MID-PACIFIC CONFERENCE

GeoWall Competition Rules

University of Nevada, Reno

Important Dates

Rules Published:
October 17th, 2015

Design Poster and
Design Report Due:
March 13th , 2016

Competition Date:
April 7th, 2016
April 9th, 2016

Revision 1.0: October 3rd, 2015

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

1. **Objective** – The objective of the GI/SEI-Wall competition is to design and build a model mechanically stabilized earth (MSE) retaining wall using paper reinforcement taped to a poster board wall facing and apply an eccentric surcharge loading using a hardwood load frame that is assembled from smaller components. The competition objectives are for students to:
    a. Design a MSE wall using the least amount of reinforcement needed to support the retained soil and design loads and construct it in a cost-efficient manner;
    b. Design a hardwood load frame, which can be assembled during competition and without the use of glue or metallic fasteners, for the purpose of loading the MSE wall;
    c. Effectively communicate their analysis and design processes, particularly linking the geotechnical and structural engineering aspects of the competition;
    d. Enjoy a friendly but spirited competition among schools; and
    e. Attend a world-class professional engineering conference.

2. **Background** – As this year's competition brings the geotechnical and structural engineering communities together, it provides an excellent opportunity to demonstrate that geotechnical and structural engineers must work and communicate together effectively to be successful.

    MSE walls have roots 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 United States, 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, such as the Veteran's Memorial Overpass in Tucson, Arizona, which supports the bridge structure at the abutments with spread footings on top of the MSE fill (Fig. 1). This year's competition will model this application of MSE walls by requiring teams to construct a three sided wall that will then be loaded using an eccentric surcharge supported by modular hardwood piles and load frame.

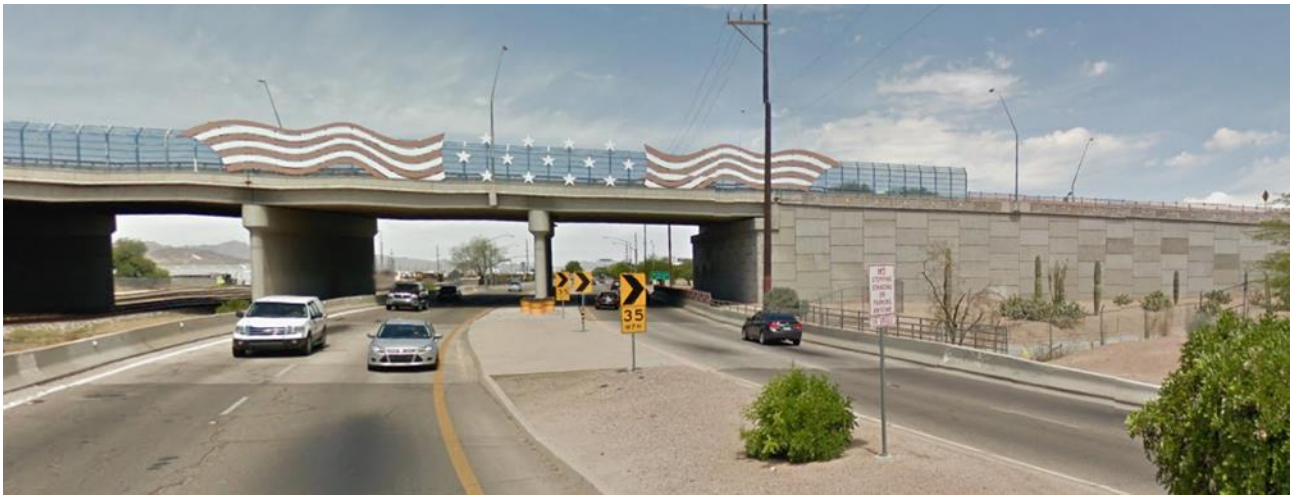


Fig. 1: The Veteran's Memorial Overpass with spread footings supporting the structure within the MSE wall (photo via Google Maps).

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 Mid-Pacific competition. Additionally, teams must compete in both the geotechnical and structural aspects of the competition, which are presented later in detail.

4. **Design Report Submittal** – This year's Mid-Pacific GeoWall Competition will include a design report similar to the National GI/SEI-Challenge 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. Appendix D, E, and F (see Item (h) below);
    c. Material properties used in design including methods (lab tests, correlations, assumptions) used to obtain the properties;
    d. Description of the engineering design and construction procedures including assumptions and equations used;
    e. A complete description of the geometry and placement of all reinforcing elements;
    f. Estimated mass of the reinforcing paper in grams (g) (not including facing material or tape);
    g. Estimated mass of the hardwood loading frame; and
    h. A safety appendix, which outlines the potential risk that is reasonably associated with each task during the competition and how the team will mitigate these risks, should be developed.

    Formatting requirements:

    i. Length shall be a maximum of three (3) pages long (not including tables, figures, references, cover page, or appendices (D, E, and F).
    j. One inch margins, single spacing, and 12 point Times New Roman font.
    k. All pages after the cover page shall contain a header identifying the team and a footer with the page number.
    l. Entire paper must be submitted in a single pdf format file with a filename of 2016GeoWall-<Participating School Name>.pdf.

    Design reports will be judged by a panel of practicing engineers and professors from the Mid-Pacific region. Judging will consider reasonableness of design equations, material properties, factors of safety, and assumptions. "Trial and error" designs will be heavily penalized. The judging rubric is presented in Appendix B part 1.

    Complete Design Report must be submitted in PDF format via email to the GeoWall committee, (*MidPacGeoWall@Gmail.com*) by 6:00 pm PST March 23rd, 2016. Subject line must include:

    "2016 GeoWall Report - <Participating School Name>."

    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 14).

Due to server limitations, your design report should not exceed 10 Mb. If it does, consider reducing the size of figures, particularly photographs. If this remains an issue, arrangements for uploading via Dropbox can be arranged, but such arrangements must be made prior to the deadline stated above.

5. **Design Poster** – Each team is to present their analysis and design on a design poster. The 24-inch x 36-inch (maximum size) poster shall be displayed in a designated area throughout the GeoWall competition. The poster is to help promote the competition to other engineers to learn about and possibly participate in the following years. It does not have to be as technical as the design paper, but should be technical enough for a peer engineer to grasp the concepts. The design poster must include:

    a. The school name and logo are to be conspicuously placed on the poster. The school name shall have at least 1-inch tall letters Cover page with name of institution;
    b. Material properties used in design including methods used to obtain the properties.
    c. Description of the engineering design 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).

    Design posters will be judged by a panel that will include practicing engineers and may include professors. Posters will be briefly described by the team captain and up to one other team member. Judges will follow up with questions and consider quality, reasonableness, and completeness of the design, material properties and assumptions. “Trial and error” designs will be heavily penalized. The judging rubric for the design poster is presented in Appendix B part 2.

