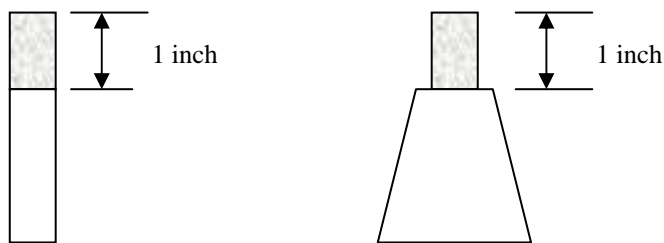


2008 Great Lakes Regional Conference GEOTECHNICAL COMPETITION

1. The objective of the geotechnical competition is to design and build a miniature reinforced earth (MSE) retaining wall using paper reinforcement taped to a poster-paper wall facing. (See photo under “Tips”). Design competition is to use the least area of paper strips and sustain a “footing” load of 50 lbs. placed on an 8” x 8” wood footing located 3 inches behind the wall top.
2. Only one team per school will be allowed to compete. A team consists of a maximum of 4 people.
3. During the competition, an apparatus hereafter referred to as the sandbox will be used. The sandbox has a bottom and three vertical sides; the constructed retaining wall will form the fourth vertical side. Essentially the box is 18” wide x 27.50” long x 16.75” high. The host school will fabricate and provide the plywood sandboxes for the competition.
4. The backfill material will be a clean sand provided by the host University. The backfill material must be used as is; no water, additives, or chemical stabilizers may be placed in the backfill material. Properties of the sand are given in Table 1.
5. Reinforcing materials and construction tools will be provided by host University. Descriptions and samples of the reinforcing materials are provided in Table 2 and on the following pages. Available tools are listed in Table 3.
6. Teams are expected to have design parameters and wall designs completed prior to arriving at the host University for competition. Most importantly, the area of reinforcement paper used must be clearly calculated and given. For example MSE walls are traditionally designed for (1) breakage, and (2) pullout., where $FS_{\text{breakage}} = (\text{Strength of reinforcing strip}) / (\text{Horizontal thrust})$, and $FS_{\text{pullout}} = (\text{Frictional Resistance}) / (\text{Horizontal thrust})$. See Das *“Principles of Foundation Engineering 4th Ed.”* page 431.and 447.
 - a. An extra one-inch should be provided on the strip length in order to tape the reinforcement strip to the poster-paper wall. This extra one-inch is included in the total reinforcement paper area.



- b. The poster-paper wall will be furnished by the host University. It will be $18 + 4 = 22$ inches wide and 16-inches tall. The extra 4-inches in width are to form 2-inch “wing-walls” on each side to retain the sand between the plywood box and poster-paper.

7. Construction of the reinforced earth retaining wall will proceed in two stages: 1) assembly of the reinforcing materials and 2) placement of the reinforcement and backfilling.
8. Each team will request a rectangular amount of reinforcement paper sufficient to fabricate the reinforcement strips for the entire wall including 1-inch attachment area. This amount should have been predetermined under (6). This amount of rectangular paper will be entered on the scoring sheet.
9. Each team will be **timed** to cut the paper reinforcement strips, and attach to the poster-paper facing. This must be assembled at the time of the competition using **only** the materials and tools provided by the host University. Use of templates is allowed.
10. After assembly, each team will be **timed** for the placing of the reinforcement in the sandbox, backfilling and positioning the loading plate as shown on the sandbox construction plans.
11. No anchoring of the reinforcing materials directly to the sandbox apparatus or modifying of the paper strips in any way will be permitted.
12. After the construction period has elapsed, the trap door of the sandbox will be opened by one of the participating team members.
13. After a stabilization period of 1 minute, incremental loading by slowly pouring sand into a 5-gal. plastic bucket placed on the 8" x 8" wood "footing" will proceed until a total footing load of 50 lbs is achieved. A stabilization period of not less than 1 minute will elapse between loadings. To be considered successful at a given surcharge level, the wall must not fail during the 1 minute stabilization period.
14. Failure of the wall will be declared after any section of the wall or reinforcing materials bulges or protrudes more than 1½" horizontally from the original plane of the wall.
15. Scoring will be based upon the least amount of paper reinforcement stock. Two sq. inches will be added for for each minute of assembly time exceeding 35 minutes. Two sq. inches will be added for each minute of construction times exceeding 30 minutes.
 - a The team with the least amount of paper wins. In the event that all competing walls fail prior to achieving the 50 lb. surcharge load, a multiplication factor = $1 + [(50 \text{ lbs.} - \text{failure load}) \div (50 \text{ lbs})]$ will be applied to the area of paper used. For example, Team A's wall used 100 in² and failed with a surcharge of 35 lbs., the calculated area would be $(1 + \frac{50 - 35}{50}) \times 100 = 130 \text{ in}^2$

