ASCE REGION 6 | STUDENT SYMPOSIUM

Competition Rules for GeoWall

ASCE Region 6 Student Symposium

2024

Adapted from the Geo-Institute of the American Society of Civil Engineers 2024 Competition Rules for the National GeoWall

1. Objective

The objective of the GeoWall competition is to design and build a model mechanically stabilized earth (MSE) retaining wall using kraft paper taped to a poster board wall facing. The competition objectives are for students to:

a) a) Design a MSE wall using the least amount of reinforcement needed to support the retained soil and the design 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 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. Sometimes the construction of MSE walls must account for underground utilities, tunnels or other obstructions (Figure 1). This year's competition will model these obstructions requiring teams to design and construct a MSE wall around a proposed tunnel.

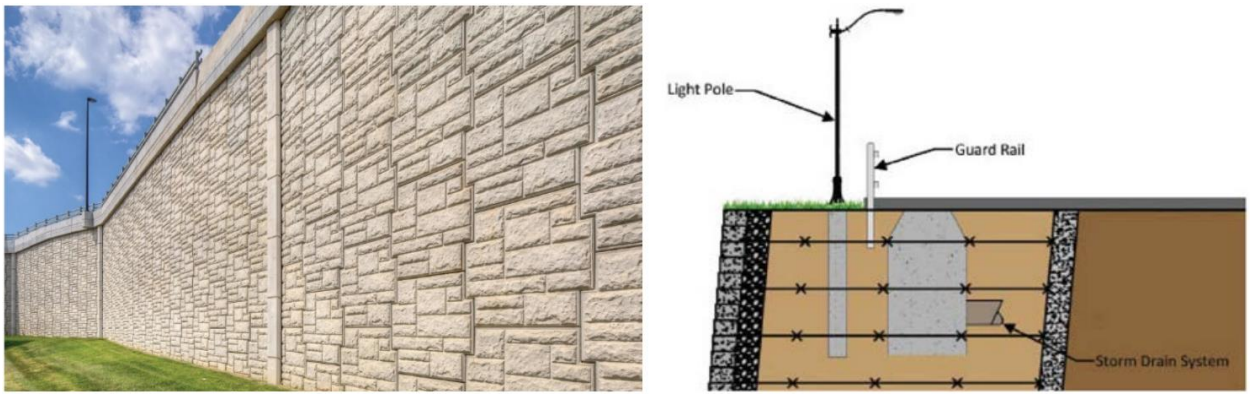

Figure 1: Examples of MSE walls

3. Eligibility

Only one team per school will be allowed to compete. A team consists of a maximum of four (4) total students. A maximum of two (2) graduate students will be allowed per team. 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 competition.

4. Design Sheet

Each team shall prepare a design sheet summarizing their design. The sheet must include:

a) School Name
b) Names of all team members
c) The mass of the reinforcement material as designed in grams
d) A copy of Appendix D: Safety Procedures and PPE.

Each team will submit their design sheet during the Captain's Meeting.

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5. Sandbox

The MSE wall will be constructed within an apparatus hereafter referred to as a sandbox. Each team will bring their own sandbox to the competition. 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 MSE wall. The sandbox will also include a PVC pipe used to represent the tunnel. Each team will bring their own PVC pipe to the competition. Dimensions of the sandbox and the PVC pipe are 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 ¾ 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 ¾ 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 a PVC pipe (Figures 3 and 4) to represent the tunnel obstruction. Temporary templates may be used to control alignment of the pipe.
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.

