



**GEO-
INSTITUTE**



Geo-Institute
of the American Society of Civil Engineers
Presents
Competition Rules
for the 2014 Pacific Southwest
Regional GeoWall
Held at San Diego State University

Important Dates

Rules published: September 30, 2013
Pre-Competition Captains' Meeting: April 4, 2014
Competition: April 5, 2014

Geo-Congress 2014 Info:

<http://content.asce.org/conferences/geo-congress2014/index.html>

GeoChallenge Official Information Site:

<http://www.mygeoworld.info/groups/profile/61033/geochallenge>

Revision 02: Oct 30, 2013



GeoWall 2014 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) 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 national competition.
3. **Submittal** – The Mechanically Stabilized Earth Wall Design 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:

- a. Poster board dimensions must be the standard 36 in. by 48 in.

Posters will be judged at the captains meeting by a panel of practicing engineers and professors. Judges will consider reasonableness of design equations, material properties, factors of safety, and assumptions. “Trial and error” designs will be penalized heavily. Presentation and poster theme will also be considered. The rubric used for judging can be found 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 is 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 23/32-inch or 3/4-inch thick plywood of any grade.
 - b. Have planar inside surfaces with the natural plywood finish.
 - 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 1-1/2" schedule 40 PVC pipe. See Figure 1 for pile locations and length requirements.
6. **Backfill Material**- The backfill material will be a mixture of 75% sand and 25% crumb rubber by weight and will provided by competition organizers on site. The sand will be a clean, dry, rounded to subrounded sand with grain size as specified in Table 1 and Figure 4. The recycled crumb rubber will be metal and fiber free with grain size as specified in Table 2, and Figure 5. The backfill material must be used as-is: no water, additives, or chemical stabilizers may be placed in the backfill material. The materials must remain well mixed during the competition.

Competition organizers will make reasonable efforts to ensure the competition backfill materials meet the specifications in Tables 1 & 2 and Figures 4 & 5. Teams will be allowed to examine a sample of the competition backfill materials at the captains' meeting. No quantitative measurements beyond determination of the angle of repose will be allowed. No backfill samples may be removed from the meeting room. Teams may modify their wall design at this time if they desire. See paragraph 11 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 6 for dimensions.
 - b. **Reinforcement** – 60 lb Kraft Paper. Quantity of reinforcement will be measured by mass to the nearest 0.01g. There are no restrictions on the shape or geometry of reinforcing elements, but all reinforcement must be cut from a single sheet 24" × 24".
 - c. **Reinforcement Attachment to Facing** – Heavy duty polypropylene packaging tape, 2" 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 this time if they desire. See paragraph 11 below.

8. **Construction Tools** - The following construction tools may be used and must be provided by the competing team (quantities of these items shall not be restricted):
 - a. Pencils, pens, and markers
 - b. Rulers and straight edges
 - c. Levels
 - d. Manually operated cutting instruments (e.g., scissors, utility knives, razor blades, hole punch)
 - e. Cutting boards or mats
 - f. Design notes, calculations and drawings
 - g. Material handling and compaction tools consisting of any hand operated devices.
 - h. Screwdrivers (battery operated drills or screwdrivers may be used, but only to remove fasteners when removing the facing panel)
 - 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. It may be necessary for teams to haul backfill 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 6.

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 four steps: 1) removal of front panel, 2) placement of vertical surcharge, 3) placement of the static horizontal surcharge, and 4) a single application of the dynamic horizontal load. 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, excessive deformation, and catastrophic failure.
- 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 place the 5 lb drop weight on top of the load frame, hang an empty 5 gallon bucket on the loading frame and place 20 lb of sand in the bucket. The team will have two (2) minutes to place the load. After the load is placed, the judge will wait one (1) minute and then check the three criteria.
- iv. If the wall does not fail catastrophically, the team will then trip the drop weight for a single application of the 5 lb weight falling 5” and impacting the top of the loading arm (see Figure 3). 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 with vertical drop weight 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 report is submitted and the wall is tested. The adjusted mass of the reinforcing material used for scoring, M , will be computed as

$$\begin{aligned}
 &\text{if } |m_D - m_A| \leq 0.25 \\
 &\quad M = m_A \\
 &\text{if } |m_D - m_A| > 0.25 \\
 &\quad M = \max \left[\begin{array}{l} (m_D - 0.25) - \frac{(m_D - m_A - 0.25)}{2} \\ m_A + \frac{(m_A - m_D - 0.25)}{2} \end{array} \right] \quad (1)
 \end{aligned}$$

Where

m_D = reinforcing mass reported in design report
 m_A = reinforcing mass used during competition