16. Two completed registration sheets from each participating school must be submitted prior to the start of competition. The registration sheet will contain the following information:

- A. Name of School
- B. Competing Members Names
- C. Detailed Reinforcement Design Dimensions

a Failure to supply the requested information prior to the start of competition will result in disqualification from the competition. Failure to strictly adhere to the submitted retaining wall design will result in disqualification from the competition.

17. If the judges feel that any team has deliberately tried to violate the spirit of the competition, the judges may disqualify that team, and the team will receive 0 points.

Tables 1 , 2, and 3

Table 1: Soil Properties

Description:
 Light brown sand with subangular to rounded particles.

Direct Shear:
 $\phi_{\text{peak}} = 40^\circ$
 $c = 0$ (assumed)

Sieve Analysis:

Sieve (#)	% Passing (%)
4	99.4
10	97.8
20	84.4
30	75.4
40	52.1
60	21.4
100	3.6
200	0.1
Pan	-

Table 2: Reinforcing Materials

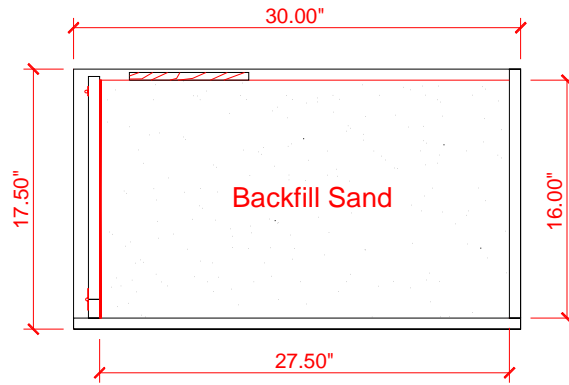
-
1. 6-ply paperboard (t = 0.045 cm)
 2. Kraft wrapping paper
 3. 3M® packaging strapping tape
-

Table 3: Construction Tools

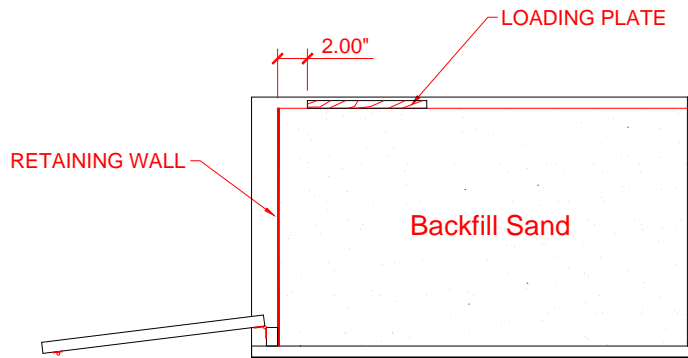
-
1. Pencil
 2. Razor knife
 3. Scissors
 4. Straight edge
 5. 1-quart scoop
 6. 5-gallon bucket
-

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RETAINING WALL SANDBOX DESIGN



