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Adding Excitement to Soils: A Geotechnical Student Design Competition*

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Undergraduate soil mechanics/engineering/design can be made more interesting by appealing to students' team spirit and competitive nature. A scale-model Mechanically Stabilized Backfill (MSB) wall design/build competition has been developed and tested that generates enthusiasm, engages students in teams, implements design, and teaches about soils engineering. The competition has been used in local, regional and national competitions in the US with much success. The processes followed to develop the MSB wall competition can be adapted for use in other engineering education disciplines.

Keywords: competition; design; geotechnical.

INTRODUCTION

THIS PAPER OUTLINES a new tool for engaging the interests of and teaching students in civil engineering curricula, particularly in geotechnical engineering. There is a need to encourage students to enter and stay in civil engineering curricula. US engineering enrollments are increasing, as are demands for engineers [5]. However, Bachelor of Science civil engineering enrollments are down as much as 17% from 1996–2001 [5]. Environmental engineering B.Sc. degrees are down 50% in the same period. Population growth, demographic shifts, infrastructure rehabilitation and environmental protection demand more civil engineers [5, 12, 15]. Globally, engineering education requirements are becoming more stringent [13]. It is particularly important to attract quality students to the profession. At present there is a strong need for more geotechnical engineers [10, 14, 18, 9].

Various professional organizations (American Society of Civil Engineers, American Society of Engineering Education, Women in Engineering Programs & Advocates Network, US National Society of Professional Engineers, and others) encourage students to consider engineering as a college major [8, 16, 17]. Retention is an equally large issue.

By its nature, civil engineering undergraduate curricula, particularly the geotechnical component, must include what would be considered today as low-tech experiences, because they are necessary to learn the basics. Undergraduate laboratory exercises in soil mechanics—covering soil classification, compressibility, shear, and fluid flow through soils—are typically deterministic and strictly controlled so that expected outcomes can be assured. The straightforward nature of the experiments can cause students to lose sight of the excitement associated with the design experience essential to civil engineering practice. Unfortunately, students miss the most interesting part of geotechnical engineering—the tremendous degree of judgment required for successful practice, in the face of uncertainties in engineering with natural materials.

The Mechanically Stabilized Backfill (MSB) Wall Competition, described below, helps with all these issues. The competition builds on student experiences in an ordinary civil engineering soils lab, incorporating elements of:

- Theoretical soil mechanics
- Design
- Optimization
- Creativity
- Teamwork
- Written communication

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Moreover, through these elements the MSB wall competition fulfills some criteria of the US Accreditation Board for Engineering and Technology (ABET) [1], the Japanese Board for Accrediting Engineering Education [11], the Engineers Australia Accreditation Board [7] and others.

DEVELOPMENT OF THE MSB WALL COMPETITION

Background

The American Society of Civil Engineers (ASCE) Board of Governors of the Geo-Institute created an ad hoc committee in 2001 to develop a national geotechnical civil engineering student competition akin to other nationwide ASCE competitions.

Historically, geotechnical events have been largely absent from regional ASCE student competitions. The few regions that included a geotechnical event usually changed it completely from year to year, requiring reinvention by the host institution. As a result, the event does not garner much attention. The Geo-Institute governors saw an opportunity to enhance the profile of geotechnical engineering among civil engineering students by promoting the development of a fun, carefully conceived geo-activity for the regional competitions. Ultimately, the regional winners would compete for the national championship.

The Geo-Institute governors charged the Task Force

"To develop and promote a student geo-event to be held at all regional ASCE Student Conferences. The committee is to locate appropriate industrial sponsorship for the event, and to work with appropriate staff at ASCE to institutionalize the geo-event at all annual regional ASCE student conferences. The event is intended to be analogous to the Concrete Canoe activity."

Regional competitions are popular in the US. It's common to have over 25 schools compete at a single regional competition, involving hundreds of students at all levels, from freshman to senior. Results of these competitions are recorded on various websites [e.g. 2, 3, 19, 20].