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

$$Score = R + 15(13 - M) - 10N_{\min} - 30N_{maj} - 2T - 7.5D - 30F \quad (2)$$

Where

R = report score out of 50 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
- $D =$ deflection rating
- 8 if wall fails deflection criterion during initial loading without surcharge
 - 4 if wall fails deflection criterion during vertical surcharge loading
 - 2 if wall fails deflection criterion during static horizontal loading
 - 1 if wall fails deflection criterion during dynamic horizontal loading
 - 0 if wall passes deflection criterion for all loading phases
- $F =$ Failure rating
- 4 if wall fails catastrophically during initial loading without surcharge
 - 3 if wall fails catastrophically during vertical surcharge loading
 - 2 if wall fails catastrophically during static horizontal loading
 - 1 if wall fails catastrophically during dynamic horizontal loading
 - 0 if wall never fails catastrophically

a. **Minor Penalties**

- i. Box dimension out of spec
- ii. Pile location out of spec
- iii. Any addendum to the design report required by judges which simply clarifies content but does not change the design
- iv. 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
- iii. Any addendum to the design report required by judges which results in a significant change to the design
- iv. Any other rule violation that in the opinion of the judges has the potential to provide the team with a significant advantage, but does not warrant disqualification

c. **Disqualification** – Teams may be disqualified for the following:

- i. Failure to send a representative to the pre-competition captains' meeting
- ii. Unsafe practices
- iii. Design or construction techniques which violate the spirit of the competition and provide 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 actual reinforcement mass, 2) higher report 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

- Report Score: 38/50, $R = 38$
- Design report specifies 6.23 g. Reinforcement used, 7.01g.

$$M = 7.01 + \frac{7.01 - 6.23 - 0.25}{2}$$

$$= 7.275$$

- 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 three loading phases but failed catastrophically during fourth loading phase, $D = 1, F = 1$

Using equation 1, the final score would be

$$Score = 38 + 15(13 - 7.275) - 5(2) - 30(1) - 10(2) - 7.5(1) - 30(1)$$

$$= 26.4$$

See Appendix C for scoring checklists.

- 12. Pre-Competition Team Captains' Meeting** – A team captains' meeting will be held on April 4th, 2014 from 6:00-8:00 pm (exact location TBD) for the purposes of: checking sandboxes for compliance, establishing competition order, gathering team biographical information, 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 on the PSWC website before the conference. 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.

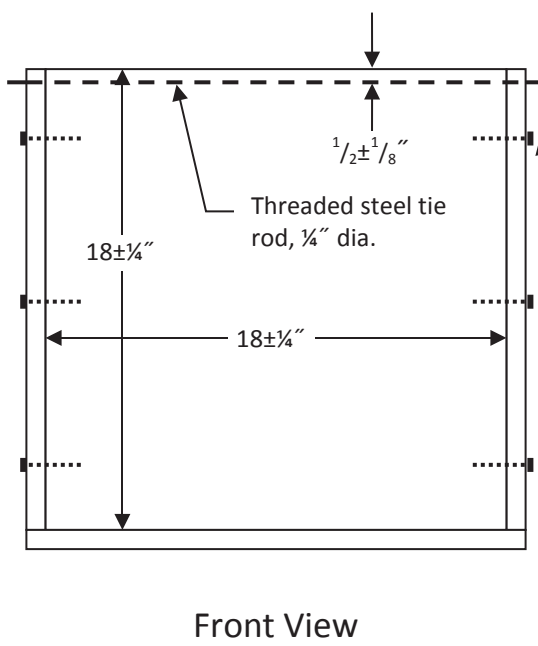
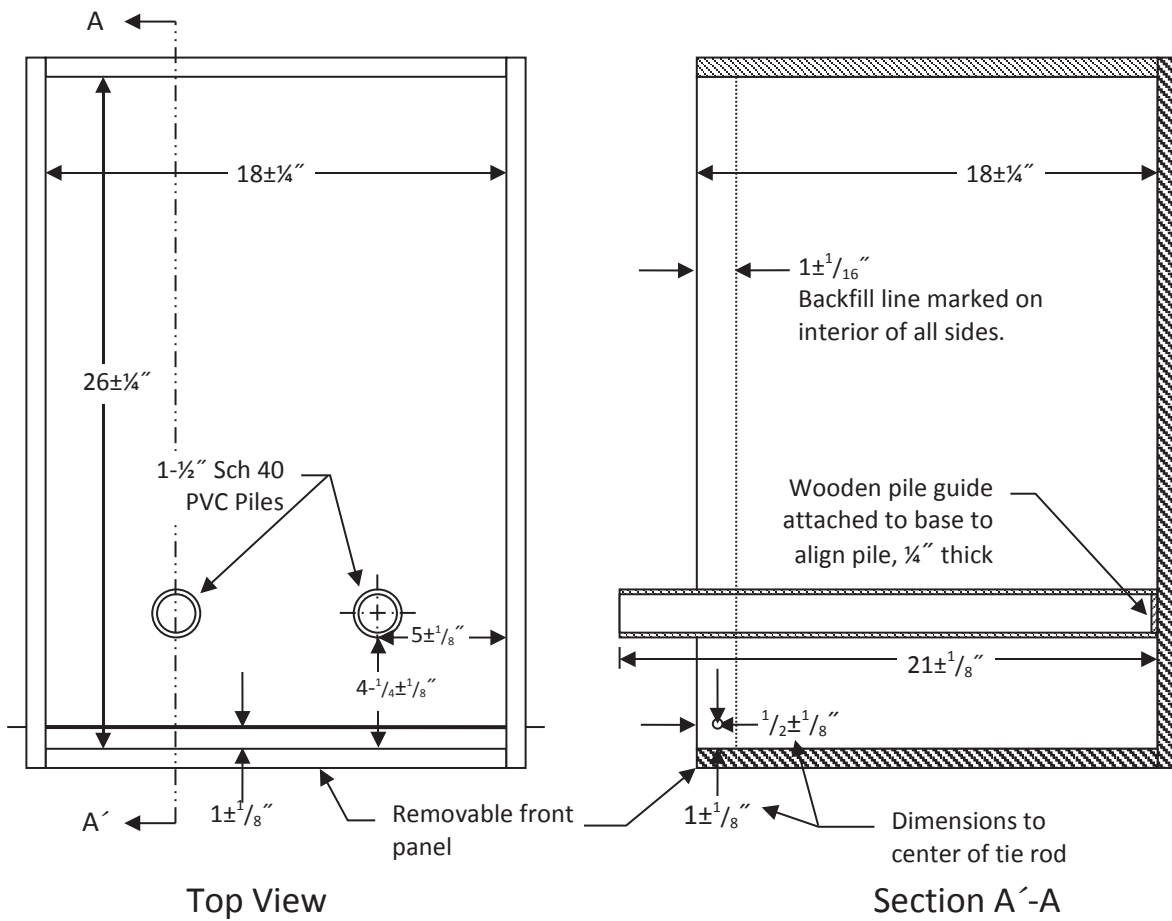
Tables and Figures