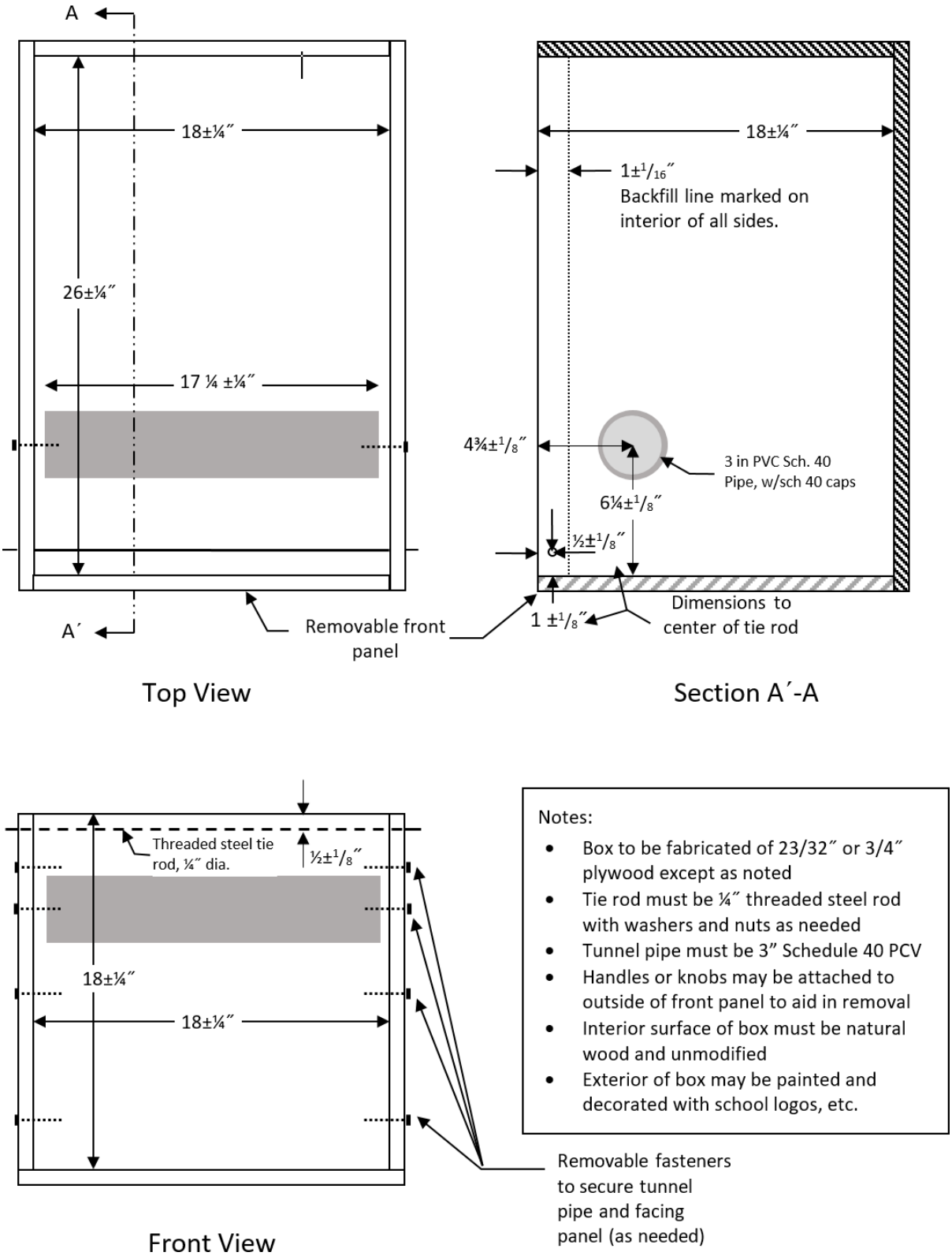

Figure 2: Sandbox Dimensions

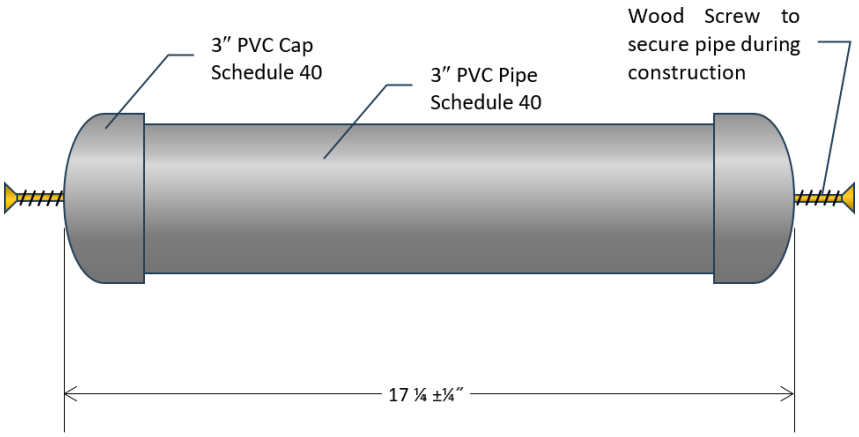

Figure 3: Dimensions of the PVC pipe (not to scale)