Competition goals

Besides geotechnical criteria, the competition would address areas that have historically been underemphasized in the typical undergraduate experience. ABET, the US national accreditation organization, and ASCE, the US national civil engineering society, responded to industry needs by mandating an increasing emphasis on teamwork, communication, and design [1]. In recent years, some US curricula have been found to be deficient in these critical areas, leaving students underprepared for typical civil engineering consulting/construction practice. Skills in communication and experience with the design process are particularly critical for professional success.

The new competition would include the following elements:

- Analysis
- Design
- Teamwork
- Competitiveness (cost and time)
- Communication

This combination would provide motivation and foster technical and practical learning.

Other competition criteria were developed and these are given in Table 1.

Table 1. Competition criteria

Other practical criteria	Reason for Criteria
Must be creative	Creativity interests students. This is what draws students to compete.
Require a team (cannot be done alone)	The teambuilding experience is essential. If the competition can be done alone, the teamwork aspect is lost.
Must be readily practiced locally, in advance of the regional competition	Teambuilding takes place during the practice leading to the competition. A competition that requires a certain locale or materials prevents engagement during the time leading up to the competition, or can give one team an unfair advantage over others.
Must be easily understood	A complicated activity (in terms of materials, performance, and construction) precludes many from entering due to excessive cost or time constraints, and detracts from fundamental goals. Simpler is better. This also reduces chances that teams will disqualify on technicalities, a demotivator.
Must be unambiguous, easy to judge; must promote creative solutions while minimizing opportunities for cheating/misinterpretation	The more the judge has to measure complicated things, or make exacting measurements, or, worse, interpret the results, the more opportunity for students to become disillusioned.
Must have rules "tight" enough that the designs are competitive (no one design would outstrip the others).	If the rules are too "loose" (allowing wildly varying designs), the air of competition (and excitement) is lost.
Must not be excessively time-consuming	Student time is limited; students might opt out of competing if the preparation is too time-consuming.
Must be challenging and address an interesting and meaningful problem	Adequate challenge is required to inspire and engage the students and to enhance the status of geotechnical engineering in their view.

Development team

The ad hoc committee consisted of six experienced geotechnical engineering teachers/researchers from US universities. Committee members were chosen based on experience, enthusiasm and ability to implement the competition at their own schools. Most had experience with ASCE regional student competitions.

CHOICE OF COMPETITION

The committee chose an MSB wall competition. An MSB wall is, simply, a pile of soil constructed with interleaving layers of reinforcement. In civil engineering practice, layers of plastic geotextile or plastic geogrid or metal are used. These take tensile forces, allowing the soil to stand almost vertically, instead of standing at the angle of repose which would happen otherwise. The resulting pile is very strong. Demonstration piles of reinforced soil, only about 0.15 m^3, hold 1000 kg easily (Figs. 1, 2). This is very impressive and catches student attention, making it excellent for this competition.

MSB is not new. The Chinese used this principle in the Great Wall, over 2600 years ago (shown in Fig. 3). Henri Vidal [21] is credited with reintroducing this principle in the late 1960s. MSB walls are widely used today.

THE RULES

The complete competition rules, given in Appendix A, are summarized here. The students construct an MSB wall with sand, kraft paper reinforcement and a cardboard face, inside an open-topped wooden box with one removable side. The students build the wall with the removable side in place. The cardboard face rests against the removable side, and the paper reinforcing strips are attached to it with tape. Sand is added; the paper reinforcement is interleaved. After construction, the removable side is removed to reveal the cardboard face with soil and paper backfill. Teams compete to build a wall adequate to hold a 23 kg design load in the shortest period of time.

In addition, teams must submit a report explaining the logic behind the design. The final score for each team is the sum of the technical paper score and the wall construction score.

MSB-wall draft rules were tested at the University of Florida, Lafayette College and the University of Alabama. Those experiences led to rule modifications including:

- engineering report presentation (more detailed);
- plywood box dimensions (larger);
- reinforcement of side walls of plywood form to prevent lateral deformation;
- type of sand used;
- the use of trapdoor pins instead of hinges (easier to use); and
- tie-breaking rules involving the surcharge weight (load to failure to determine winner).

Fig. 1. Unreinforced soil.

Fig. 2. Reinforced soil.