Table 1: Representative grain-size distribution for GeoChallenge competition sand.

Typical Distribution		Lower Bound		Upper Bound	
Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing
2.00	100.0	1.30	100.0	2.50	100.0
1.70	96.8	1.20	96.9	2.30	96.9
1.18	41.8	1.15	93.7	2.10	93.7
1.00	15.8	0.80	38.7	1.60	38.7
0.85	3.3	0.60	12.7	1.30	12.7
		0.50	2.0	1.10	2.0

Table 2: Representative grain-size distribution for GeoChallenge competition crumb rubber.

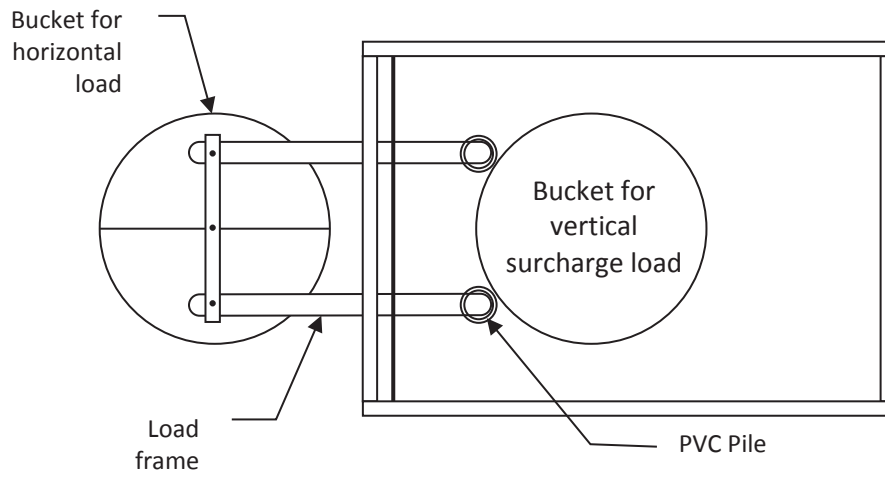
Typical Distribution		Lower Bound		Upper Bound	
Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing
2.00	100.0	1.30	100.0	2.30	100.0
1.70	96.8	1.20	96.9	2.10	96.9
1.18	35.0	1.15	93.7	2.00	93.7
1.00	20.0	0.95	38.7	1.60	38.7
0.85	11.0	0.83	20.0	1.30	12.7
0.425	3.5	0.425	8.0	1.10	2.0



