



**GEO-
INSTITUTE**



Geo-Institute
of the American Society of Civil Engineers
Presents
Competition Rules
for the Pacific South West Regional
GeoWall
Held at Cal Poly Pomona
Important Dates

Rules published: December 19, 2012

Pre-Competition Captains' Meeting: Friday March 23rd, 2012

Competition: Saturday March 24th, 2012

Competition Info: <http://www.pswc2012.org/geotechnical.html>

Revision 01: December 15, 2011



GeoWall 2012 Competition Rules

Geo-Institute of the ASCE

1. **Objective** -- The objective of the GeoWall competition is to design and build a model mechanically stabilized earth (MSE) retaining wall using paper reinforcement taped to a posterboard wall facing. The design objective is to use the least amount of reinforcement needed to support the retained soil plus both vertical and horizontal surcharge loads.
2. **Eligibility** -- Only one team per school will be allowed to compete. A team consists of a maximum of four (4) undergraduate 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 competition. All team members must be registered participants of PSWC 2012.
3. **Submittal** – The Mechanically Stabilized Earth Wall Poster:

The poster must include:

- a. Name of institution; names and status (graduate, undergraduate) of each team member; identification of team captain with email address; and name, title, and email address of faculty advisor.
- b. Material properties used in design including methods (lab tests, correlations, assumptions) used to obtain the properties.
- c. Description of the engineering design and construction procedures including assumptions and equations used.
- d. A complete description of the geometry and placement of all reinforcing elements. Estimated mass of the reinforcing paper in grams (not including facing material or tape).

Formatting requirements:

- e. Poster board dimensions are the standard 36 in. by 48 in.

Posters will be judged at captains' meeting by a panel of practicing engineers and professors. Judging will consider reasonableness of design equations, material properties, factors of safety, and assumptions. "Trial and error" designs will be heavily penalized. In addition, presentation and theme of the poster will be taken account. The judging rubric is presented in Appendix B.

4. **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 are encouraged. The sandbox shall be made up of a bottom and three fixed vertical sides. The fourth side, also vertical, must be a removable facing panel that serves as the temporary form against which the MSE wall is constructed. The sandbox will also include two PVC piles used to apply the horizontal load. Dimension of the box are shown in Figures 1 through 3. The sandbox will meet the following requirements
 - a. Have exterior walls and base constructed of standard $\frac{3}{4}$ -inch A-C grade plywood.
 - b. Have planar inside surfaces.

- c. Removable facing panel will be flush with the front of the box and held in place with threaded inserts, screws or other easily removable fasteners.
- d. Include a steel tie rod designed to keep the two fixed sides of the box parallel after removal of the facing panel.
- e. Include circular guides to ensure bases of piles are held in the correct location. A temporary template may be used to control alignment of the top of the piles. Any templates used must be removed after wall construction and before testing.
- f. All dimensions of the sandbox shall be as shown in Figures 1 and 2.

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.

- 5. **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. See Figure 1 for pile locations and length requirements.
- 6. **Backfill Sand**- The backfill material will be clean, dry sand provided by the host school at the competition site. The sand selected for use is **Oglebay-Norton #12 Blastsand**. Sand specifications are shown in Table 1, and Figure 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 the specified sand is provided. In the event the specified sand cannot be provided at the location and time of the competition, substitute sand will be provided. Teams will be allowed to examine a sample of the competition sand at the captains meeting. No quantitative measurements beyond determination of the angle of repose will be allowed. No samples may be removed from the meeting room. Teams may modify their wall design at this time if they desire. See paragraph 10 below.

- 7. **Wall Materials** – Materials will be provided by competition organizers on site. See Appendix A for detailed specifications.
 - a. **Facing** - Poster board. See Figure 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" × 24".
 - c. **Reinforcement Attachment to Facing** – Heavy duty polypropylene packaging tape, 2" wide.
- 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. Cardboard or poster board templates.

- e. Manually operated cutting instruments (e.g., scissors, utility knives, razor blades, hole punch)
- f. Cutting boards or mats
- g. Design notes, calculations and drawings
- h. Compaction tools consisting of any hand operated devices with no moving parts.
- i. Screwdrivers (battery operated drills or screwdrivers may be used, but only to remove fasteners when removing the facing panel)
- j. 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.

Scoops, buckets and shovels will be provided by the competition organizers. It may be necessary for teams to haul sand a distance up to 20 feet.

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" × 24". 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 single sheet of poster-board (22" × 28") 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 Figure 5.