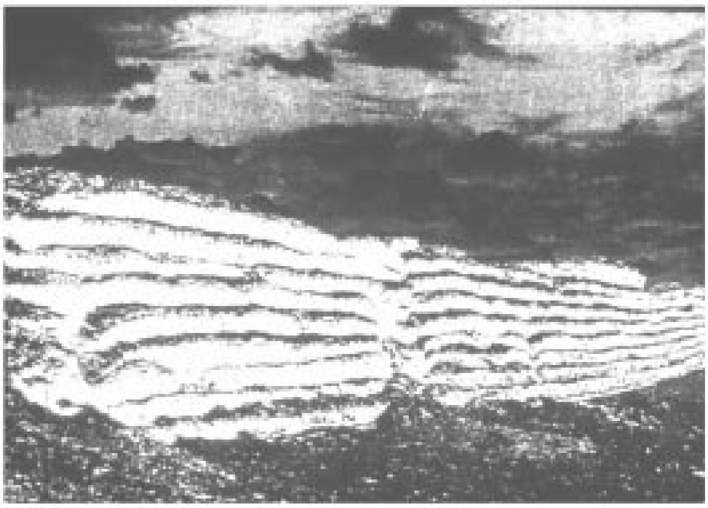

Fig. 3. Great Wall of China.

Fig. 4. The construction steps, and loading. (l to r) Cutting the paper, building the wall, loading the wall.

JUDGING THE COMPETITION

Two activities are judged: the report and the wall construction per se.

The report is judged on technical merit, adherence to guidelines (length, etc.), clarity of presentation, and English composition. The project description, basis for design, final design, use of figures and overall quality were judged subjectively by four judges from academia, industry and government. Forty points were awarded to a perfect paper. The judges' average score was reported for each team.

Wall construction was judged objectively. Points were awarded for the amount of paper reinforcement used (less is better), speed in assembly and loading (faster is better), and capacity to sustain the specified design load without failure. "Failure" consisted of wall movement beyond the edge of the open side of the box. This was determined by sliding a straightedge along the box. If the straightedge touched the cardboard face, failure had occurred. This simple method was chosen to reduce disputes.

The judging forms are in Appendices B and C.

NATIONAL COMPETITION

The MSB wall competition was conducted nationally at the ASCE Geo-Institute GeoFrontiers conference in January 2005 in Austin, Texas, which was attended by over 1800 professionals. An open invitation went to US campuses, by email, to submit proposals to participate. The request for proposals and competition rules were posted on the ASCE website, and sent to almost all US geotechnical faculty through the United States University Council on Geotechnical Education and Research listserver. This listserver services about 95% of US geotechnical faculty.

Proposals from each team included a team name and slogan, the list of team members (maximum four), team qualifications (maximum 500-word essay), a letter of support from the department head including additional financial support if needed, and the impact of the competition on the school (maximum 500-word essay). These proposals were sent to four judges who ranked the proposals on the basis of their qualifications and the impact statement.

Sixteen teams applied. The five finalists were the

University of Idaho, the University of Missouri—Columbia, the University of Toledo, Washington State University, and the University of Texas at Austin. The teams were sent samples of the sand to be used in the competition, and subsequently submitted design reports.

There was great creativity in preparation and design methods. Most teams measured soil friction angles and some measured kraft paper tensile strength. Design procedures ranged from empirical testing to finite element analysis. Key variables were length, width and number of paper strips, placement of strips on the face, and means of attachment to the face. A panel of judges rated the design reports.

The competition was held outdoors in the conference exhibits area, creating a synergistic audience draw from the convention hall, a block away. Care was taken to publicize the competition before and during the conference to stimulate audience interest.

A graduate student from the host university handled contest logistics and general trouble-shooting. The competing teams specified in advance the amount of paper they would use (as a part of the design process). The amount was kept confidential until competition day, when it was posted on a "leader board" at the competition site. The competition proceeded in two phases: preparation of materials, and wall construction. Each phase was timed. The students used their own approved tools to cut the paper and assemble the reinforcing materials. All other materials were provided by the organizers. This phase took less than five minutes. The teams then constructed the wall using sand and the reinforcing paper. A separate judge watched, timed and made measurements for each team. This phase took less than fifteen minutes. When the judge signaled, the team members removed one side of the box. This was the first test of the designs. The Idaho team's wall failed catastrophically.