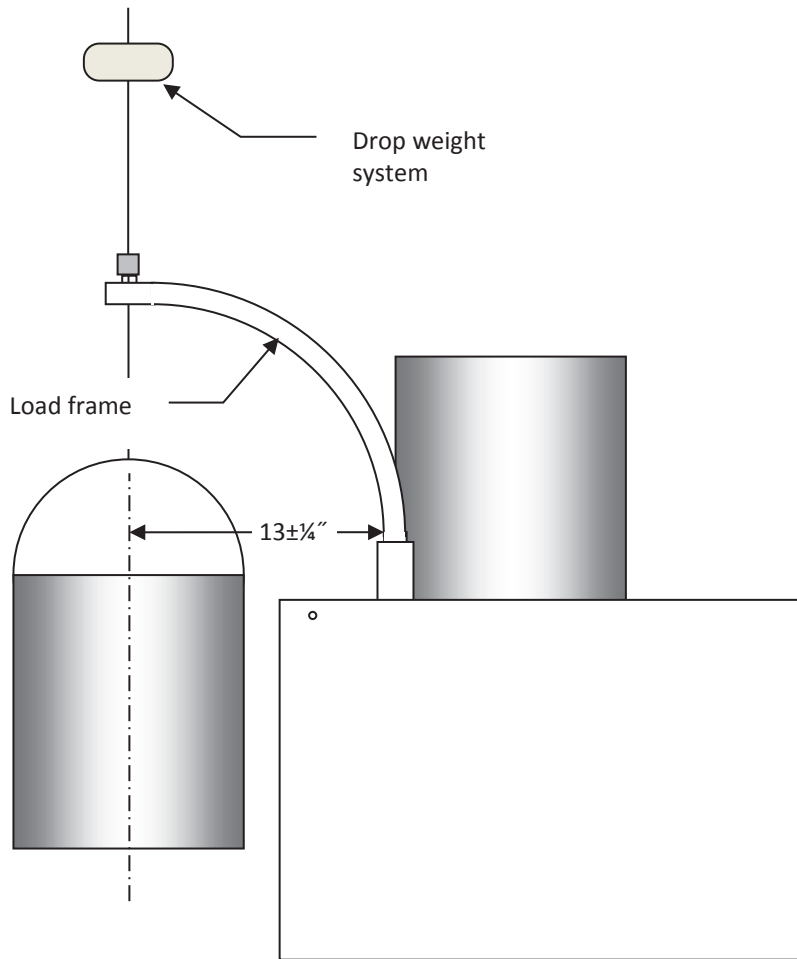
- Notes:
- Box to be fabricated of 23/32 " or 3/4" plywood except as noted
 - Tie rod must be 1/4" threaded steel rod with washers and nuts as needed
 - Piles must be 1-1/2" Schedule 40 PVC and must slide over wooden guides; piles may not be attached to guides or box
 - Handles or knobs may be attached to outside of front panel to aid in removal
 - Interior surface of box must be natural wood and unmodified
 - Exterior of box may be painted and decorated with school logos etc.

Removable fasteners to secure facing panel (as needed)

Figure 1: Sandbox Dimensions (not to scale)



Top View



Side View

Figure 2: Load Placement (not to scale)

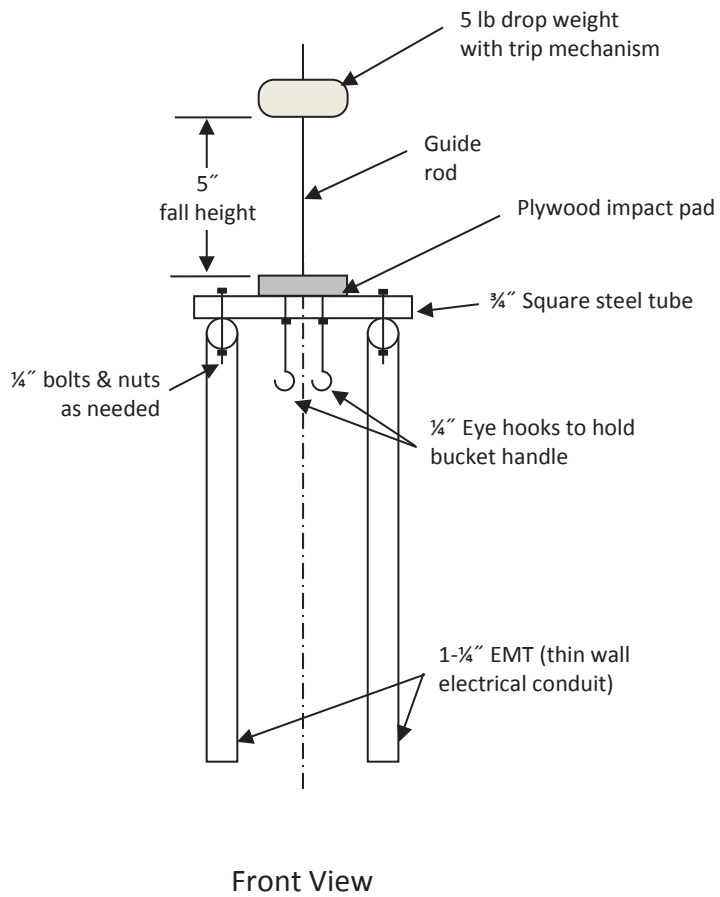
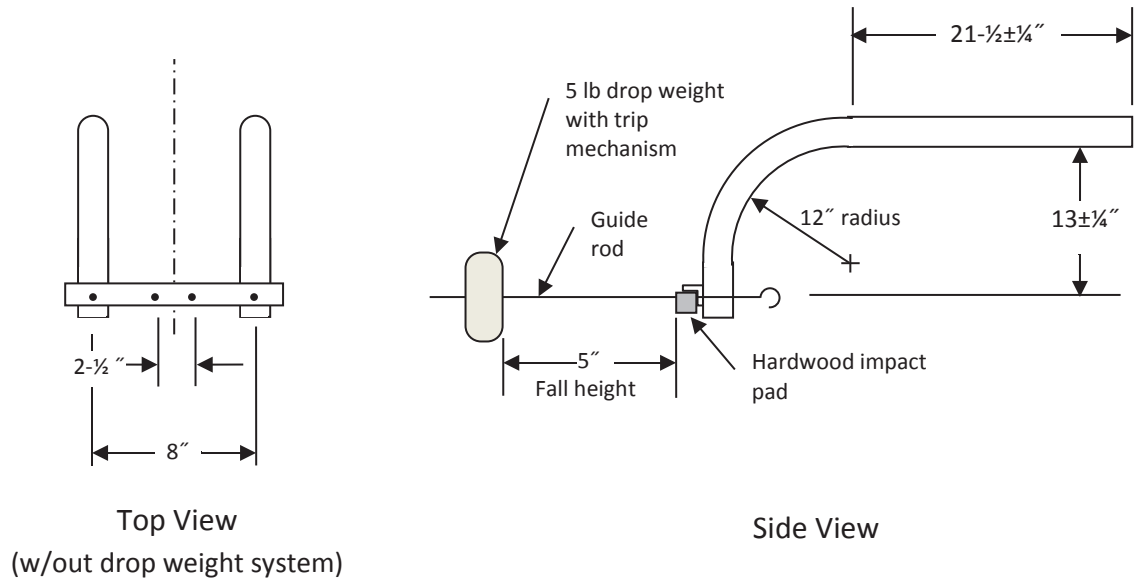