    Complete Design Report must be submitted in PDF format via email to the GeoWall committee, (*MidPacGeoWall@Gmail.com*) by 6:00 pm PST March 23rd, 2016. Subject line must include:

    “2016 GeoWall Poster - <Participating School Name>.”

    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 14).

    Due to server limitations, your design report should not exceed 10 Mb. If it does, consider reducing the size of figures, particularly photographs. If this remains an issue, arrangements for uploading via Dropbox can be arranged, but such arrangements must be made prior to the deadline stated above.

6. **Interactive Sketchup Pro Model:** The following sections describe the sandbox, piles, load frame and sequencing of the competition. To assist in transmitting the many dimensional and logistic requirements, an accurately dimensioned Sketchup Pro model of the sandbox, piles, pile stabilizer, load frame, deflection frame, etc. has been developed and may be downloaded from the GI/SEI-Challenge Official Information Website. In addition to the control dimensions, this model features layered views of each

competition stage as outlined later in these rules, some notes as to the intent of the rules, schematics of the paper reinforcement, and a schematic of the hardwood load frame. If you have trouble obtaining Sketchup Pro, please contact your faculty advisor as it is free to university faculty members.

7. **Sandbox** – The 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 and part of the two side panels will be removable as shown in Fig. 2a. The removable box panels will be in place during wall construction and removed after construction to expose the MSE wall. The sandbox will meet the following requirements:
    a. Have exteriors walls and base constructed of any grade of plywood 23/32-inch or 3/4-inch (19 mm) thick.
    b. Have planar inside surfaces with the natural plywood finish. No restrictions are placed on the exterior.
    c. Have removable front and side panels as shown in Fig. 2a. Panels must be flush with the base of the box and held in place with threaded inserts, screws, hinges, clasps, 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 and side panels have been removed *(the base should extend to the outside of the vertical walls so that the bottom can be used as a deflection guide in Steps 13.e.iii and 13.e.iv).*
    e. Include a steel tie rod designed to keep the two fixed sides of the box parallel during the construction phase of the competition.
    f. All dimensions of the sandbox shall be as shown in Fig. 2b (see also Item 6 above).

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

    Sandboxes will be checked for compliance at the pre-competition captains' meeting. Teams will have until the beginning of competition to correct any compliance issues. Any team with a box out of compliance at the start of competition will be penalized.

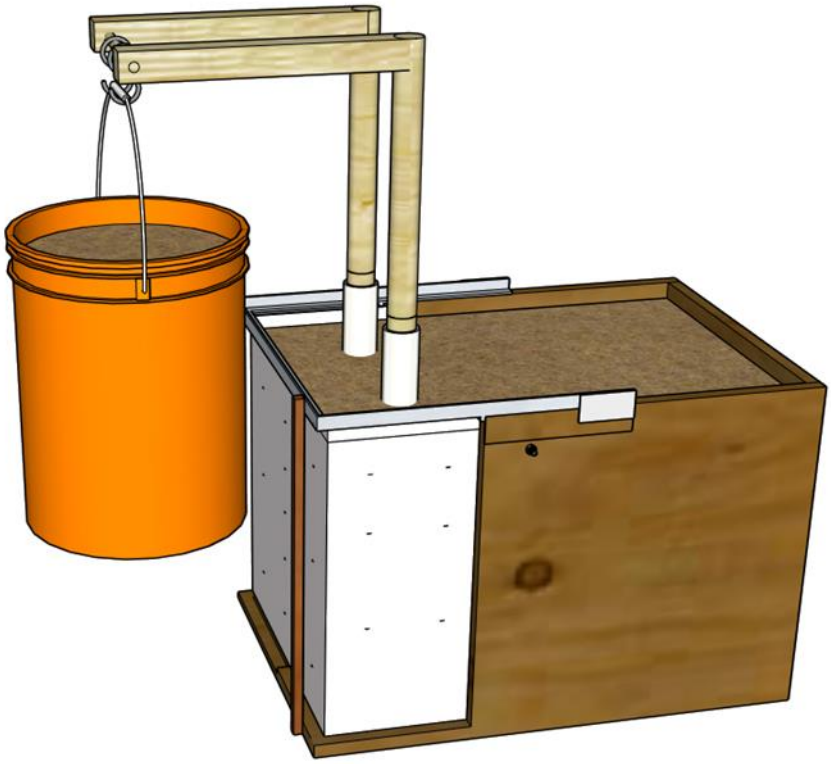
8. **Piles –** Two vertical piles will be used to apply the horizontal load to the backfill behind the wall. Each team will provide their own piles. The 21-inch long piles are to be fabricated out of 1-½″ schedule 40 PVC pipe. See the Sketchup Pro model for specific requirements on the pile locations.

9. **Hardwood Load Frame** – The MSE wall will be loaded by hanging an eccentric surcharge load onto a hardwood load frame, hereafter referred to as a load frame, which will be supported by piles constructed into the MSE wall backfill sand. Painting and addition of school or sponsor logos and other decorations to the load frame is highly encouraged. The load frame shall be made up of modular pieces of hardwood so that once assembled, it may be inserted into PVC piles constructed within the sandbox. The load frame must provide proper support for a bucket for the purpose of applying a load to the MSE wall.

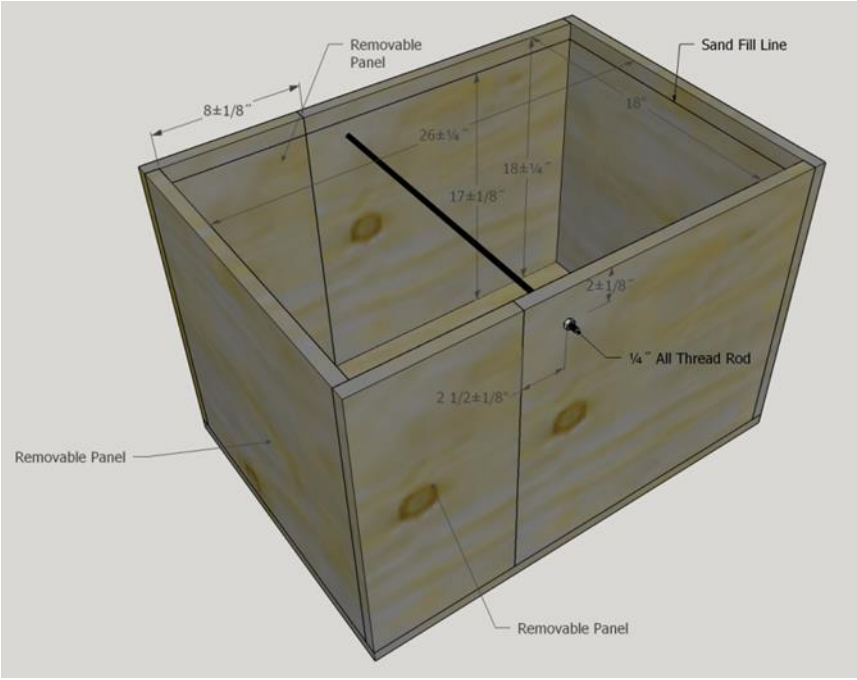
   The dimensions required of the hardwood load frame are identical those of the steel load frame that was last used in the 2014 competition. This includes the eccentricity of the bucket to the wall, the height that the bucket is suspended, and the location of the piles within the sandbox. This means that that steel load frames that may be available are well-suited for practice.