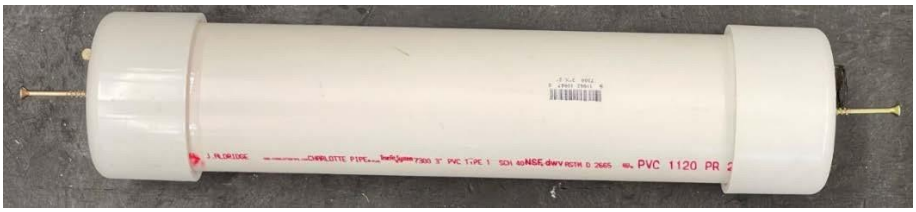

Figure 4: Picture of PVC Pipe

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

The sandboxes and the PVC pipe will be checked for compliance at the pre-competition captains' 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 pipe out of compliance at the start of the competition will be penalized.

6. 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 10 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

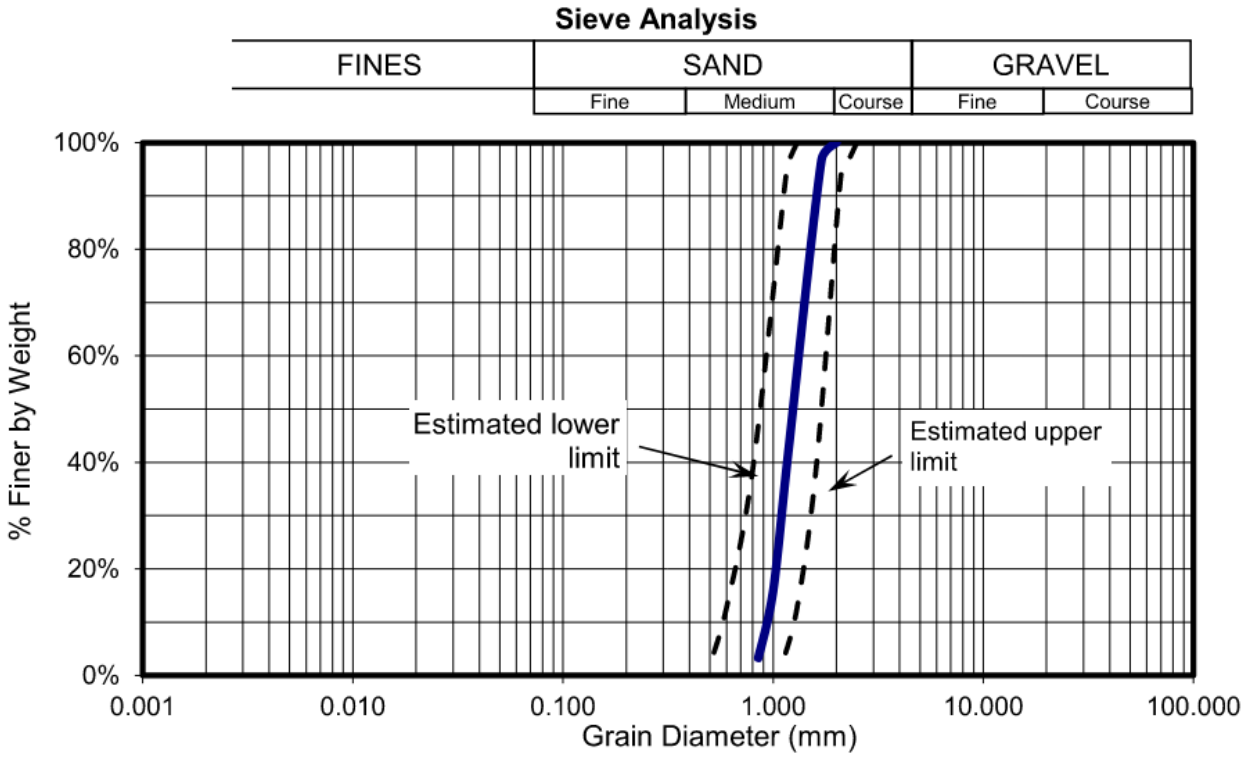

Figure 5: Estimated grain size distribution of backfill sand

7. Wall Materials

Materials will be provided by competition organizers on site. See Appendix A for detailed specifications.

a) Facing – One piece of poster board. 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 of 24” × 24” kraft paper.
c) Reinforcement Attachment to Facing – Heavy-duty polypropylene packing tape that is 2” wide.