The remaining four teams loaded their walls with sand-filled buckets. The judges measured the weight of the buckets and checked wall movement. The University of Texas—Austin wall failed by excessive deflection. The three remaining teams passed the loading phase. The competition was now officially over. However, in the interest of entertainment, the walls were overloaded with soil and students until all failed.

While the simple score sheet allowed the winners to be announced immediately, in this case the winners were announced at the conference banquet, when prizes were awarded. The University of Missouri—Columbia team won the competition, with a score of 162 points. The runner-up team scored 149. Team scores ranged upwards from 97. Kudos went to runner-up Washington State University. The winners received a plaque and complimentary registration at an upcoming geosynthetics conference.

SPONSORSHIP

The conference organizers enlisted corporate sponsors who paid for travel, accommodation, T-shirts, complimentary conference registrations for all of the students participating and their faculty advisors, and materials and equipment for the competition. Sponsors were listed at the event site, and on competitor T-shirts.

EVALUATION

The effectiveness of the national competition in meeting the goals outlined above was evaluated by post-competition survey.

Methods

A follow-up survey was sent to all participating students ($n = 20$) and faculty ($n = 6$) to gather information about the participants and feedback about the competition. All information was provided anonymously, to ensure confidentiality.

Sample

Thirteen students and five faculty advisors responded to the survey. Table 2 is a summary of sample demographics. The typical student participant was male (76.9%), Caucasian (69.2%), and enrolled as an engineering student (69.2%). Students' ages ranged from 20 to 41 with a mean of 25.31. The typical faculty member was also male (83.3%) and Caucasian (83.3%), while the current position held was bimodal (33.3% Assistant Professor and 33.3% Professor).

Perceptions of the competition

Table 3 is a summary of participant perceptions. Reliability analysis yielded support for the internal consistency of these twelve items (Cronbach's alpha = 0.800 [4]). A comparison of the two groups failed to conclude significant differences in attitudes toward the competition ($t = 0.940$, $p = 0.360$). Overall, participants were very positive, with average responses to 9 of the 12 items at 4.0 or higher (on a 5-point scale) for both students and faculty. Overwhelmingly, both groups enjoyed the competition and wanted to participate again. Participants indicated that the competition challenged students' technical skills, improved their technical expertise, developed an appreciation for teamwork and time management, built camaraderie and leadership ability, and fostered continued interest in engineering. Analysis and design criteria were not polled, though these important items will be included in future evaluations. The criteria in Table 1 were largely met.

How did students and teams prepare for the competition?

Students described their preparation in a very similar manner. This preparation included brainstorming and designing sessions and lots of prac-

Table 2. Sample characteristics

	Students (n = 13) N (Percent)	Faculty (n = 6) N (Percent)
Gender		
Male	10 (76.9)	5 (83.3)
Female	3 (23.1)	
Not Reported		1 (16.7)
Ethnicity		
Caucasian American	9 (69.2)	5 (83.3)
Latino/American	4 (30.8)	1 (16.7)
Current Position		
Student	9 (69.2)	
Engineer	3 (23.1)	
Both student and engineer	1 (7.7)	
Assistant Professor		2 (33.3)
Associate Professor		1 (16.7)
Full Professor		2 (33.3)
Not Reported		1 (16.7)
Age	Mean = 25.31 SD = 6.1 Range 20–41	

tice testing out their ideas and designs. Of the thirteen students, five emphasized the importance of brainstorming with other students and the faculty advisor, while eight identified a consistent routine of trial-and-error experimentation.

Five of six faculty assumed the role of a resource person, providing students with the resources they needed to get started. These resources included relevant research literature, materials, and technical guidance. Two faculty members specifically mentioned reviewing alternative wall plans in a theory class and one of these faculty described his/her role as an active design and building member of the team. All faculty viewed this competition (and preparation for it) as a great learning experience. When something didn't work, they saw it as an opportunity to figure out why and modify their design.

What were the greatest benefits of the competition?

