

# Civil Engineering Water Tower Structure and Foundation Project Specifications

## Engineering Competition, Engineering Day February 26, 2010

**Design and construct a balsa wood prototype model of a Water Tower, at a feasible cost, that can support a minimum of 1 pound of water and withstand forces of simulated earthquakes.**

*The specifications for this project are minimal to allow for creative engineering.*

All measurements will be calculated in English Units.

The shake table providing the earthquake simulation will provide 4 levels of compression, the first level being one pound of water. At each compression level, the tower will be subjected to 3 simulation levels of earthquakes. Water tower models sustaining little or no damage through the third simulation level will then be subjected to the next level of compression with an additional  $\frac{1}{2}$  pound weight added to the top of the water tank for each compression level.

Create a to-scale drawing of your Water Tower Model before you begin purchasing materials for the construction of your prototype. You will have to consider trade-offs, as the ratio of cost vs. strength will be considered in determining your performance score. If you revise your design, create another to-scale drawing of the actual working model you plan to test during the competition. Teams will submit this drawing as part of the project.

Keep a record of all materials purchased to submit with your project. Use the attached Price List for Materials for calculating the cost of your water tower. The cost will include all materials used in the construction of the tower and the foundation. The hypothetical cost of each water tower will be evaluated and the official cost will be determined at the competition by a committee using the Price List for Materials. Water Towers will be rated according to cost.

You will need a  $16\frac{1}{2}$  inch x 20 inch foundation for your water tower. The foundation may be a plywood board or other material, with a maximum thickness of  $\frac{3}{16}$  inch. You may drill holes or add supports to the legs on the top of the board to create a secure foundation for your tower; however, reinforcement of the water tower from the foundation may not exceed  $1\frac{1}{4}$  inches in height above the shake table platform.

At the competition, the foundation board will be attached to the shake table with two clamps. Securing the tower to the foundation is the responsibility of the student team. The legs of your water tower must be firmly fastened to the foundation. Once the testing begins, students will not be allowed touch their water tower or foundation, except to add weights.

The orientation of your water tower on the foundation board is an important consideration. The foundation board will move back and forth. The board will be positioned such that the ends, measuring  $16\frac{1}{2}$  inches are perpendicular to the movement of the shake table and the 20 inch sides of the foundation board are parallel to the back and forth movement of the shake table.

The legs for the water tower will be maximum  $\frac{3}{16}$  inch sq. balsa sticks, maximum length per leg = 18 inches. All balsa sticks used for support and reinforcement on the tower must be less than  $\frac{3}{16}$  inch sq. The  $\frac{3}{16}$  inch sq. balsa may be used on the foundation.

The height of the water tower must be at least  $16\frac{3}{4}$  inches, measured from the surface of the shake table to the bottom of the platform supporting the water tank.

The distance between any two legs, measured at the foundation, cannot exceed 11 inches.

The water tank will consist of a plastic container filled with 2 cups of water. The plastic container required is a 2 cup Ziploc, Twist'n Loc, small round container with a  $3\frac{7}{8}$  inch base.

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### Price List for Materials

18" x 3/16" balsa sticks (for legs and foundation only) = \$0.25/inch

1/8" balsa sticks for reinforcement = \$0.10/inch

4" x 1/8" balsa sheets (to support water tank only) = \$1.00/sq. inch

4" x 1/16" balsa sheets for reinforcement = \$0.75/sq. inch

3" x 1/16" balsa sheets for reinforcement = \$0.60/sq. inch

Thin cardboard = \$0.25/sq. inch

Corrugated board (3 sheets of thin cardboard) = \$0.75/sq. inch

String/Thread = \$0.01/inch

Wire = \$0.05/inch

Glue (hot glue guns) per spot = \$0.10/spot

Globs of glue will be counted as multiple spots

Model glue per spot = \$0.05/spot

Masking tape = \$0.15/sq. inch

Rubber bands = \$0.10 each

Putty adhesive = \$1.00/half inch diameter ball

Styrofoam or similar material = \$2.00/cubic inch

Foundation board, exactly 16½ inch x 20 inch, maximum thickness 3/16 inch = \$5.00  
(required for all water towers)

Duct Tape is not allowed.      Dowels are not allowed.