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 and facing material at the captains’ meeting. No reinforcing and facing 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.

8. 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 knifes, 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.

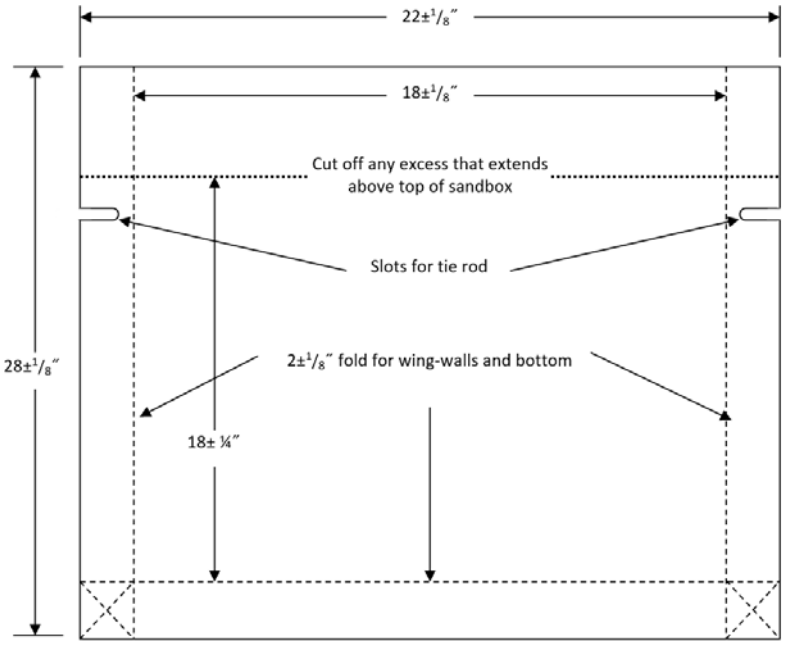

Figure 6: Dimensions of the poster board wall facing (not to scale)

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

b) **Wall Assembly Stage** – After each team's reinforcing elements have been fabricated and weighed, the team will be provided with a sheet 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 area shown in Figure 6.

   i) Tape may be only be used to attach reinforcement to the wall facing 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. All tape pieces must be placed on the vertical plane forming the wall facing only.

   ii) 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 material or reinforcement to the box, securing the PVC pipe, anchoring facing material or reinforcement to the box.

   iii) 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 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, the wall is placed in the sandbox, and both the tie rod and PVC pipe are properly in place. 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 5 gallon vertical surcharge bucket on top of the sand centered 1 in behind the wall facing. 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 efore 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 the phase, judges will check fill placement and the placement of the empty vertical surcharge loading bucket to ensure that they meet the requirements.

d) **Loading Stage** – This stage occurs in two steps: 1) removal of pipe restraints and front panel and 2) placement of 50 lb vertical surcharge load. During each step, the wall will be checked for the following three criteria: 1) excessive deformation (any portion of the wall extending outside the imaginary plane 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 but will be disqualified for a catastrophic failure.
    i) When directed by judge, the team shall remove the pipe restraints and the front panel of the sandbox. After the panel and restraints 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.

10. Design Changes

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

$$if\,|m_D - m_A| \leq 0.25 \qquad M = m_A$$

$$if\,|m_D - m_A| > 0.25 \qquad M = max\begin{bmatrix}(m_D - 0.25) - \dfrac{(m_D - m_A - 0.25)}{2} \\ m_A + \dfrac{(m_A - m_D - 0.25)}{2}\end{bmatrix}$$

Where,

$m_D = reinforcing\ mass\ (g)\ reported\ in\ design\ poster;$
$m_A = reinforcing\ mass\ (g)\ used\ during\ competition;$
$M = adjusted\ mass\ (g)\ rounded\ to\ two\ decimal\ places$