Getting the opportunity to learn and apply their skills to a design situation was identified as the greatest benefit of the competition. This benefit was suggested by eight of the thirteen students and five of the six faculty members. Other benefits primarily regarded opportunities to interact and work with others as four students identified the interactions with other students and three said they benefited from networking with professionals. Both these interaction benefits were also suggested by two of the faculty members. Furthermore, three faculty members indicated that some of their students expressed an interest in becoming geotechnical engineers as one student obtained an undergraduate research fellowship and another a summer position at a geotechnical firm.

How can the competition be improved?

Generally, faculty expressed their support for future competitions with one faculty member stating "Just do it again." Faculty were very pleased with the competition and primarily suggested ways to expand it. Three faculty members expressed a desire to have more teams participate, perhaps even regional competitions. They also recognized the expenses involved, but thought that depart-

Table 3. Perceptions of the wall competition

	Students (N = 13) Mean (SD)	Faculty (N = 6) Mean (SD)
I (My students) enjoyed the competition.	4.85 (0.376)	4.67 (0.516)
I would like to participate again.	4.62 (0.506)	5.00 (0.000)
The competition fostered a continued interest in a career in engineering.	4.54 (0.660)	4.33 (0.516)
The competition challenged my (students) technical skills.	4.31 (0.630)	4.50 (0.548)
My (students') technical expertise improved as a result of this competition.	4.23 (0.439)	4.50 (0.837)
The competition/experience helped me (my students) develop a sense of camaraderie with team members.	4.23 (0.599)	4.33 (0.516)
I (My students) gained an appreciation for time management by having this competition timed.	4.08 (0.760)	4.67 (0.516)
The competition helped me (my students) develop an appreciation for teamwork.	4.00 (0.816)	4.33 (0.516)
I (My students) developed leadership skills as a result of this competition/experience.	4.00 (0.816)	4.00 (0.000)
I (My students) established valuable professional contacts when attending the GeoFrontiers Conference.	3.77 (0.832)	3.83 (1.17)
The competition helped me (my students) develop better writing skills.	3.69 (0.751)	3.67 (0.516)
Participation in this competition helped (or will help) me (my students) get a job in the field.	3.31 (0.751)	3.67 (0.516)

ment heads, deans, and industry would be able to help. One faculty member suggested including a poster presentation component for students to prepare while another faculty member thought faculty should stay out of it and have graduate students lead teams. Finally, one faculty member indicated that the description of the types of materials used in the competition could be clearer so that teams could better prepare.

LESSONS LEARNED

Several lessons were learned from this competition:

1. The committee approach to rule development worked, and was essential to the speedy development of the competition.
2. The format generated student excitement.
3. The rules are essentially complete—no major problems were found, although suggestions for improvement surfaced. The competition was keen. There were large variations in the design and construction procedures, which were desired.
4. The students enjoyed the competition.
5. Use of multifaceted judging was vindicated. Several teams were very close in the construction phase. The criteria provided adequate means to rank the teams.
6. Limit team memberships to either undergraduate or graduate students. The only all-graduate student team won, perhaps because of extra training.
7. Consider modifying the rules so that the team loses points if the wall is over-designed.
8. Consider computer or other modeling of the wall as part of the design procedure.
9. Consider modifying the rules to reduce emphasis on speed and increase emphasis on quality design and construction.

MODELS FOR THE FUTURE

The MSB wall competition experience can be adapted for other venues, including

- Middle and high-school competitions (no formal engineering training needed)
- Student recruitment demonstrations
- Undergraduate, introduction to engineering classes
- Non-conference competitions

The model rules, in Appendix A, can be adapted to other competitions. The key elements of successful competition (given in Table 1) have broad applicability.

CONCLUSIONS

The MSB wall competition, used in several venues, has been found to engage students in civil engineering. The use of committees to develop rules is useful and effective. The multifaceted rules containing analysis, design, competition, communication, and teamwork created an environment to achieve a useful, fun and productive experience. The use of objective and subjective judging was effective.

The evaluation indicated that the competition was a success. Both faculty and student participants enjoyed the competition and were eager to participate again. Both groups expressed very positive feedback, indicating that the competition had an impact on technical and leadership abilities. Participants also viewed the competition as an opportunity to develop an appreciation for teamwork and time management, build camaraderie and foster a continued interest in engineering.

The current rules, in Appendix A, are expected to be refined with experience to improve the event, add variety, and to keep the competition from becoming stale.

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APPENDIX A. MSB Competition Rules

Overview

Four teams from ABET accredited institutions will be selected to compete in a competition to be held on January 25, 2005 at the Geo-Frontiers conference in Austin, Texas. Each team will design and build a mechanically stabilized earth wall. Walls will be judged based on the wall's ability to hold a known surcharge load, efficient use of reinforcing material, efficient construction methods, and a summary report documenting the wall design process.

Selection of teams

Any team from an ABET accredited institution may apply for the competition. Each application must include the following:

- Team name and slogan
- List of team members
- Team qualifications (maximum 500 word essay)
- Impact of competition on school (maximum 500 word essay)
- Letter of support from department head (including additional financial support if needed).

Applications must be sent to the address shown below and must be received by October 15, 2004. Dr. Mary Roth, Department of Civil and Environmental Engineering, Lafayette College, Easton, Pennsylvania 18042.

Teams will be notified of their acceptance by November 1, 2004. Selected teams will receive the following:

- Travel funds (up to a maximum of $2000 USD per team)
- Free conference registration for each team member and the team's faculty advisor.

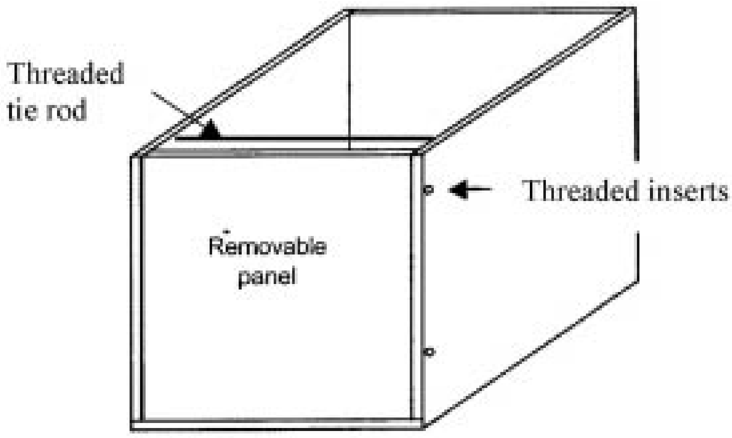

Fig. A1. Schematic of plywood sandbox: front view.