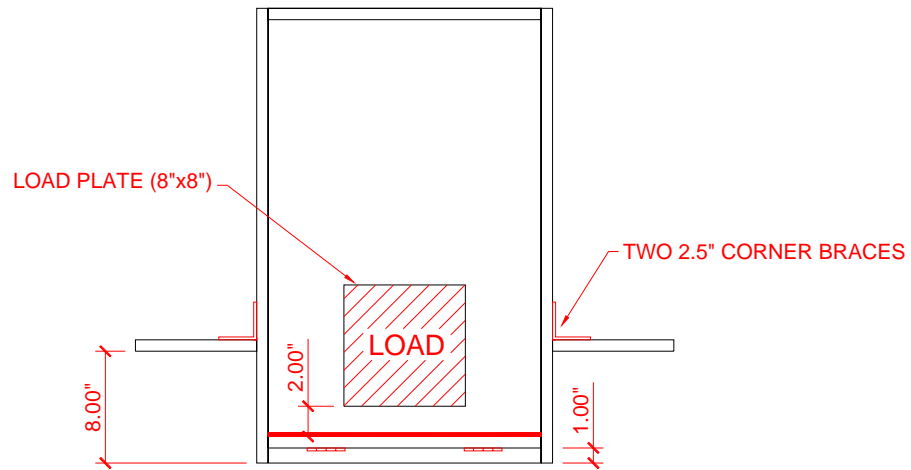
SIDE VIEW SECTION WITH TRAP DOOR CLOSED



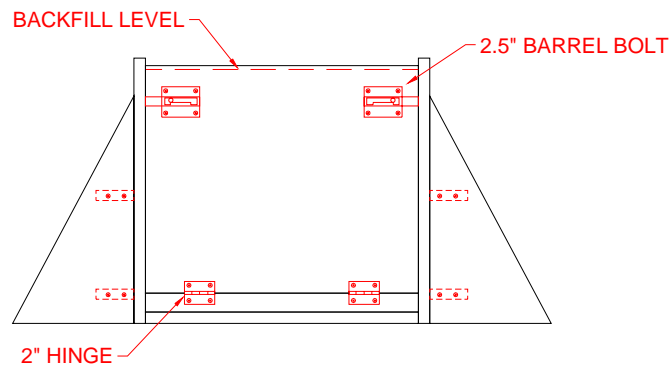
SIDE VIEW SECTION WITH TRAP DOOR OPEN

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RETAINING WALL SANDBOX DESIGN



SANDBOX TOP VIEW



SANDBOX FRONT VIEW

SCORE SHEET

Name of University _____

Name of Team Captain _____

A. Reinforcement Paper Quantity

Quantity of paper used ----- _____ inches²

B. Wall Assembly Speed and Time Penalties

Clock time = _____ minutes

minus 35 minutes = _____ minutes times two inch² = + _____ inches²

C. Wall Construction Speed and Time Penalties

Clock time = _____ minutes

minus 30 minutes = _____ minutes times two inch² = + _____ inches²

D. Total paper area used

_____ inches²

Materials

The material chosen for the strip material was selected based on the availability of the product. The material chosen was Pacon Spectra® ArtKraft found at Office Depot. The roll is 4-feet wide.

The material used for the wall face was chosen to be poster board. This selection was mainly due to prior experience building paper walls. Poster board is cheap and accessible at a variety of retail stores. The material is strong enough to perform adequately while still placing the design emphasis on the paper strips.

Tips for Design Teams

Realize that the intent of the competition is to foster engineering design team-work and sportsmanship. The competition rewards innovative engineering in minimizing the amount of reinforcement, but maintains practicality in assembly and construction times. That is, a wall with 100 reinforcement strips may have the smallest area, but assembly and construction times are not practical.

1. The engineering variables deal with the (a) strength and (b) frictional resistance of the strips. Both of which, are controlled by the reinforcement strip area. However, all strips are not required to have the same geometry. That is, long narrow strips may best resist frictional pullout near the top of the wall, while short wide strips may be needed at the base to resist greater breakage forces.
2. Strip geometry should consider assembly time for cutting strips. Prepare a template for cutting reinforcement strips
3. The top layer and bottom layer of strips should be about 1-2 inches from edge of poster-paper wall.
4. Consider a template for marking strip location of the poster-paper wall for ease in location and taping.
5. During construction apply a slight tension to the paper reinforcing strips and pour the sand directly on the strip to anchor with tension.

Wall Construction

The construction of the wall required several considerations in order to avoid premature failure. The strips were attached to the wall by leaving an extra one-inch of strip material on which the tape will connect the strip to the wall. This will ensure that no tape will be used on the portion of the strip that is perpendicular to the wall. The strips were first measured and carefully cut to achieve the dimensions called for in the design. The wall assembly began with the layout of the poster board with the strip positions marked. The strips were then positioned and taped.



The wall above was considerably oversized and held a surcharge of 265lbs and did not fail. Following conventional theory, the wall was designed to a factor of safety of (1) for a surcharge of 50 lbs. However, judgement underestimated the soil properties which lead to this very conservative design.