11. Scoring

After completion of the loading stage, the score for each team will be computed using the following formula:

$$Score = 50 + 15(20 - M) - 10N_{min} - 40N_{maj} - 2T - 20D$$

Where,

$M = adjusted\ mass\ of\ the\ reinforcement\ material\ in\ grams\ from\ Equation\ 1$
$N_{min} = number\ of\ minor\ rules\ violations$
$N_{maj} = number\ of\ major\ rules\ violations$
$T = total\ number\ of\ minutes\ over\ time\ limit\ for\ all\ phases\ each\ rounded\ up\ to\ nearest\ minute$
$D = deflection\ rating$
$8\ if\ wall\ fails\ deflection\ criterion\ during\ initial\ loading\ without\ surcharge$
$4\ if\ wall\ fails\ deflection\ criterion\ during\ vertical\ surcharge\ loading$
$0\ if\ wall\ passes\ deflection\ criterion\ for\ all\ loading\ phases$

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

a) Minor Penalties

i) Box dimension out of spec
ii) PVC tunnel location out of spec
iii) Minor safety mishaps

iv) Lack of minimum personnel protective equipment (PPE) – See safety appendix (Appendix D)
v) Any other rule violation that in the opinion of the judges that has the potential to provide the team with a measureable, but minor advantage

b) Major Penalties

i) Soil leakage greater than 30 cm3 (volume of standard 1 oz plastic medicine cup)
ii) Improper use of adhesive tape
iii) Major safety mishaps including any mishap that results in injury
iv) 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

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/or 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) lowest deflection rating, and 3) judges' consensus of best team and competition spirit.

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.

12. Pre-Competition Team Captains Meeting

A team captains' meeting will be held prior to the competition for the purposes of: checking sandboxes and PVC pipe for compliance if provided by the invited design teams, establishing competition order, submission of Design Sheet and Appendix E, 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 listed in the symposium schedule before the conference. Teams without a representative at the captains' meeting may be disqualified.

Teams should bring any hardware or tools needed for assembly. Sandboxes and pipes will be assembled and checked for compliance at the captains' 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.

13. Appendices

Appendix A: Material Specifications

Sand:

- Clean sand with grain size distribution as specified in Table 1 and Figure 5
- Grain shape will be rounded to sub-rounded

Sandbox Material:

- Walls and Base: 23/32 or ¾ inch plywood, any grade
- Tie Rod: ¼ inch threaded steel rod with washers and nuts as needed
- Fasteners: any suitable wood fasteners

Pipe Material:

- 3 inch Schedule 40 PVC pipe
- 3 inch Schedule 40 PVC caps
- Restraints: any suitable removal screws

Facing Material:

- Poster Board, 22 inch x 28 inch, White
- Grammage: 194 g/m^2, 0.125 g/in^2
- Office Depot® Item # 858277 (Pack Of 10)

Reinforcing Material:

- 60 lb Kraft Paper
- Grammage: 97.7 g/m^2, 0.063 g/in^2
- Office Depot® Postal Wrap Item # 444835 (2 ft x 50 ft roll)

Adhesive Material:

- Heavy duty, clear, 2 inch wide, polypropylene package tape
- Scotch® 142-B Super Strength Mailing Tape, clear
- Office Depot® Item #650457, 2 inch x 22.2 yd with dispenser

Vertical Surcharge Bucket:

- 5 gallon Home Depot Bucket
- Home Depot Internet SKU #100087613

Appendix B: This Appendix is Not Used

AppendixC: Judges' Scoring Checklist

C1: Captains' meeting—Box check

Team School:		Deductions	
Item	**Instruction**	**Minor**	**Major**
Plywood	☐ 23/32 or ¾-inch thickness ☐ Inside surfaces planar and natural		
Box dimensions	☐ Within tolerance ☐ Sand fill height marked		
Facing panels	☐ Flush to box base ☐ Removable fasteners ☐ Base extends to outside of vertical facing panel		
Tie rod	☐ ¼-inch diameter ☐ Located within tolerances		
Pipe	☐ 3-inch Sch. 40 PVC ☐ 3-inch Sch. 40 PVC caps ☐ Length in tolerance ☐ Locations in tolerance ☐ Restraints are easily removable		
Tools	☐ Only authorized tools used		
Other minor, explain:			
Other major, explain:			
Disqualification, explain:			
	Total deductions		

