SUMMER INSTITUTE FOR ENGINEERING AND TECHNOLOGY EDUCATION

MECHANICAL ENGINEERING - TEACHER MODULE 4

BRIDGE CONSTRUCTION

TEACHER NOTE: This will require more than one standard class period.

CONCEPT

This experiment is designed to show how the strength of different kinds of materials vary, and how these materials are used to our advantage to build bridges, buildings, roads.

OBJECTIVES

- Students will learn how and why structures fail.
- Students will learn what happens when a structure is subjected to a load.
- Students will learn the kinds of forces the bridges are subjected to and how this knowledge helps in the selection of materials for construction of bridges.

SCIENCE PROCESS SKILLS

- Informing
- Describing
- Recognizing
- Designing
- Constructing Models
- Formulating and Solving Problems

AAAS SCIENCE BENCHMARK

1B Scientific Inquiry
2B Mathematics, Science and Technology
8E Information Process
11B Models
12C Manipulation and Observation

SCIENCE EDUCATION CONTENT STANDARDS (NRC):

Grades 5 - 8

- Scientific explanations
- Use appropriate tools and techniques, and analyze data
- Construct models and experiment

Grades 9 - 12

- Scientific explanations
- Use appropriate tools and techniques, and analyze data
- Construct models and experiment
- Recognize and analyze alternative explanations and models

STATE SCIENCE CURRICULUM FRAMEWORKS

Grades 5-8: 1.1.9, 1.1.10, 1.1.11, 1.1.13, 1.1.14, 1.1.15, 1.1.16, 3.1.2, 3.1.3, 3.1.7, 3.1.8, 3.1.21, 3.1.22, 3.1.23

Grades 9-12: 1.1.20, 1.1.21, 1.1.22, 1.1.23, 1.1.24, 2.1.14, 2.1.15, 3.1.34, 3.1.38, 3.1.39

MATERIALS

(These are materials to choose from. Assign a dollar value for each item)

For A Group Of 3-4

- Popsicle sticks(Approximately 100)
- Raw spaghetti
- Rubber bands
- Binding materials like Glue, Scotch tape, masking tape.
- 4 Bricks or 2 Shoe boxes or 2 tables placed apart. (to be used to support the ends of the bridge)

THE JOB

Your job is to design a bridge of length 24 inches making use of the materials provided to you. Your aim is to design a bridge that will survive the maximum permissible load for the materials provided to you. at the minimum cost. **When the experiment is complete each group's bridge will be evaluated by placing weights on the bridge to test which one of the bridges will survive the maximum weight.**

PROCEDURES:

When engineers solve problems the first questions they ask themselves are Why ....? ,How....?, and What happens.....?.

The problem that we are presented with here is to design a bridge that will survive the maximum weight. The first question we ask is, "Why do bridges or any structures fail?" The bridges fail due to a number of reasons, but the most important reason is stress.

> **Grades 9-12:** Stress is an internal resistance developed in a structure because of an external force. If a weight of 500 pounds is suspended by a rope, a stress of 500 pounds exists in every cross-section of the rope. The stress in a structure is produced whenever there is a force which tends to shorten or elongate the structure.

The next question we ask is, "What happens when a structure is subjected to stress?" A stress is always accompanied by a 'deformation' or a change in shape of the body. As the applied force increases, the stress increases, as well as the deformation.

"What kinds of forces are the bridges normally subjected to?" The bridges are normally subjected to compression.

"How does compression affect the structure?" When a structure is subjected to compression there is shortening in length of the structure and this deformation increases with the increase in the compressing force. This deformation continues with the increase in force only up to a certain limit, which in engineering terms is called the elastic limit, later causing the structure to fail. If the stress in the structure is less than the elastic limit, the structure returns to its original shape when the stress is removed. We can notice this if we were to stand on the side walk of a bridge and a 90 ton truck just passed by).

"What kind of material would you prefer to build a bridge--a material with high elastic limit or low elastic limit?"

TEACHER NOTES

Have students consider both horizontal and vertical forces when designing bridges.

ASSESSMENT

Grades 5-12:

After testing the strength of the bridges, have each group redesign their bridge to improve the stability.

Grades 9-12:

Have all students write an informal lab report.

BIBLIOGRAPHY

Strength And Fracture Of Engineering Solids, David K. Felbeck, Anthony G. Atkins, Englewood Cliffs, NJ, Prentice-Hall, 1984

Strength Of Structural Materials: Understanding Basic Structural Design, Giuseppe de Campoli, Wiley, New York, 1984

Statics And Strength Of Materials, George P. Kraut, Reston, VA, Reston Pub Co, 1984

Statics And Strength Of Materials, Irving Granet, New York, Holt, Rinehart and Winston, 1982

History Of Strength Of Materials: With A Brief Account Of The History Of Theory Of Elasticity And Theory Of Structures, Timoshenko, Stephen, New York, McGraw-Hill, 1953