Image of drop weight system

Figure 3: Dimensions of Horizontal load Frame (not to scale)

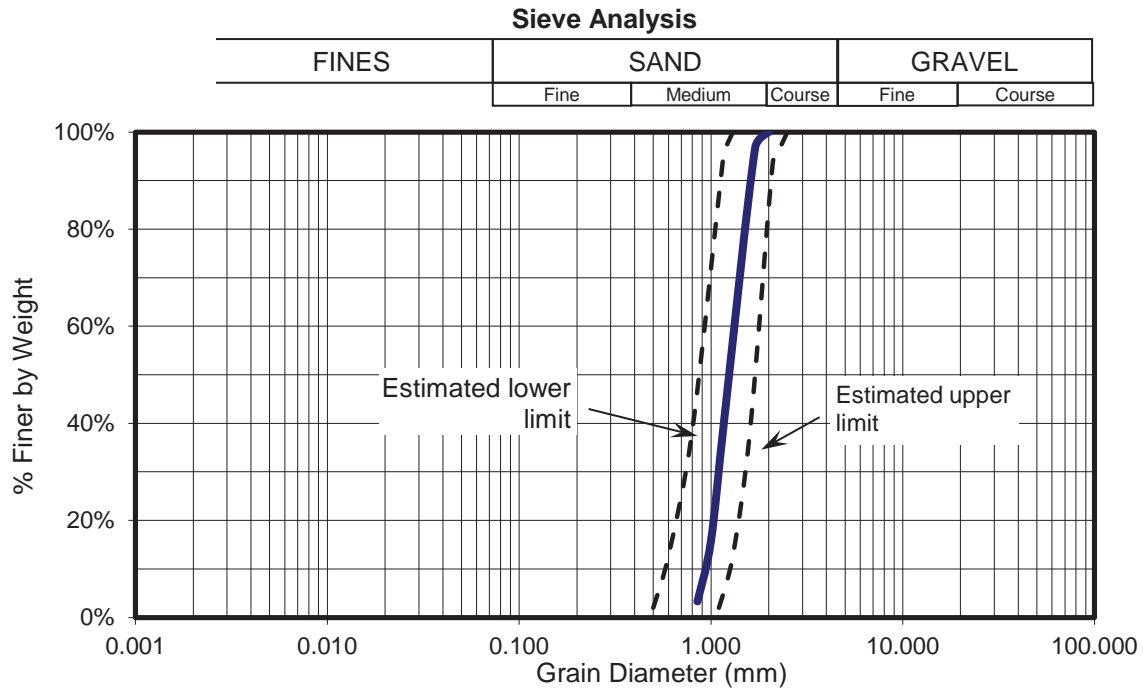


Figure 4: Estimated grain size distribution of backfill sand