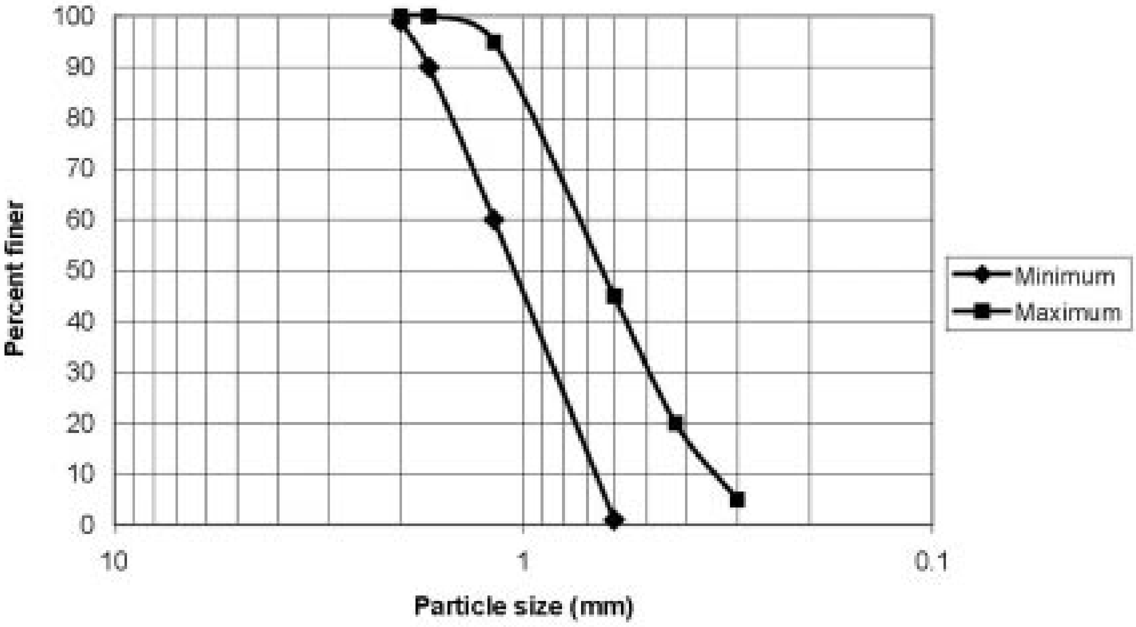

Fig. A2. Particle size distribution curve for blasting sand.

Sandbox

The wall will be built inside an apparatus referred to as the "sandbox". Each team will be supplied with a sandbox at the competition. The sandbox has a bottom and three fixed, vertical sides. The fourth side, also vertical, is a removable panel that serves as the temporary form against which the reinforced wall is constructed. The box is made from standard 19 mm "A-C" type plywood, with the "A"-side to the inside. The inside dimensions of the box are 45 cm wide, 45 cm high, and 66 cm long. The inside surfaces are planar. The removable panel is flush with the front of the box. The removable panel is held in place with threaded inserts and thumbscrews. When the panel is removed, the two fixed parallel sides of the box are held in place by a threaded tie rod located 2.5 cm below the top of the box and 2.5 cm back from the inside face of the removable panel. A conceptual sandbox layout is illustrated in Figure A1.

Notes:

a. No fastener, attachment, or other part of the box can protrude beyond its front or top.
b. The inside surface of the box may not be textured or altered in any way.

Backfill material

The backfill material will be dry, medium blasting sand. The range of particle size distribution that can be expected is shown in Figure A2. Four kilogram samples of the sand will be sent to each of the competing teams. The same material will be used as ballast to apply the design load.

Table A1. Reinforcing materials construction

MSB Wall Component	Material
Facing	Poster board, standard grade, 43 x 56 cm; one sheet
Soil reinforcement	Kraft paper, standard grade, 76 cm wide roll; each team will specify the length needed for their design by January 17, 2005
Reinforcement—facing attachment	Packaging tape or carton-sealing tape, standard grade, 4.8 cm wide

Reinforcing materials

The reinforcing materials are specified in Table A1.

Construction tools

Each team provides its own construction tools. Permitted tools are pencils, pens, markers, rulers, straight edges, cardboard or poster board templates, scissors, razor knives, and rulers. Quantities of these materials will not be restricted. **Scoops, buckets, and shovels will be provided at the competition.** The only other items that are permitted for use during the competition are design notes, calculations, and drawings. It will be necessary to use the bucket(s) to haul sand a distance not to exceed 60 m.

During the competition, construction will proceed in two stages. Each stage must be completed in 30 minutes or less. No marking, layout, or assembly of the reinforcing materials is permitted prior to the start of construction.

a. *Assembly stage*

Reinforcement and facing are marked, cut, configured, and placed in the box as appropriate, preparatory to placement of sand. No sand can be placed or otherwise handled during this stage. The facing panel provided is larger than the height and width of the MSB wall so that small "wings" can be folded back to protect against spillage of sand around the edges. **All tape used must be laid flat against the poster board wall facing, with the sticky side facing the poster board** (i.e. tape can only be placed vertically on the wall facing; tape cannot be used to increase the strength of the paper reinforcement in a horizontal direction).

b. *Execution stage*

The box must be filled with sand to **within 5 cm** of the top and the sand surface should be horizontal. The loading bucket is then placed on top of the sand, 13 cm back from the wall facing and centered between the side walls. The loading bucket is a construction-standard, 19 liter plastic bucket. Construction is not considered to be complete until the loading bucket is in place.

Loading: Loading of the constructed wall will proceed as follows: When directed by the judge, the team will be directed to remove the front panel of their sandbox. After a stabilization period of 1 minute, team members will apply a 23 kg surcharge load by pouring sand into the loading bucket. The 23 kg of sand will have been measured and verified by the judge prior to this stage. Loading must be completed within ten minutes after the end of the stabilization period.

Failure: Failure of the wall will be declared if any part of the wall system, included paper, tape and retained sand, reaches the front plane of the sandbox. If failure occurs before loading is complete, the judge will record the weight of sand in the loading bucket at time of failure.

Scoring: The team that scores the most points will be declared the winner. Points will be awarded as follows:

- One point (up to a maximum of 50 points) for two kilograms of surcharge the wall holds without failing.
- (100–X) points for total area of paper requested by the team where X is the area measured in square centimeters.
- (30–Y) points for the time taken during the assembly stage where Y is the time measured in minutes.
- (30–Z) points for the time taken during the execution stage where Z is the time measured in minutes.
- Up to 40 points will be awarded based on the quality of the summary report developed by the team to document the design process used.

Awards will be given to the winning team members during the evening of January 25, 2005.

Grounds for disqualification

The following are grounds for disqualification:

- Failure to adhere to the prescribed construction standards for the retaining wall.
- At least three judges agree that a team has deliberately tried to violate the spirit of the competition.

Note: the summary reports must be submitted in triplicate by January 17, 2005. While the number of figures and tables is unlimited, the text of the report must be under 1000 words. Quality of the reports will be judged by a minimum of three judges.

APPENDIX B. Judging Form for MSB Competition—Wall Construction and Loading

Team Name: ______________________________

Team School: ______________________________

Team Judge: ______________________________

Wall Data:

Total area of paper requested (cm^2): X = ______________________________

Time taken during assembly stage (minutes): Y = ______________________________

Time taken during execution stage (minutes): Z = ______________________________

Kilograms of surcharge held without failing (kg): ______________________________

Calculation of Score (negative values are allowed):

Points for surcharge (one point per 2 kg held): ______________________________

Points for paper used (= 100—X): ______________________________

Points for assembly stage (= 30—Y): ______________________________

Points for execution stage (= 30—Z): ______________________________

Points for summary report (average of judges' scores): ______________________________

TOTAL POINTS: ______________________________

Comments (to be shared with the team):

APPENDIX C. Judging Form for MSB Competition—Team Summary Reports

Team Name: ______________________________

Team School: ______________________________

(1) Report is within the 1000 word limit (maximum score: 5 points) ______________________________

(2) Mechanics: punctuation, grammar, editing (maximum score: 5 points) ______________________________

(3) Description of the design process:

(a) Description is clear and concise (maximum score: 10 points) ______________________________

(b) Figures and tables are used in a way that clearly supports the description (maximum score: 10 points) ______________________________

(4) Overall quality of the report (maximum score: 10 points) ______________________________

TOTAL POINTS:

Comments (to be shared with the team):

David Elton is an Associate Professor of Civil Engineering at Auburn University, Auburn, AL, USA. He earned a Ph.D. from Purdue University, where he specialized in geotechnical engineering. His current interests include geosynthetics, education, foundations, site investigation, and bubblepoint testing. He teaches a wide variety of geotechnical courses, and has published in many areas of geotechnical engineering. He is currently President-Elect of the North American Geosynthetics Society.

Barbara Luke is Associate Professor of Civil Engineering at the University of Nevada Las Vegas, Las Vegas, NV, USA. She is a registered Professional Engineer in the State of Nevada. Her area of specialization is geotechnical engineering, with emphasis in soil dynamics and engineering geophysics. She is very active in professional service, currently serving as President of the Environmental and Engineering Geophysical Society and Chair of the Technical Coordination Council of the Geo-Institute of the American Society of Civil Engineers. Dr. Luke advises her campus' student chapter of the Society of Women Engineers. She served briefly as her College's Associate Dean for undergraduate programs and assessment.

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David Shannon earned a Ph.D. in Research Methodology and Statistics from the University of Virginia and is a Professor at Auburn University, Auburn, AL, USA. He coordinates the doctoral program in Educational Psychology and teaches classes in research methods and statistics. His research focuses on teaching and student assessment, evaluation and methodological issues. He has published papers on assessment and statistical analysis. He currently serves as the President-Elect for the Eastern Educational Research Association and is the editor for one regional and one international journal. In his spare time, he enjoys snowboarding in the Alabama mountains and hang gliding.

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