Prices for materials not included in the above list will be determined by the Materials-Prices Evaluation Committee at the Competition.

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### Water Tower Testing and Scoring Worksheet

Team Number: \_\_\_\_\_

Prototype: Design: multiple types of bracing, stability, neatness, creativity, etc.  
 Max 35 pts

10 pts. \_\_\_\_\_

Specifications: Height \_\_\_\_\_, 7 pts. \_\_\_\_\_

Leg Length \_\_\_\_\_, 5 pts. \_\_\_\_\_

Stick Diameter \_\_\_\_\_, 5 pts. \_\_\_\_\_

Foundation Bracing/Height \_\_\_\_\_, 5 pts. \_\_\_\_\_

Foundation: \_\_\_\_\_ X \_\_\_\_\_, 3 pts. \_\_\_\_\_

Design and Construction: Cost: \_\_\_\_\_ Cost Points: 15 pts. \_\_\_\_\_  
 Max 25 pts

Scale Drawing: 5 pts. \_\_\_\_\_ Discussion: 5 pts. \_\_\_\_\_

**Total Prototype Points** \_\_\_\_\_

*Simulation earthquake level: 1) slight 2) moderate 3) severe*

*Performance-damage rating: 1) catastrophic 2) extensive 3) moderate 4) slight 5) no damage*

Performance: Compression level 1: Simulation level: 1 2 3  
 Max 40 pts Water  
 Performance: 1 2 3 4 5 10 pts. \_\_\_\_\_

Compression level 2: Simulation level: 1 2 3  
 Water + 1 lb  
 Performance: 1 2 3 4 5 15 pts. \_\_\_\_\_

Compression level 3: Simulation level: 1 2 3  
 Water + 2 lbs  
 Performance: 1 2 3 4 5 10 pts. \_\_\_\_\_

Compression level 4: Simulation level: 1 2 3  
 Water + 3 lbs  
 Performance: 1 2 3 4 5 5 pts. \_\_\_\_\_

**Total Performance Points** \_\_\_\_\_

**Total Points (Prototype + Performance) for Balsa Water Tower Competition:** \_\_\_\_\_

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### Water Tower Testing and Scoring Rubric

Each team will be scored on the following at the Competition.

#### 1. WATER TOWER PROTOTYPE (35 points)

- Overall stable design
- Model must meet specifications and be firmly attached to the foundation
- Use of multiple types of bracing
- Neatness of prototype construction
- Height specification (top of the platform supporting the water tank must be at least 16  $\frac{3}{4}$  inches above the surface of the shake table)

#### 2. DESIGN AND CONSTRUCTION (25 points)

- Scale drawing of final design along with preliminary design sketches
- Construction cost of materials for tower and foundation, using hypothetical Price List for Materials. The hypothetical cost of each water tower will be evaluated and the official cost will be determined at the competition by a committee using the Price List for Materials.
- Brief discussion of the types of loads and stresses expected and how the design of the water tower will react to these forces
- Brief discussion of tower foundation and orientation

#### 3. PERFORMANCE (40 points)

- The water tower will be subjected to various simulation levels on the shake table.
- For each simulation the tower will receive a performance rating. If the tower survives level 3 with no damage to moderate damage, the process will be repeated with additional weights added to the tower.

##### *Compression level (weights)*

- 1) water tank containing 1 pound of water; 2) water tank w/ 1lb. weight; 3) water tank w/ 2lb. weights; 4) water tank w/ 3 lb. weights

##### *Earthquake Simulation Level*

- 1) slight 2) moderate 3) severe

##### *Performance / Damage Rating*

- 1) catastrophic 2) extensive 3) moderate 4) slight 5) no damage

**THE OVERALL SCORE FOR THE WATER TOWERS WITHSTANDING EARTHQUAKE SIMULATIONS WILL BE DETERMINED BY TOTAL POINTS WITH CONSIDERATION GIVEN TO THE RELATIONSHIP OF COST TO PERFORMANCE.**

Models completing Compression Level 4 with moderate to no damage will be tested with additional compression weight at the end of the competition.