   The load frame will meet the following requirements:

   a. Be made of one of more species of hardwood (https://en.wikipedia.org/wiki/List_of_woods).
   b. Be comprised of smaller components that are assembled to make the overall load frame.
   c. Be assembled at the competition during timed construction without the use of metallic fasteners, glue, or tape.
   d. Provide proper support (1/2 inch diameter hardwood rod) for the loading bucket at specific locations (Figs. 2a and 3).
   e. The lower approximately 21.5 inches of the load frame (the portion that fits into the PVC piles and 0.75 inches above the PVC piles) are to have a uniform external cross section (not necessarily circular). The tightness or sloppiness of the fit into the PVC piles is at the discretion of each team. The load frame must slip into the PVC piles during the Load Frame Assembly stage. Deviations from the uniform cross section are permitted as required for making a connection (such as installation of a peg to secure a joint).



(a)



(b)

Fig. 2: Sandbox illustrations: a) Box with wall and backfill in place and front and side planes removed. Note obstruction free area above the tie rod required for placement of temporary deflection monitoring frame. Deflection monitoring frame will be provided by conference organizers. b) Assembled box before wall placement with dimensions.

f. When disassembled, each component must fit into a 2-inch by 2-inch by 12-inch prism.
g. Each component may be made of smaller pieces of hardwood that are glued together (prior to the competition) to form the desired shape or function.
h. Components are to connect to each other using joints that include, but are not limited to threads, dovetail joints, mortise and tenon joints, slip joints, lap joints, or pins. The intent is to reward innovative designs and craftsmanship rather than be restrictive. However, each connection should not be able to slip apart through tension, compression, or shear. This may require additional parts, such as a wooden peg, to secure the connection.

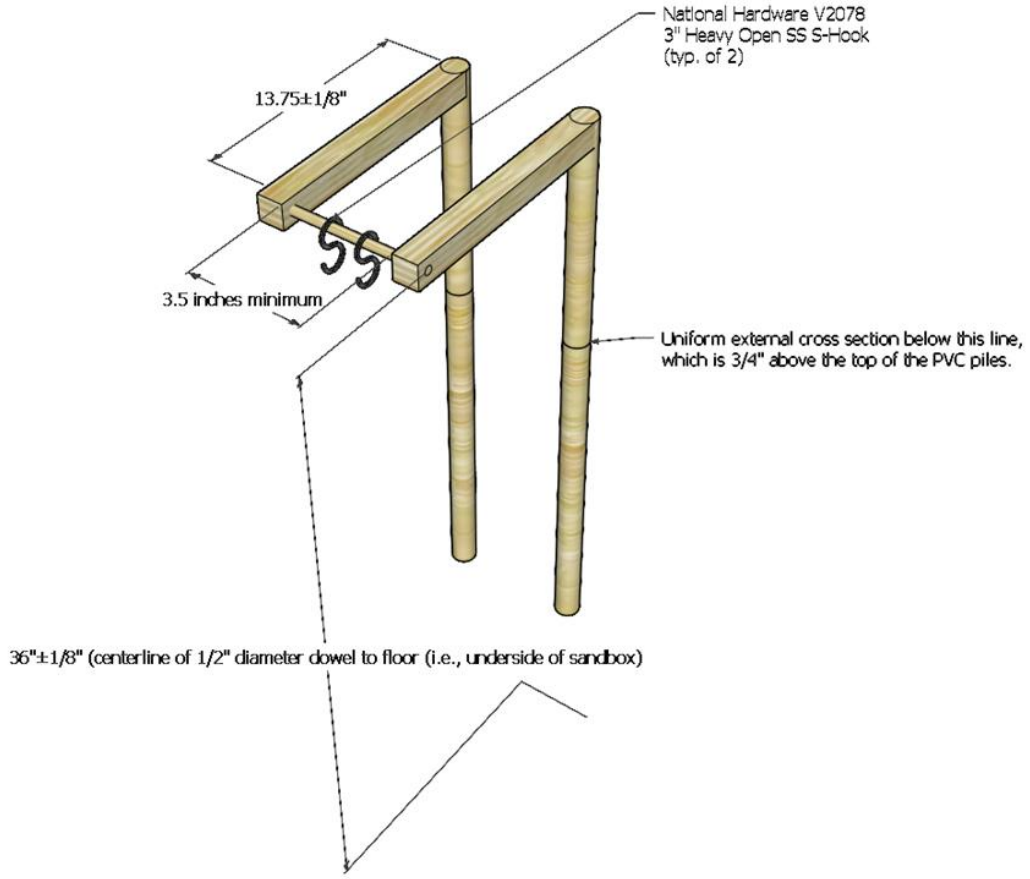


Fig. 3: Dimensioned hardwood load frame. See Sketchup Pro model for other views. Note: the shape of this load frame is shown schematically only.

10. **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 Fig. 4. 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 that the competition backfill materials meet the specifications in Table 1 and Fig. 4. 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 14).

Table 1: Representative grain-size distribution for GI/SEI-Wall competition sand.

Typical Distribution		Lower Bound		Upper Bound	
Size (mm)	**% Passing**	**Size (mm)**	**% Passing**	**Size (mm)**	**% Passing**
2.36	100	1.30	100.0	2.50	100.0
1.70	96	1.20	96.9	2.10	96.9
1.18	20	1.15	93.7	2.00	93.7
0.85	1	0.95	38.7	1.60	38.7
0.60	1	0.83	12.7	1.30	12.7
		0.70	2.0	1.10	2.0

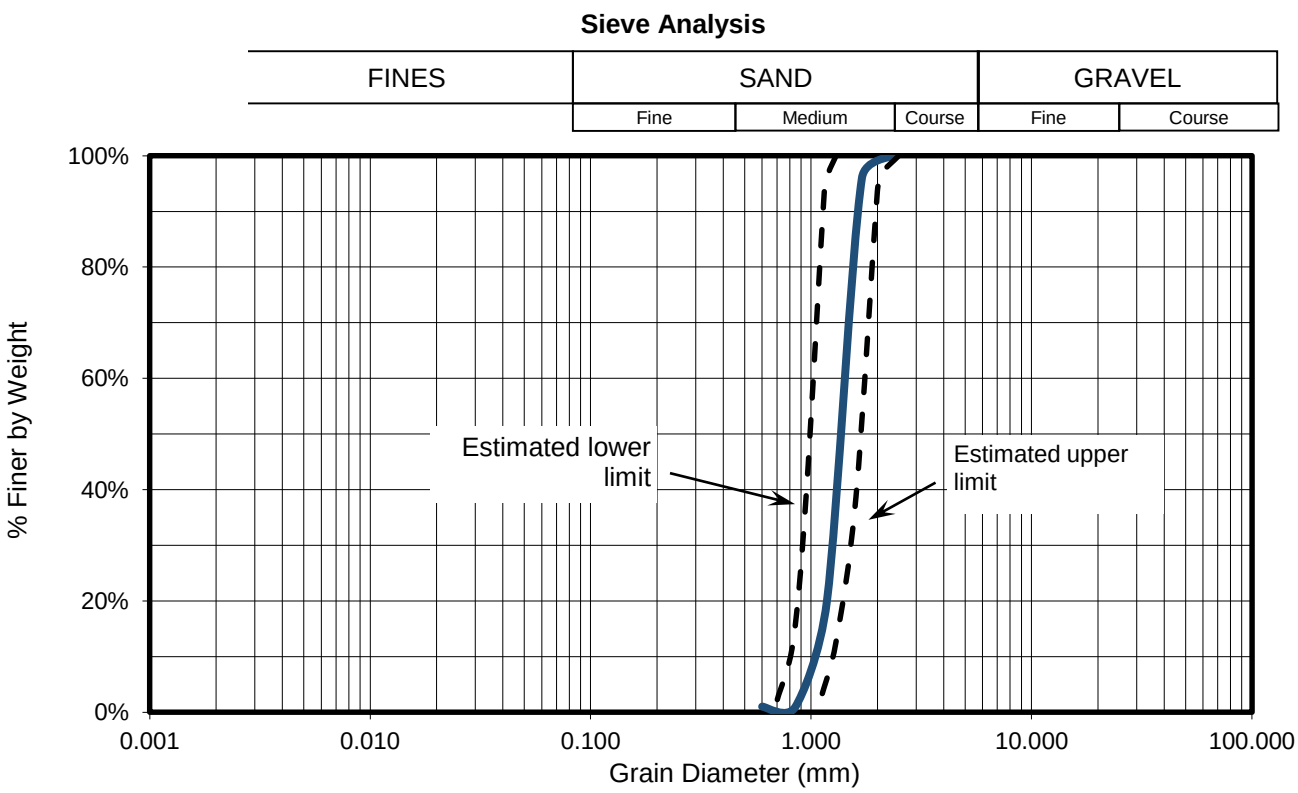


Fig. 2: Estimated grain size distribution of backfill sand

11. **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 Fig. 5 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-inch × 24-inch.
    c. Reinforcement Attachment to Facing – Heavy duty polypropylene packaging tape, 2-inch wide.

    Competition organizers will make reasonable efforts to ensure the wall materials meet the specifications in Appendix A. Teams will be provided small samples of the reinforcing material at the captains' meeting. Teams may modify their wall design at any time prior to the actual competition; see Paragraph 14 below.

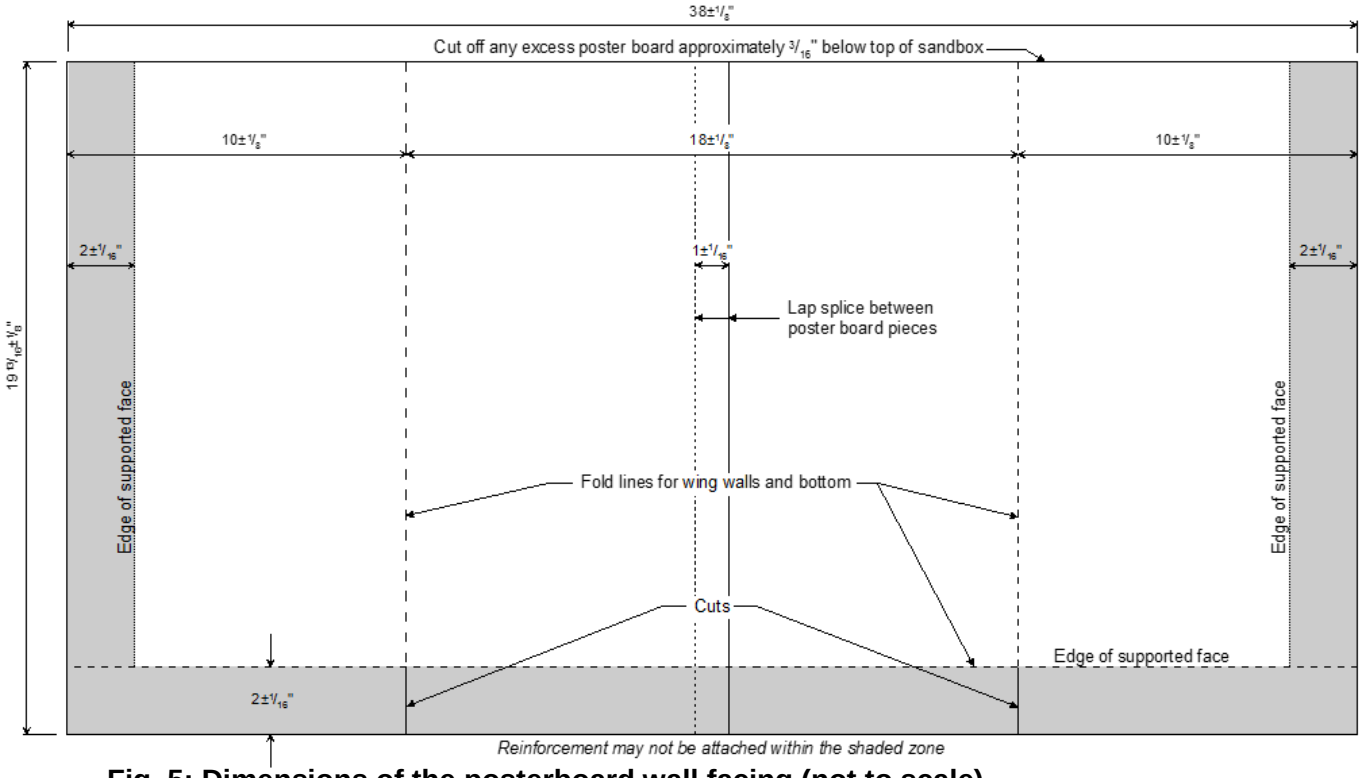


Fig. 5: Dimensions of the posterboard wall facing (not to scale)

12. **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, including scissors, paper cutting tools, and hole punches. **Open bladed utility knives or razor blades will not be permitted**. See Safety section for additional information on this.
    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. May be made of any material, must not have any moving parts, must be removed at the end of any stage in which they are used.