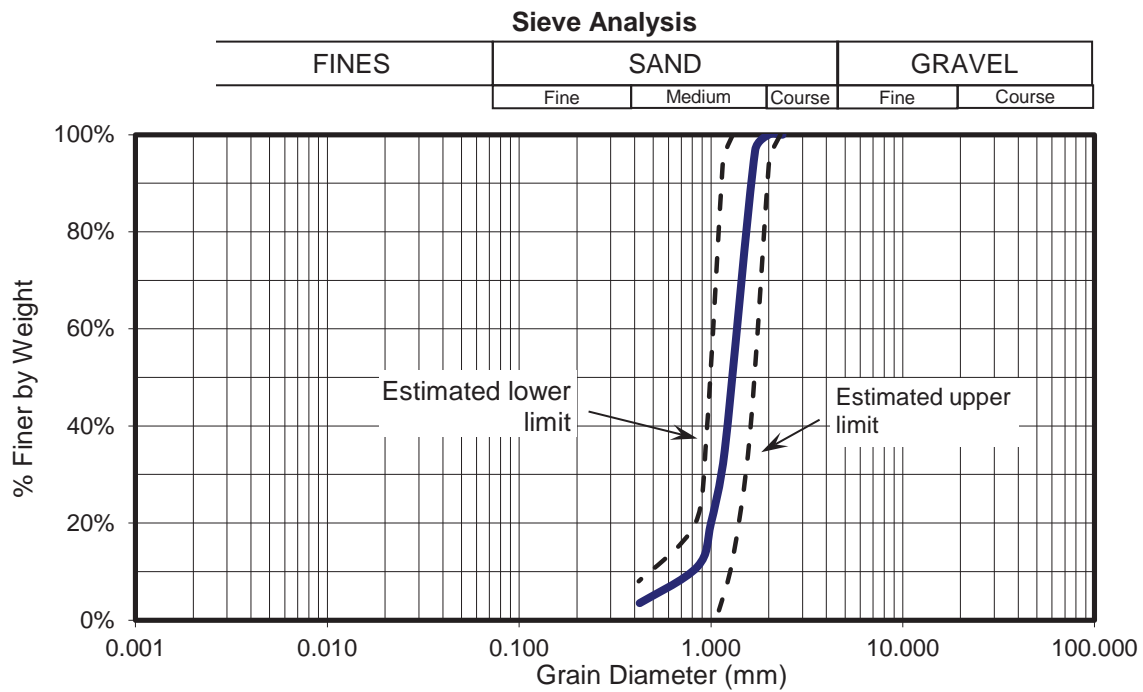


Figure 5: Estimated grain size distribution of crumb rubber

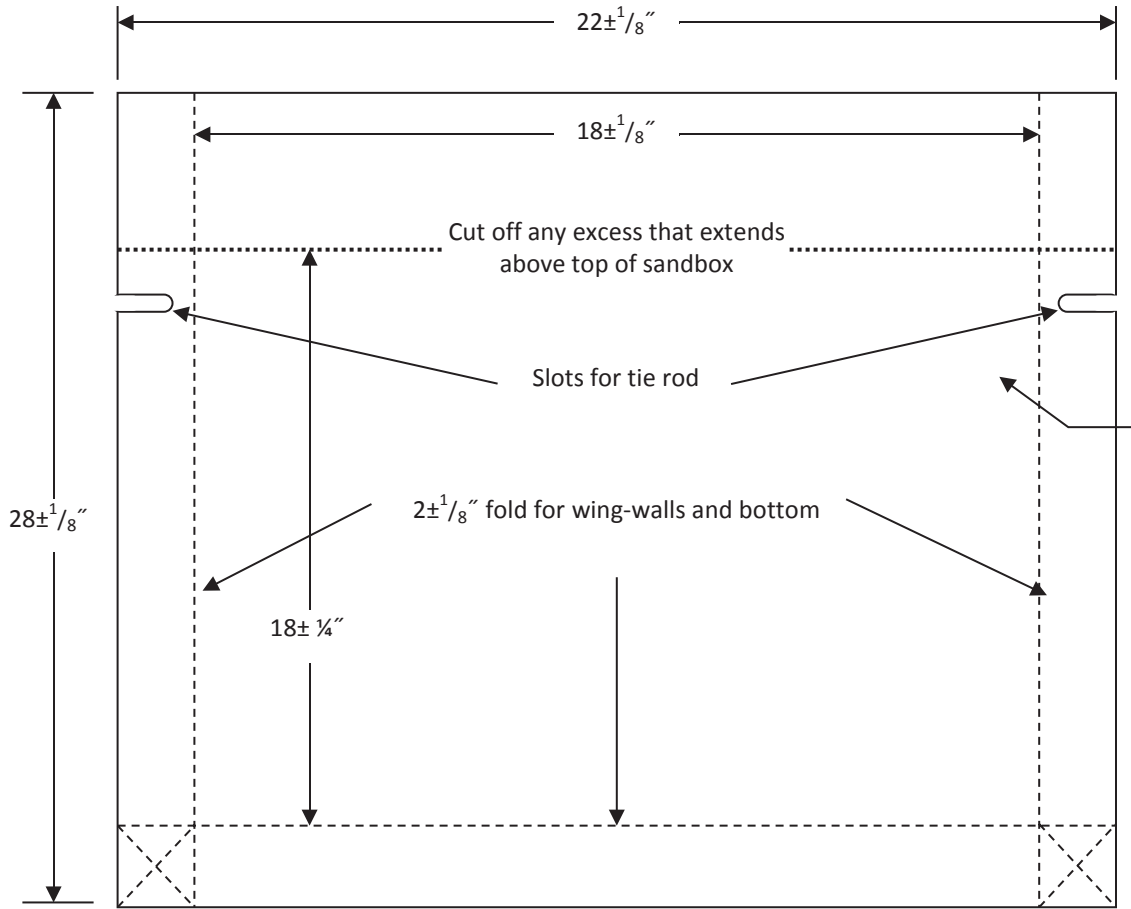


Figure 6: Dimensions of the posterboard wall facing (not to scale)

