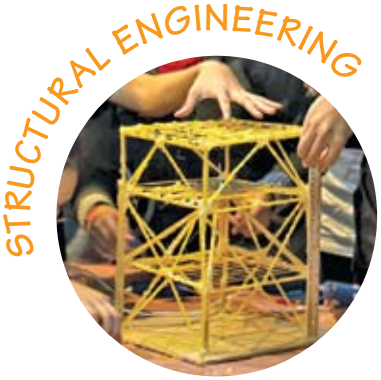
ACE MENTOR PROGRAM
ARCHITECTURE • CONSTRUCTION • ENGINEERING

STRUCTURAL ACTIVITIES
PASTA STRUCTURE CONTEST

DEVELOPED BY:
THE ACE MENTOR PROGRAM OF LOS ANGELES - ORANGE CO.

Pasta Structure Contest

created by Fred Case,
with Clark Construction,
in collaboration
with Avivah Rapoport,
of Perkins & Will, for the
Los Angeles Metro
Area affiliate



Educational Goals Design, sketch and fabricate a multi-level structure according to certain parameters. Understand structural forces.

Description Created by the Los Angeles Metro Area affiliate, this activity was designed as a competition among all the schools participating in the ACE program. Note: Most individual ACE teams will find this activity, as presently designed, difficult to replicate because it involves dynamic testing of the structure with a seismic shake table.

Students first design and sketch a multi-story building to meet predetermined requirements. Next they construct their building according to their design and using various kinds of pasta and some other materials. At the conclusion the structures undergo static and dynamic load tests.

Time 2-3 hours

Materials

Each team will be provided with the following materials:

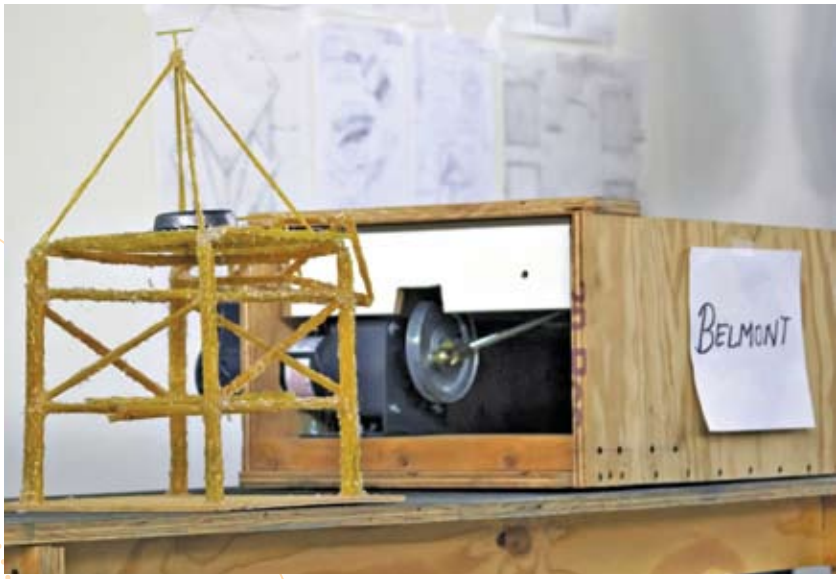
- Several hot-melt glue guns
- Hot-melt glue sticks
- Pasta (spaghetti, penne, ziti, rigatoni, and rotelle)
- Paper (for drawing the bridge design and making calculations)
- Ruler
- One base plate – a 12" x 12" x 1/4" piece of plywood, pre-drilled for the shake table's bolted connection and importantly, with four 10D hot-dip galvanized common framing nails set from below and protruding upward at the corners.
- Two test-weight holders – a small perforated metal plate that is to be glued into the students' structure at a designated location. A machine screw, oriented upwards, is set into the plate. Small Simpson wood framing plates make excellent test-weight holders. These must be glued into the structure at specified places (see Design Rules below).
- A copy of the Design Requirements and Construction Rules set forth below.

Judges will also need the following items for purposes of testing the completed structures:

- A set of scales with which to weigh student-made structures (for purposes of determining structural efficiency).
- Two 2½ -pound test weights. A 5-pound ingot can be purchased from a plumbing supply store. It is shaped like a hockey puck. Cut the ingot in half the flat way and drill a hole in the center of each half so it will fit over the screw on the test holder and be retained during the shake test.
- A seismic shake table (see photo.) One can be constructed as follows. Make a strong plywood box about 12"H x 18"W x 30"L. Inside mount a drawer set upside down on full-extension ball-bearing slides. This is connected by a tie-rod to a sheave on a 90V DC motor. The motor (available from Grainger Industrial Supply) is connected to a rheostat so that the speed can be varied. The sheave has two eccentric connection points for the tie-rod so that the amplitude can be varied as well. The tie-rod should utilize quality ball-bearing ends. The drawer bottom has four bolts protruding up to receive the structure base plate, which is held down with wing nuts to prevent overturning.

Concept

Teams will consist of ACE students and their mentors. Only the students may work on the problem; however, the mentors may advise and coach. Teams will design and build a pasta structure represent-



Seismic shake table

ing a multi-story building. The designs and structures will be judged for several qualities (including structural efficiency, i.e., strength-to-weight ratio), and then tested for capacity with static and dynamic loadings.

Schedule

A. Once the competition begins, there will be ten minutes dedicated to questions and answers regarding the problem. After that, there will be two hours for the design and construction of the structures.

B. Each team must develop a design for their structure and produce a drawing(s) during the two-hour period.

C. Each team makes its own decision as to when it is appropriate to begin physical construction of its building, and must complete construction within the two-hour period. The judges should urge teams to begin construction as soon as their basic design approach is determined so that there will be adequate time to complete the work.

D. At the end of the two-hour period, design and construction must stop, and judging and testing will begin.

Design Requirements

A. Each structure must represent a building with a ground floor plate size of 9" x 9" (81 square inches).

B. Each structure must be multi-storied; having at least two elevated floors. Each floor must be a minimum of 4" in height (floor-to-floor).

C. Each structure must provide a minimum of 243 square inches of total floor space on all floors (including the ground floor).

D. Each structure must have two floors above the base plate, one at level 9" (or higher) and the other at 18" (or higher). These are the "test-weight loading floors," where the test weights will be secured and loads applied during testing.

E. There is no limit as to the total height of any structure.

F. Cantilevering may be utilized to gain additional floor space above the ground level.

Construction Rules

A. Only the supplied materials may be used.

B. Structures must utilize the base plate provided to each team as the base of their building, using the four upturned nails as the corners of their building. This will make the ground level of the buildings approximately 9" x 9" (or 81 square inches) in area. The building's ground level may not be larger in plan than the square represented by these corners, although upper levels may have larger or smaller floor plate sizes. *The four base columns must be firmly glued to the upturned nails to prevent uplift failure during testing*.

C. No component of the structure may touch the base plate other than the four corner columns.

D. Structures must have at least two elevated floors or flat roof decks, with one located a minimum 9" above the base plate and the other at 18" above the base plate. These floors or decks are where the test weights will be placed, and so it must be accessible from above or the side to accommodate placing the weights. On each of these floors or decks, a test-weight holder must be glued securely to the center of the structure to prevent shifting of the test weights during dynamic testing.

E. Structures must exhibit open floor plates without excessive structure impeding tenants. Interior columns are not allowed within the 81-square-inch plan, but may be utilized in any cantilevered areas outside the 81-square-inch area. Interior bracing is allowed in tenant areas but may not touch the interior floor space. Floors need not be solid, but must have sufficient framing so that a 1" ball cannot pass through to the level below.

F. There is no limit on the number or configuration of pasta elements

that can be used to make-up individual columns, beams or braces. There is no limit on the amount of glue used. Pasta may be cut, broken, bent, laminated, or otherwise manipulated in any way desired by the team.

G. Only the hot-melt glue may be used to connect pasta together.

Initial Judging

Judges will evaluate the following characteristics of the designs:

- Clarity of the drawings – is the intent of the design obvious?
- Draftsmanship – is the drawing work neat and professional?
- Compliance – do the drawings reflect compliance with the design rules?

Judges will evaluate the following characteristics of the construction:

- Does the structure utilize only the materials supplied for the competition?
- Does the structure comply with the dimensional requirements?
- Does the structure match the design depicted on the team's drawing(s)?
- Are all elements of the structure attached?
- How neat and craftsman-like is the construction?
- How aesthetically pleasing is the structure?
- How creative or distinctive is the structure?

Once the initial judging is complete, the structures will be tested for load-carrying capacity.

Static Testing

The purpose of static testing is to calculate the structural efficiency ratio of the structures (the ratio of the structure's weight to the total weight supported).

1. Each structure will be weighed prior to testing.
2. Each structure will then be tested to determine whether it will support the specified live loads, using the following procedure:
   - The structure will be mounted in position at the testing station.
   - The static load will consist of a 2½ -pound lead weight placed on the center of the two test mount plates.

Structural failure is defined below.

Dynamic Testing

Each structure, while still loaded with the test weight, will then be subjected to dynamic testing to simulate an earthquake, using the following procedure:

1. The structure will remain mounted in position at the testing station.
2. The test station will be set to amplitude level one and energized to frequency level one for approximately five seconds
3. The test station will be turned up to frequency level two for approximately five seconds
4. The test station frequency will continue to be increased, running for approximately five seconds at each step, until it reaches the maximum frequency level of 10.

5. If the structure has not failed, the test station will be adapted to amplitude level 2 and the above frequency sequence repeated.

Structural failure is defined below.

Structural Failure

Structural failure is defined as the first occurrence of any of the following:

1. Permanent deflection of any portion of the structure in any direction by 2 inches or more.
2. Failure of the structure to retain the load test block on the floor surface.

Awards

Ideally every team goes home a winner. Consequently, many different awards can be created such as follows:

Highest Floor Plate *(tallest building, measured to the top-most level)*	**Most Aesthetically Pleasing Project***(most aesthetically attractive appearance, regardless of function)*
Most Efficient Structure *(the greatest strength-to-weight ratio)*	**Most Innovative Project** *(most unique, creative or unconventional design)*
Strongest Structure *(withstands the greatest loading, regardless of its weight)*	**Best Seismic Performance** *(no column failures)*
Best Construction Workmanship *(neatest, most precise construction)*	**Judges' Award** *(discretionary)*
Best Design Drawings *(neatest, most draftsman-like work, as well as accurately depicting the actual structure built)*	