Buckets and shovels will be provided by the competition organizers.

13. **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″ × 24″. The team must fabricate their reinforcing elements from this sheet using authorized construction tools. Teams will be timed for this stage with overtime charges when fifteen (15) minutes has been exceeded. After the 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 two sheets of poster-board (22 inches × 28 inches) and a roll of packaging tape. The team must assemble their wall using these materials and authorized construction tools. Dimensions for the wall facing are shown in Fig. 5.
        i. Tape may be used for only two purposes: 1) to join the two poster-board sheets 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 not exceeding 1 inch 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 inches × 2 inches. 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 one of the three vertical planes forming the wall facing.
        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.
        iv. 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 inch below the top of the sandbox must be trimmed off. The assembly stage is complete when the facing material is properly folded and trimmed, the reinforcing elements are attached to the facing, the wall is placed in the sandbox, and the PVC pile sleeves are installed and stabilized. No sand is added to the box in this stage. Twenty (20) minutes will be allotted 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 Fig. 2b) is covered and the backfill is level. The facing material must be in direct contact with the inside of the sandbox at all times during this stage. 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, and any temporary templates or guides have been removed (including the PVC pile stabilizer). A maximum of twenty five (25) minutes will be allotted for this stage, but teams may finish early (see scoring). At the end of the phase, judges will check fill and pile placement to ensure they meet requirements.

d. **Load Frame Assembly Stage** – This stage is completed just prior to the Loading Stage. The components will be weighed to the nearest 0.1 grams. The team should have the components of their load frame laid out along with the two S-hooks and the empty surcharge bucket. The Load Frame Assembly Stage is complete with the load frame is assembled and installed into the PVC piles, and the surcharge loading bucket with 5 pounds (lbs) sand within the bucket is placed on the S-hooks. The intent of the 5-lbs of sand is to take up any slack in the hardwood load frame prior to zeroing the deflection gauge. This step is timed – see Equation 3.

e. **Loading Stage** – This stage occurs in three steps: 1) loading of the load frame with placement of a vertical surcharge, 2) removal of that vertical surcharge followed by removal of front & side panels, and 3) placement of a second vertical surcharge. Prior to the first step, the deflection will be zeroed. During the second step, only the load frame will be checked for deflection criteria. For the two final steps, the wall and load frame will be checked for the following four 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 cm^3 of sand passing out of the sandbox), 3) catastrophic failure, and 4) excessive deflection of the load frame and/or vertical surcharge bucket. The team will be penalized for poor performance in each of these four areas.
   i. With the surcharge bucket and 5-lb sand supported by the load frame, the vertical deflection gauge is zeroed.
   ii. When directed by a judge, the team shall place 55 lbs of sand in the vertical surcharge bucket that is supported by the load frame. 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 deflection of the hardwood load frame. Once the judge checks the deflection, the team will remove the vertical surcharge load and place a second surcharge loading bucket with 5 lbs of sand back on the hardwood load frame.

      If a load frame breaks at this stage, the score will be computed based on this step and loading Steps (iii) and (iv) are not completed.

iii. When directed by judge, the team shall remove the front and side panels of the sandbox. After the panels are removed, the stopwatch will be started and then the judges will clamp the deflection frame to the sandbox. At the end of one (1) minute, the judges will check the four criteria.

If the wall fails at this stage, the score will be computed based on this step and loading Step (iv) is not completed.

iv. If the wall does not fail catastrophically, the team will then place 25 lbs of sand in the vertical surcharge bucket that is suspended from the hardwood load frame. 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 four criteria.

14. **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:

$$M = m_A + (m_D - m_A + 0.50)^2 \tag{1}$$

where

M = rounded and then truncated (2 decimals) mass reinforcing score;
m_D = reinforcing mass reported in design report; and
m_A = actual reinforcing mass used during competition

15. **Scoring** – The raw geotechnical and structural scores will be normalized by the highest ranking school of each category, respectfully (as a percent), and then the overall score computed as the weighted sum of the two categories. The geotechnical portion will be weighted by 60 percent and the structural category weighted by 40 percent. Note that scores can become negative.

Geotechnical Contribution:

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

$$\text{Raw Geo Score} = R + 15(20 - M) - 10N_{\min} - 40N_{maj} - 2T - 20D_1 - 40F_1 \qquad (2)$$

where

R = report score out of 60 points

M = adjusted mass of the reinforcement material in grams

$N_{\min}$ = 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 nearest minute

D_1 = deflection rating

0 if load frame fails deflection criterion during Step 13.e.ii;
5 if wall fails deflection criterion during Step 13.e.iii;
3 if wall fails deflection criterion during Step 13.e.iv; and
0 if wall passes deflection criterion for all loading phases.

F_1 = Failure rating (in addition to the appropriate deflection rating)

8 if load frame fails during Step 13.e.ii;
6 if wall fails catastrophically during Step 13.e.iii;
3 if wall fails catastrophically during Step 13.e.iv; and
0 if wall never fails catastrophically.

a. Minor Penalties
   i. Box dimension out of spec;
   ii. Pile location out of spec;
   iii. Improper use of adhesive tape (overlapping) resulting from sloppiness of construction;
   iv. Improper placement of reinforcement strips resulting from sloppiness of construction (they should avoid the gray areas as presented in Fig. 5);
   v. Any addendum to the design report required by judges that simply clarifies content but does not change the design; and
   vi. 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 cm^3 (volume of standard 1 oz plastic medicine cup);
   ii. Improper use of adhesive tape (overlapping) resulting from design flaw, such as designing the reinforcement strips too close together;
   iii. Improper placement of reinforcement strips by design (they should avoid the gray areas as presented in Fig. 5);
   iv. Any addendum to the design report required by judges that results in a significant change to the design; and
   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, including use of open blade knives; and
   iii. Design or construction techniques that violate the spirit of the competition and provide a large and/or unfair advantage.

Once all of the raw geotechnical scores are posted, they will be normalized by the highest raw geotechnical score. The normalizations will be multiplied by 60. Hence, the highest possible score from this category is 60. There is no lower limit for a score.

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

• Report Score: 48/60, *R* = 48

• Design report specifies 8.57 g. Actual reinforcement used is 8.25 g.

$$\mathrm{M} = 8.25 + (8.57 - 8.25 + 0.50)^2 = 8.92$$

- 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 1min)
  - Wall assembly: 16:05 (1:05 over allotted time, round up to 2 min)
  - Construction: 24:27 (under allotted time)
  - 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 first loading phase (Step 13.e.iii) but failed deflection test during second loading phase (Step 13.e.iv), D_1 = 3, F_1 = 0

Using Eq. 1, the raw geotechnical score is

Raw Geo Score

$$= 48 + 15(20 - 8.92) - 10(1) - 40(0) - 2(3) - 20(3) - 40(0) = 138.20$$

Suppose that at the end of the competition, the highest raw geotechnical score of all of the teams is 272.82. Thus, the final geotechnical score for this example team is:

$$\text{Corrected Geo Score} = \frac{138.20}{272.82}(60) = 30.39$$

Structural Contribution:

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

$$\text{Raw Structural Score } = 3200 - L - (P)(C)(Z) - 4M_{comp} - 25N_{maj,2} - 175D_2 - 500F_2 \qquad (3)$$

where

L = mass of the hardwood load frame in grams

P = number of people for the load frame assembly at any time during its assembly. This includes any type of work sharing (one person does first half, another the second – still two people);

C = overall time for construction of the load frame in seconds (independent of the number of people used);

Z = 1.0 if C is less than 300, otherwise Z will be 1.1

M_{comp} = total mass of component(s) not meeting specifications

$N_{maj,2}$ = number of major deductions

D_2 = deflection rating *(as the wall, the deflection criteria is ¾-inch vertical as measured at the dowel rod)*

3 if load frame fails deflection criterion during Step 13.e.ii;
2 if load frame fails deflection criterion during Step 13.e.iii; and
1 if load frame fails deflection criterion before or during Step 13.e.iv; and
0 if load frame passes deflection criterion for all loading phases.

F_2 = Failure rating (in addition to the appropriate deflection rating)

2 if load frame fails during Step 13.e.ii;
1 if wall fails during Step 13.e.iii;
1 if load frame fails during Steps 13.e.iii or 13.e.iv; and
0 if load frame never fails.

Failure of the load frame is defined as either a catastrophic failure or such deflection that the supported load is no longer supported by the piles alone (e.g., the bucket makes contact with the floor). This means that if your wall fails during Step 13.e.iv, the bucket will contact the floor creating a load frame failure.

a. Major Penalties

   i. Load frame components may not slip apart from each other in shear, tension, or compression. For example, if two adjacent components can be disassembled by tension alone, then $N_{maj,2}$ = 1 for these two component alone.

b. Disqualification – Teams may be disqualified for the following:
   i. Load frame does not disassemble or is not present;
   ii. Unsafe practices; and
   iii. Design or construction techniques that violate the spirit of the competition and provide a large and/or unfair advantage.

Once all of the raw structural scores are posted, they will be normalized by the highest raw structural score. The normalizations will be multiplied by 40. Hence, the highest possible score from this category is 40. There is no lower limit for a score.

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

- The team's load frame has a total mass of 1359.2 grams
- One component did not fit into the prism. The mass of this one component is 78.5 grams.
- During the assembly, one person did the majority of the work, but a second person was needed for 15 seconds to align two components for assembly. The person doing the majority of the work took a total of 63 seconds for assembly of the load frame.

  - P = 2
  - C = 63
  - Z = 1.0

- Each of the component connections could not be disassembled through shear, tension, or compression alone. Hence, $N_{maj,2}$ = 0.
- The load frame passed deflection test in first loading phase but failed deflection (likely due to the wall deflection) test during the placement of the 25 lbs of sand. Hence, D_2 = 1, F_2 = 0

Using Eq. 3, the raw structural score is:

Raw Structural Score

$$= 3200 - 1359.2 - (2)(63)(1.0) - 4(78.5) - 25(0) - 175(1) - 500(0) = 1225.8$$

At the end of the competition, the highest raw structural score of all of the teams is 2167.5. Thus, the final structural score for this example team is:

$$\text{Corrected Structural Score } = \frac{1225.8}{2167.5}(40) = 22.62$$

Hence, the total overall score for this team is 30.39 + 22.62 = 53.02

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.

See Appendix C for scoring checklists.

16. **Pre-Competition Team Captains' Meeting** – A team captains' meeting will be held prior to the competition for the purposes of: checking sandboxes and load frames for compliance, establishing competition order, 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 in Mailer 3 before the conference. Teams without a representative at the captains' meeting will be disqualified.

    Teams should bring their sandboxes, load frames, piles, pile stabilizers, and any hardware or tools needed for assembly. Sandboxes, piles, and load frames will be assembled and checked for compliance at the meeting. Teams will have until one hour prior to the beginning of the competition to correct any compliance issues identified during the captains' meeting (any sandboxes, piles, or load frames found out of compliance at the captains' meeting will be rechecked April 9th before the construction portion of the competition).

Appendices

Appendix A: Material Specifications

- **Sand**:
  - Clean sand with grain size distribution as specified in Table 1 and Fig. 4
  - Grain shape will be rounded to sub-rounded

- **Sandbox Material**:
  - Walls and Base: 23/32 or ¾-inch thick plywood, any grade
  - Tie Rod: ¼-inch diameter threaded steel rod with washers and nuts as needed
  - With the exception of the tie rod itself, hardware on the inside of the box (e.g., nuts and washers for the tierod) should be countersunk
  - Fasteners: any suitable wood fasteners

- **Facing Material**:
  - Poster Board, 22 inches x 28 inches, White
  - Grammage: 194 g/m2, 0.125 g/in2
  - Office Depot® Item # 858277 (Pack Of 10)

- **Reinforcing Material**:
  - 60 lb Kraft Paper
  - Grammage: 97.7 g/m2, 0.063 g/in2
  - Office Depot® Postal Wrap Item # 444835 (2 feet x 50 feet roll)

- **Adhesive Material**:
  - Heavy duty, clear, 2 inches wide, polypropylene package tape
  - Scotch® 142-B Super Strength Mailing Tape, clear
  - Office Depot® Item #650457, 2 inches x 22.2 yards with dispenser

- **Load Frame Material:**
  - Hardwood meeting wood type and size criteria
  - Bucket Support rod: ½-inch diameter hardwood