Appendices

Appendix A: Material Specifications

- **Sand:**
 - Clean sand with grain size distribution as specified in Table 1 and Figure 4
 - Grain shape will be rounded to sub-rounded
- **Crumb rubber:**
 - Recycled crumb rubber with grain size distribution as specified in Table 2 and Figure 5
 - Rubber will be metal and fiber free
 - This is a standard specification of crumb rubber used for subgrade below artificial turf and should be readily available from any artificial turf supplier. Teams may contact Christy Newmeyer at CRM (cnewmeyer@crmrubber.com 949-263-9100) for supplier info.
- **Sandbox Material:**
 - Walls and Base: 23/32 or 3/4" plywood, any grade
 - Pile guide: any wood material 1/4" thick or less
 - Tie Rod: 1/4" threaded steel rod with washers and nuts as needed
 - Fasteners: any suitable wood fasteners
- **Pile Material:** 1-1/2" Schedule 40 PVC pipe
- **Horizontal Load Frame Materials:** These are recommended materials. Teams may fabricate their load frames out of any materials so long as they have the correct moment arm as shown in Figures 2 and 3. The load frames provided by organizers for the competition will use the following materials and meet dimension shown in Figure 3.
 - 1-1/4" steel EMT conduit (thin wall electrical conduit)
 - 3/4" steel L
 - 1/4" bolts
 - 1/4" eye hooks
- **Facing Material:**
 - Poster Board, 22" x 28", 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' x 50' roll)
- **Adhesive Material:**
 - Heavy duty, clear, 2" wide, polypropylene package tape
 - Scotch® 142-B Super Strength Mailing Tape, clear
 - Office Depot® Item #650457, 2" x 22.2 Yd with dispenser

Appendix B: Design Poster Judging Rubric

Geo-Institute of the ASCE: GeoWall Design Poster – Scoring Form			
Reviewer Guidelines:			
1) Place weight on the team ability of 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 higher score if verifying design parameters beyond assumptions and references			
Team School:			
Criterion	Max	Actual	Notes
1) Formatting, Mechanics and Grammar:			
a. Paper length, margins & font are acceptable	2		
b. Layout, or structure, of paper is logical	2		
c. Grammar and punctuation are correct	2		
d. Figures & tables are clear, properly numbered, captioned and referenced in the text	2		
e. References are reasonably formatted and complete	2		
2) Experimental Methods, Analyses and Design:			
a. Methods to obtain backfill properties	3		Experimental methods are reasonable and clearly described
b. Methods to determine reinforcement properties	3		Experimental methods are reasonable and clearly described
c. Methods to determine backfill-reinforcement interaction	3		Experimental methods are reasonable and clearly described
d. Engineering properties are reasonable	3		Backfill unit weight, friction angle, interface friction angle, reinforcement strength are compared to typical values
e. Earth-pressure calculations provided (backfill only)	3		Calculations are correct and presented in a logical, readily followed format
f. Vertical surcharge loads included in the design	3		Considers both lateral loads on wall and effect on reinforcement pullout
g. Method used to compute pressure applied from laterally loaded piles addressed in report	3		Considers distribution of lateral load on wall, both static and dynamic
f. Determination of reinforcement length	3		Method and assumptions are reasonable
g. Determination of reinforcement spacing	3		Method and assumptions are reasonable
j. Evaluation of connection strength	3		Method and assumptions are reasonable
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 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".
Total	50		

Appendix C: Judges' Scoring Checklist for GeoWall Competition

C1: Captains' meeting—Box check

Team School:		Deductions	
Item	Instruction	Minor	Major
Plywood	<input type="checkbox"/> 23/32 or 3/4" thickess <input type="checkbox"/> Inside surfaces planar and natural		
Box dimensions	<input type="checkbox"/> Within tolerance <input type="checkbox"/> Sand fill height marked		
Facing panel	<input type="checkbox"/> Flush to box front <input type="checkbox"/> Removable fasteners		
Tie rod	<input type="checkbox"/> 1/4" dia <input type="checkbox"/> Located within tolerances		
Piles	<input type="checkbox"/> 1-1/2" Sch 40 PVC <input type="checkbox"/> Length in tolerance <input type="checkbox"/> Base guides ≤ 1/4" thick <input type="checkbox"/> Locations in tolerance <input type="checkbox"/> Upper pile template easily removable		
Tools	<input type="checkbox"/> Only authorized tools used		
Other minor, explain:			
Other major, explain:			
Disqualification, explain:			
Total deductions			

Notes:

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 , as max of a) average of design & actual or b) actual		$M =$	
		Deductions	
		Minor	Major
Tools	Only authorized tools used		
Other, explain			
Total deductions			

Notes:

C3: Wall Assembly

Team School:			
Item	Instruction	Time	
		Total	> 15:00 (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
Tape piece	<input type="checkbox"/> Each $\leq (2'' \times 2'')$ <input type="checkbox"/> On vertical front plane only <input type="checkbox"/> Not overlapping <input type="checkbox"/> Touch both wall and reinforcement		
Slots for tie rod	<input type="checkbox"/> Cut so rod does not support wall		
Dimension	<input type="checkbox"/> Trimmed to top of wall		
Tools	<input type="checkbox"/> Only authorized tools used		
Total deductions			

Notes:

C4: Construction

Item	Instruction	Time	
		Total	> 20:00 (Min:sec)
Time	Give start command. Time ends when soil filled to line and empty bucket & load frame are in place		
		Deductions	
		Minor	Major
Backfill	<input type="checkbox"/> Level <input type="checkbox"/> Filled within 1" of top		
Tools	<input type="checkbox"/> Only authorized tools used		
Pile	<input type="checkbox"/> Template removed <input type="checkbox"/> Location within tolerance		
Tools	<input type="checkbox"/> Only authorized tools used		
Total deductions			

Notes:

C5: Loading

Team School:			
Item	Instruction		
Stage 1: Backfill only	<ul style="list-style-type: none"> Place clean posterboard on floor in front of box At judge's direction students remove front panel of box. Electric drills/screwdriver may be used to remove fasteners. Once panel is completely removed start 1 min wait period At end of 1 min make following checks 		
	<input type="checkbox"/> Swipe front wall face with straight edge to check wall deflection	<input type="checkbox"/> Pass	<input type="checkbox"/> Fail $D = 8$
	<input type="checkbox"/> Less than 30 cm ³ sand leaked from box onto floor	<input type="checkbox"/> Pass	<input type="checkbox"/> Fail Major Ded
	<input type="checkbox"/> Catastrophic failure	<input type="checkbox"/> Pass	<input type="checkbox"/> Fail $F = 4$
Stage 2: Vertical Surcharge	<ul style="list-style-type: none"> Bucket preweighed with 50 lbs of sand should be ready. At judge's direction students add 50 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 		
	<input type="checkbox"/> Loading complete within 1 minute	<input type="checkbox"/> Yes	<input type="checkbox"/> No Minor Ded
	<input type="checkbox"/> Swipe front wall face with straight edge to check wall deflection	<input type="checkbox"/> Pass	<input type="checkbox"/> Fail $D = 4$
	<input type="checkbox"/> Less than 30 cm ³ sand leaked from box onto floor	<input type="checkbox"/> Pass	<input type="checkbox"/> Fail Major Ded
	<input type="checkbox"/> Catastrophic failure	<input type="checkbox"/> Pass	<input type="checkbox"/> Fail $F = 3$
Stage 3: Static Horizontal Load	<ul style="list-style-type: none"> Bucket preweighed with 20 lbs of sand should be ready. At judge's direction students add 20 lbs of sand to horizontal loading bucket and 5 lb drop weight to loading arm. Students have one minute to complete loading. At end of 1 min make following checks 		
	<input type="checkbox"/> Loading complete within 1 minute	<input type="checkbox"/> Yes	<input type="checkbox"/> No Minor Ded
	<input type="checkbox"/> Swipe front wall face with straight edge to check wall deflection	<input type="checkbox"/> Pass	<input type="checkbox"/> Fail $D = 2$
	<input type="checkbox"/> Less than 30 cm ³ sand leaked from box onto floor	<input type="checkbox"/> Pass	<input type="checkbox"/> Fail Major Ded
	<input type="checkbox"/> Catastrophic failure	<input type="checkbox"/> Pass	<input type="checkbox"/> Fail $F = 2$
Stage 4: Dynamic Horizontal Load	<ul style="list-style-type: none"> Drop weight height checked. At judge's direction students trip drop weight. , then start 1 min wait period At end of 1 min make following checks 		
	<input type="checkbox"/> Loading complete within 1 minute	<input type="checkbox"/> Yes	<input type="checkbox"/> No Minor Ded
	<input type="checkbox"/> Swipe front wall face with straight edge to check wall deflection	<input type="checkbox"/> Pass $D = 0$	<input type="checkbox"/> Fail $D = 1$
	<input type="checkbox"/> Less than 30 cm ³ sand leaked from box onto floor	<input type="checkbox"/> Pass	<input type="checkbox"/> Fail Major Ded
	<input type="checkbox"/> Catastrophic failure	<input type="checkbox"/> Pass $F = 0$	<input type="checkbox"/> Fail $F = 1$

C6: Scoring

Adjusted mass, M , computed by

if $|m_D - m_A| \leq 0.25$

$$M = m_A$$

if $|m_D - m_A| > 0.25$

$$M = \max \left[\begin{array}{l} (m_D - 0.25) - \frac{(m_D - m_A - 0.25)}{2} \\ m_A + \frac{(m_A - m_D - 0.25)}{2} \end{array} \right]$$

$$Score = R + 15(13 - M) - 10N_{min} - 30N_{maj} - 2T - 7.5D - 30F$$

Team School:			
Item	Score	Weight	Extended
Report score out of 50, R		1	
Reinforcement mass score, enter as $(13 - M)$		15	
Total # of minor deductions, N_{min}		-10	
Total # of major deductions, N_{maj}		-30	
Total time over limit rounded up to nearest whole minute, T		-2	
Deflection rating, D 8 = Deflection exceeded at Stage 1 4 = Deflection exceeded at Stage 2 2 = Deflection exceeded at Stage 3 1 = Deflection exceeded at Stage 4 0 = Deflection never exceeded		-7.5	
Failure rating, F 4 = Catastrophic failure at Stage 1 3 = Catastrophic failure at Stage 2 2 = Catastrophic failure at Stage 3 1 = Catastrophic failure at Stage 4 0 = No catastrophic failure		-30	
		Final Score	

Notes: