equation 2, the final score would be

$$\text{Score} = 48 + 15(60 - 47.53) + 5(10 - 7.5) - 10(2) - 40(0) - 2(3) - 20(4) = 141.2$$

See Appendix C for scoring checklists.

- 13. Pre-Competition Team Captains' Meeting** – A team captains' meeting will be held prior to the competition for the purposes of: checking sandboxes for compliance, 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. Sandboxes and piles will be assembled and 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.