Appendix B part 1: Design Report Judging Rubric

Mid-Pacific GeoWall Design Paper – Scoring Form			
Reviewer Guidelines: 1) Place weight on the team ability for engineering reasoning not technical knowledge 2) Place weight on team communication skills on procedures, findings and observations 3) Score in 0.5-point increments 4) Team to be awarded a higher score if verifying design parameters beyond assumptions and references			
Criterion	**Max**	**Actual**	**Notes**
1) Formatting, Mechanics, Grammar & Safety			
a. Paper length, margins & font are acceptable	1		Paper complies with specifications
b. Layout, or structure, of paper is logical	1		Paper organization is clear and supports the message.
c. Grammar and punctuation are correct	1		Error free paper with writing that clearly presents design.
d. Figures & tables are clear, properly numbered, captioned and referenced in the text	1		Good choice of tables vs. figures, clear presentation of data.
e. References are reasonably formatted and complete	1		Quantity appropriate with correct citations and references
f. Appendix A and Safety appendix complete with reasonable controls	1		Clearly identifies key safety concerns and provides viable plans to keep team safe during competition.
2) Experimental Methods, Analyses and Design:			
a. Methods to obtain soil properties	2		Experimental methods are reasonable and clearly described
b. Methods to determine reinforcement properties	2		Experimental methods are reasonable and clearly described
c. Methods to determine backfill-reinforcement interaction	2		Experimental methods are reasonable and clearly described
d. Engineering properties are reasonable	2		Backfill unit weight, friction angle, interface friction angle, reinforcement strength are compared to typical values
e. Earth-pressure calculations	2		Calculations for both backfill and surcharge are correct and presented in a logical, readily followed format
f. Method used to account for 3-D wall geometry	2		Method and assumptions are reasonable
g. Design of reinforcement length	2		Model accounting for 3-D geometry is reasonable and appropriate
i. Design of reinforcement spacing	2		Method and assumptions are reasonable
j. Evaluation of connection strength	2		Method and assumptions are reasonable
k. Methods to obtain hardwood properties	2		Referenced or experimental
l. Detail to connections of modular components	2		Discussed with attention to function and ease of assembly
m. Structural analysis of load frame	2		Model accounting for 3-D geometry and misfit is reasonable and appropriate
3) Engineering Reasoning and Communication			
The report is, on the whole, clear, precise, and well-reasoned. Engineering terms and distinctions are used effectively and in keeping with established professional usage. The report demonstrates a clear and precise analysis of the MSE wall and load frame design problem, very little or no irrelevant information is presented, key assumptions are identified, and key concepts are clarified. The authors have shown, through their report, excellent engineering reasoning and problem-solving skills.	10		Scores may range from 0 to 10. It is the opinion of the reviewer as to how the overall report measures up to the criteria listed under item 3 "engineering reasoning and communication".
Design Paper Sub Total	40		

Appendix B Part 2: Design Poster Judging Rubric

Mid-Pacific GeoWall Design Poster – Scoring Form			
Reviewer Guidelines: 1) Place weight on the team ability for engineering reasoning not technical knowledge 2) Place weight on team communication skills on procedures, findings and observations 3) Score in 0.5-point increments 4) Team to be awarded a higher score if verifying design parameters beyond assumptions and references			
Criterion	**Max**	**Actual**	**Notes**
1) Formatting, Mechanics, Grammar & Safety			
a. Poster size (24x36" max), headings, fonts, margins and layout	1		Poster complies with specifications
c. Grammar and punctuation are correct	1		Error free paper with writing that clearly presents design.
d. Figures & tables are clear, properly numbered, captioned and referenced in the text	1		Good choice of tables vs. figures, clear presentation of data.
e. References are reasonably formatted and complete	1		Quantity appropriate with correct citations and references
2) Experimental Methods, Analyses and Design:			
a. Conveys the Experimental Methods, Analyses and Design steps used to plan the GeoWall construction	3		Experimental methods, analyses, and design of the project are displayed. This is not as in-depth as the report, but technical enough for another engineer to grasp the concepts and gain an understanding of the GeoWall Competition.
3) Engineering Reasoning and Communication			
a. The poster is, on the whole, clear, precise, and well-reasoned. Engineering terms and distinctions are used effectively and in keeping with established professional usage. The poster demonstrates a clear and precise analysis of the MSE wall and load frame design problem, very little or no irrelevant information is presented, key assumptions are identified, and key concepts are clarified. The authors have shown, through their poster, excellent engineering reasoning and problem-solving skills.	3		Scores may range from 0 to 2. It is the opinion of the reviewer as to how the overall report measures up to the criteria listed under item 3 "engineering reasoning and communication".
b. Answering judges questions	10		This score reflects the team's ability to professionally answer the judge's questions and clearly explain the material.
Design Poster Sub Total	20		

Mid-Pacific GeoWall Design Paper and Poster – Scoring Form			
Criterion	**Max**	**Actual**	**Notes**
Design Paper and Poster Combined Total	**60**		Add together Design Paper and Poster Sub Totals to be used in the geotechnical raw scoring.

Appendix C: Judges Scoring Checklist for GeoWall Competition
C1: Captains Meeting – Box Check

Team School:		**Deductions**	
Item	**Instruction**	**Minor**	**Major**
	Sandbox		
Plywood	☐ 23/32 or ¾-inch or 19 mm thickness ☐ Inside surfaces planar and natural		
Box dimensions	☐ Within tolerance ☐ Sand fill height marked		
Facing panels	☐ Flush to box base ☐ Base extends to outside of vertical facing panels ☐ Removable fasteners		
Tie rod	☐ ¼-inch dia ☐ Located within tolerances		
Piles	☐ 1-½ inch Sch 40 PVC ☐ Length in tolerance ☐ Base guides ≤ ¼-inch thick ☐ Locations in tolerance ☐ Upper pile template easily removable		
Deflection frame attachment	☐ Frame fits properly on box		
Tools	☐ Only authorized tools used		
Other minor, explain:			
Other major, explain:			
Disqualification, explain:			
	Hardwood Load Frame		
Materials	☐ Constructed of hardwood ☐ No metallic or other reinforcement		
Frame Dimensions	☐ Eccentricity ☐ Height ☐ Width at bucket support ☐ Bucket support rod is ½ inch diameter		
Components	☐ Components fit into prism (see C5)		g
Full Assemblage	☐ Components cannot be disassembled with shear, tension, or compression of joints alone ☐ Wooden pins used for securing components excepted from this ☐ No non-wooden fasteners		
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 Mass, *M*, using Equation 2		*M* =	
		Deductions	
Deductions		Minor	Major
Tools	Only authorized tools used, especially no open blade knives		
Safety	No mishaps		
Other, explain			
	Total deductions		

C3: Wall Assembly

Team School:			
Item	**Instruction**	**Time**	
		Total	> 20:00 (Min:sec)
Time	Give start command. Time ends when wall is assembled and trial fit to box (NO SAND PLACED DURING THIS PHASE)		
		Deductions	
		Minor	Major
Facing construction	☐ Single lap joint 1 inch wide ☐ Trimmed ~3/16 inch below top of wall		
Reinforcement attachment	☐ Each tape piece ≤ (2 inches × 2 inches) ☐ On vertical front/side planes only ☐ Not overlapping (see 15.a-b) ☐ Touch both wall and reinforcement		
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 students signal end (hands up)		
		Deductions	
		Minor	Major
Backfill	☐ Level ☐ Filled to fill line		
Tools	☐ Only authorized tools used		
Safety	☐ No mishaps		
	Total deductions		