Tape may be used only to attach reinforcement to wall facing. Tape must be used in individual pieces no larger than 2" × 2". 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 wall facing in the vertical plane of the wall facing (not on the wings or bottom of the facing). 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.

The wall should be trial-fitted to the sandbox during this stage. Any portion of the wall which rises more than ¼" above the top of the sandbox must be trimmed off. The assembly stage is complete when the facing material is properly folded and trimmed, and all the reinforcing elements are attached to the facing. No sand is added to the box in this stage. Fifteen (15) 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 installs

their wall in the sandbox, places the piles, fills the box with sand to within one (1) inch of the top of the box places the horizontal loading frame in the piles, 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 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 is level and within one (1) inch of the top of the box, any temporary templates have been removed, the horizontal loading frame is in place, and the empty vertical surcharge loading bucket is in place. Twenty (20) minutes will be allotted for this stage. At the end of the phase, judges will check fill and pile placement to ensure they meet requirements.

- d. **Loading Stage** – This stage occurs in three steps: 1) removal of front panel, 2) placement of vertical surcharge, and 3) removal of vertical surcharge and placement of horizontal surcharge. During each step the wall will be checked for the following three criteria: 1) excessive deformation (any portion of the wall extending outside of the 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. Catastrophic failure will disqualify the team.
- i. When directed by judge, the team shall remove the front panel of the sandbox. After the panel is 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 remove the vertical surcharge load, hang an empty 5 gallon bucket on the loading frame and place 25 lbs of sand in the bucket. The team will have one (1) minute to complete this loading sequence. After the sequence is complete, the judge will wait one (1) minute and then check the three criteria. The horizontal load frame will be provided by the competition organizers. Teams should not bring their own load frames to the competition.

10. **Design Changes** – Teams may change their design between the time the design poster is presented and the wall is tested. The official mass of the reinforcing material used for scoring will be computed as the greater of a) the average of the mass reported in the design poster and the mass actually used or b) the mass actually used.

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

$$Score = R + 16(13 - M) - 5(N_{\min}) - 25(N_{\max}) - 2(T) - 20(D) \quad (1)$$

Where

- R = poster score out of 50 points
- M = official 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 = deflection rating
 - 3 if wall fails deflection criterion during initial loading without surcharge
 - 2 if wall fails deflection criterion during vertical surcharge loading
 - 1 if wall fails deflection criterion during horizontal surcharge loading
 - 0 if wall passes deflection criterion for all loading phases

a. **Minor Penalties**

- i. Box dimension out of spec
- ii. Pile location out of spec
- iii. 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. Improper use of adhesive tape
- 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 send a representative to the pre-competition captains' meeting (time and location TBD.)
- ii. Catastrophic wall failure
- iii. Unsafe practices
- iv. Design or construction techniques which violate the spirit of the competition and provide an large and unfair advantage

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 reinforcement mass, 2) higher poster score, 3) lowest deflection rating, 4) 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. Decisions of the head judge are final.

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

- Poster Score: 38/50, $R = 38$
- Design poster specifies 7.44 g. Reinforcement used, 6.42g.

$$M = \frac{7.44 + 6.42}{2} = 6.93$$

- Minor deductions for tape overlapping on wall face and pile misalignment, $N_{min} = 2$
- One major deduction for leakage of more than 30 cm³ of sand out of box, $N_{maj} = 1$
- Execution times were
 - Reinforcement fabrication: 15:18 (18 sec over allotted time)
 - Wall assembly: 16:05 (1:05 over allotted time)
 - Construction: 18:27 (under allotted time)
 - Total time over: 1:23, $T = 2$

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 two loading phases but failed during third loading phase, $D = 1$

Using equation 1, the final score would be

$$\begin{aligned} \text{Score} &= 38 + 16(13 - 6.93) - 5(2) - 25(1) - 2(2) - 20(1) \\ &= 76.12 \end{aligned}$$

See Appendix C for scoring checklists.

12. **Pre-Competition Team Captains' Meeting** – A team captains' meeting will be held Friday March 23th 2012 from **6:00 pm – 8:15 pm at Shilo Inn Hotel** in the city of Pomona for the purposes of: grading posters, checking sandboxes for compliance, establishing competition order, and disseminating any logistical or administrative information. **This is a MANDATORY meeting, and teams will be assigned a specific time to attend within the meeting time range.** Each team must have the team captain (or designee) present. All team members are encouraged to attend. 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 the beginning of competition to correct any compliance issues identified during the captains' meeting.