C2: Reinforcement fabrication

Item	**Instruction**	**Time**	
		Total	**> 15:00 (min:sec)**
Time	Give start command. Time ends when all elements cut to size and shape		
		Mass (g)	
		Design	**Actual**
Mass	Weigh reinforcement to nearest 0.01 g		
Compute official adjusted Mass, *M*, using Equation 1		*M* =	
		Deductions	
Deductions		**Minor**	**Major**
Tools	☐ Only authorized tools used		
Safety	☐ No mishaps		
	Total deductions		

C3: Wall Assembly

Item	Instruction	Time	
		Total	**> 15:00 (min:sec)**
Time	Give start command. Time ends when soil filled to line and empty loading platform is in place		
		Deductions	
		Minor	**Major**
Backfill	☐ Level ☐ Filled to fill line		
Tools	☐ Only authorized tools used		
Safety	☐ No mishaps		
	Total deductions		

C4: Construction

Item	Instruction	Time	
		Total	**> 25:00 (min:sec)**
Time	Give start command. Time ends when soil filled to line and empty bucket is in place		
		Deductions	
		Minor	**Major**
Backfill	☐ Level ☐ Filled to fill line		
Tools	☐ Only authorized tools used		
Safety	☐ No mishaps		
	Total deductions		

C5: Loading

Team School:			
Item	**Instruction**	**Scoring Guidelines**	
Stage 1: Backfill Only	• Place clean poster board on floor in front of box • At judge's direction, students remove pipe restraints and front panel from box. Electric drills/screwdrivers may be used to remove fasteners. • Once the pipe restraints and the front panel are completely removed, start 1 min wait period. • At end of 1 min, make following checks:		
	☐ Swipe front wall front and sides with straight edge to check wall deflection	☐ Pass	☐ Fail D = 8
	☐ Less than 30 cm3 sand leaked from box onto floor	☐ Pass	☐ Fail Major Ded.
	☐ Catastrophic failure	☐ Pass	☐ Fail Disqualified
Stage 2: Vertical Surcharge	• Bucket pre-weighed with 50 lbs of sand should be ready. • At judge's direction, students add 50 lbs of sand to surcharge bucket. Students have 1 min to complete loading. • Once load is placed, start 1 min wait period. • At end of 1 min, make following checks:		
	☐ Loading complete within 1 minute	☐ Yes	☐ No Minor Ded.
	☐ Swipe wall front with straight edge to check wall deflection	☐ Pass	☐ Fail D = 4
	☐ Less than 30 cm3 sand leaked from box onto floor	☐ Pass	☐ Fail Major Ded.
	☐ Catastrophic failure	☐ Pass	☐ Fail Disqualified

C6: Scoring

Adjusted mass, *M*, will be computed as

$$if\,|m_D - m_A| \leq 0.25 \qquad M = m_A$$

$$if\,|m_D - m_A| > 0.25 \qquad M = max\begin{bmatrix}(m_D - 0.25) - \dfrac{(m_D - m_A - 0.25)}{2} \\ m_A + \dfrac{(m_A - m_D - 0.25)}{2}\end{bmatrix}$$

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

Team School:			
Item	**Score**	**Weight**	**Extended**
Base Score of 50	50	1	50
Reinforcement mass score, enter as (20 – *M*)		15	
Total # of minor deductions, N_{min}		-10	
Total # of major deductions, N_{maj}		-40	
Total time over limit rounded up to nearest whole minute, *T*		-2	
Deflection rating, *D* 8 = Deflection exceeded at Stage 1 4 = Deflection exceeded at Stage 2 0 = Deflection never exceeded		-20	
Catastrophic failure any stage disqualifies the team	**DQ**	**Stage #**	
		Final Score	

Appendix D: Safety Procedures and PPE

This section is intended for each team to consider the competition steps and manage safety risk. Use additional rows as necessary.

Title	Work Task	Hazards	Controls

Notes:

1. Proper personal protective equipment (PPE; such as, masks, safety googles, closed toed shoes, gloves, etc.) should be identified and used during the competition. Failing to use PPE will result in major and/or minor penalties based on judges' discretion.
2. At a minimum, closed toed shoes, eye protection, and respiratory dust protection are required for all team members. Each missing occurrence of minimum PPE will be incur a minor penalty. After three reminders from the judges to use the proper PPE, the team will incur a major penalty for each occurrence.
3. Safety mishaps that result in bleeding will be classified as "major."