C5: Load Frame Assembly

Item	Instruction		
Time	Give start command. Time ends when the load frame is assembled, installed in the piles, and the bucket is in place	C = sec	
Persons	# persons completing assemblage	P =	
		Mass (g)	
Mass	Weigh components to nearest 0.1 g. This measurement to be made just prior to Load Frame Assembly.	L =	
		Mass (g)	
Total mass of components that do not fit into the 2-inch x 2-inch x 12-inch prism		M_{comp} =	
Deductions from C1	# of components that can slip apart without pin or other being removed	$N_{maj,2}$ =	
Other, explain			
	Total deductions		

C6: Loading

Team School:			
Item	**Instruction**		
Stage i	• Bucket with 5-lbs sand supported. Zero out vertical deflection gauge on dowel rod		
Stage ii: Load Frame Loading	• Bucket preweighed with 55 lbs of sand should be ready. • At judge's direction students add 55 lbs of sand to surcharge bucket. Students have one minute to complete loading. • Once load is placed start 1 min wait period • At end of 1 min make following checks • Remove surcharge bucket.		
	☐ Check vertical deflection at end of load frame support.	☐ Pass	☐ Fail $D_2 = 3$
	☐ Failure (frame breaks or bucket transmits load)	☐ Pass	☐ *Fail $D_1 = 0$* ☐ Fail $F_1 = 8$ ☐ Fail $D_2 = 3$ ☐ Fail $F_2 = 2$
Stage iii: Backfill only	• Replace a new surcharge bucket with 5-lbs sand • Place clean posterboard on floor in front and sides of box • At judge's direction students remove panels from box. Electric drills/screwdriver may be used to remove fasteners. • Once panels are completely removed start 1 min wait period • Attach measuring frame • At end of 1 min make following checks		
	☐ Swipe front wall front and sides with straight edge to check wall deflection	☐ Pass	☐ Fail $D_1 = 5$
	☐ Less than 30 cm^3 sand leaked from box onto floor	☐ Pass	☐ Fail Major Ded
	☐ Catastrophic failure of the wall.	☐ Pass	☐ *Fail $D_1 = 5$* ☐ Fail $F_1 = 6$ ☐ Fail $D_2 = 2$ ☐ Fail $F_2 = 2$
	☐ Check vertical deflection at load frame support.	☐ Pass	☐ Fail, $D_2 = 2$
Stage iv: Eccentric Vertical Surcharge	• Bucket preweighed with 25 lbs of sand should be ready. • At judge's direction students add 25 lbs of sand to surcharge bucket. Students have one minute 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 front wall face with straight edge to check wall deflection	☐ Pass	☐ Fail $D_1 = 3$
	☐ Less than 30 cm^3 sand leaked from box onto floor	☐ Pass	☐ Fail Major Ded
	☐ Catastrophic failure of the MSE wall	☐ Pass	☐ Fail $D_1 = 3$ ☐ Fail $F_1 = 3$
	☐ Check vertical deflection at load frame support.	☐ Pass	☐ Fail, $D_2 = 1$
	☐ Load frame breaks or bucket touches floor	☐ Pass	☐ Fail $D_2 = 1$ ☐ Fail $F_2 = 1$

C7: Raw Scoring

Raw Geotechnical Score $= R + 15(20 - M) - 10N_{min} - 40N_{maj} - 2T - 20D_1 - 40F_1$

Adjusted mass, *M*, computed by

$M = m_A + (m_D - m_A + 0.50)^2$ *(round and truncate M to two decimal places)*

Team School:			
Item	**Score**	**Weight**	**Extended**
Report and poster score out of 60, *R*		1	
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_1 (see Appendix D6)		-20	
Failure rating, F_1 (see Appendix D6)		-40	
Geotechnical	**Final Raw Score**		

Raw Structural Score $= 3200 - L - (P)(C)(Z) - 4M_{comp} - 25N_{maj,2} - 175D_2 - 500F_2$

Item	**Score**	**Weight**	**Extended**
Load frame mass, L		-1	
Assembly time (use Z = 1.0 if C < 300, else 1.1), enter as PCZ		-1	
Total mass of large components, M_{comp}		-4	
Total # of major deductions, $N_{maj,2}$		-25	
Deflection rating, D_2 (See Appendix D6)		-175	
Failure rating, F_2 (see Appendix D6)		-500	
Structural	**Final Raw Score**		

Notes:

C8: Final Scoring

Item	**Weight**		**Quotient**
Raw Geotechnical Score (RGS)			
Highest Overall Raw Geotechnical Score			
	Value	**Weight**	**Extension**
Quotient from above:		60	
Item	**Weight**		**Quotient**
Raw Structural Score			
Highest Overall Raw Structural Score			
	Value	**Weight**	**Extension**
Quotient from above		40	
	Extension	Extension	
Total Score (sum of corrected scores)			

Appendix D: Safety

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

Title	Work Task	Hazards	Controls

Notes:

1) *Due to cuts during the 2014 and 2015 competitions, open-bladed knives or utility razors, including those by Martor, will not be allowed at all this year. There are a number of possible substitutions, including*
    - *Paper trimmers (http://www2.fiskars.com/Products/Crafting-and-Sewing/Paper-Trimmers/Portable-Rotary-Paper-Trimmer-12)*
    - *Scissors*
    - *Spagetti Cutters (http://www.amazon.com/Marcato-Atlas-Wellness-Pasta-Stainless/dp/B0009U5OSO)*
2) *Safety mishaps that result in bleeding will be classified as "major".*

Appendix E: Bio-form to be completed by each <u>team captain</u> and submitted to the chief judge at the pre-competition meeting

Geotechnical & Structural Engineering Congress 2016 **GI/SEI-Wall Competition Bios**
Team School:
Team Mascot:
No. of Years Competing at Nationals:
Team Advisor:
Team Captain:
Current Year in School (junior, senior, MS, or PhD):
Hometown (City and State or Country)
Other School Activities:
Interests/Hobbies:
Future Plans, e.g., graduate school, consulting, government, other?
Geographical preferences?

Appendix F: Bio-form to be completed by each <u>team member</u> and submitted to the chief judge at the pre-competition meeting

Geotechnical & Structural Engineering Congress 2016 **GI/SEI-Wall Competition Bios**
Team School:
Team Mascot:
No. of Years Competing at Nationals:
Team Advisor:
Team Member:
Current Year in School (junior, senior, MS, or PhD):
Hometown (City and State or Country)
Other School Activities:
Interests/Hobbies:
Future Plans, e.g., graduate school, consulting, government, other?
Geographical preferences?