

MOREnet, MODOT and RoundTrips Present:
Bridge Failures: A Look at Stress

Date: March 13, 2009

Times: 9:00 a.m. to 9:50 a.m. Central Time and 10:00 a.m. to 10:50 a.m. Central Time

Grade Levels: 7-12

Cost: No Fee

Abstract:

Why do seemingly well-designed bridges suddenly collapse? How do forces, both natural and man-made create stress and cause bridge failure? What's the science involved in these events? Meet with engineers and ask your questions as you investigate real-life bridge failures.

Program Description:

On November 7, 1940, in what may be the most dramatic footage of a bridge failure ever caught on film, the Tacoma Narrows Bridge in Washington collapsed while being buffeted by wind. Luckily no one was injured. On August 1, 2007, during the height of rush hour traffic, the I-35W Bridge collapsed in Minneapolis, plunging dozens of cars and their occupants into the Mississippi River. On April 5, 1987, after days of record rainfall and floods, the Schoharie Creek Bridge in New York collapsed killing ten people.

Why do seemingly well-designed bridges suddenly collapse? How do forces, both natural and man-made create stress and cause bridge failure? The causes for the three bridge failures above were each different. However, the investigation for each resulted in the same opportunity: to learn from that failure, to be able to design, construct, and maintain better bridges.

What's the science involved in these events? Find out for yourself as you interact with engineers and ask your questions as you investigate these and other real-life bridge failures. Learn about stress points, important elements in design and maintenance, and the effect of natural forces like wind, rain and river flow on the life of a bridge. Find out what engineers do to counteract those forces and create the best bridge design possible. Join us for our fifth program in our continuing series of programs produced with the Missouri Department of Transportation as they build a new bridge over the Missouri River at Glasgow, Missouri.

Program Objectives:

1. The participant will explore the essential elements involved in basic bridge design.
2. The participant will interact with experts involved in planning and executing bridge design and construction and learn about their occupations and work process.
3. The participant will gain knowledge about the engineering of bridges.

Program Format:

The program will focus on the causes of bridge failure, both natural and man-made.

Program Order—The videoconference program will consist of the following segments.

1. Welcome and Introduction—Student groups and experts will be introduced and welcomed to the program. Information will be given on the series of interactive programs that will continue throughout the school year as the new bridge is constructed.
2. Creation of Stress/Causes of Failure—Students will interact with engineers as they take them through various examples of bridge collapse caused by varying factors. Examples will include the ones mentioned in the program description as well as others. Video footage, pictures, and graphic elements will be included to help the students understand what caused the bridge to fail and how engineers now seek to counteract those forces in future bridges. Students will have many opportunities to ask questions during the program. Websites included in the program's learning activities section can be used to help students develop these questions.
4. Summary and Closing—We'll summarize the major concepts learned today, seek final questions from students, and invite participation in the school year series of programs that will follow the construction of the new bridge.

Featured National Standards: (Science)

From the Center for Science, Mathematics and Engineering Education

6.5 Science and Technology Standards**Grades 9- 12**

Abilities of technological design

Understanding about science and technology

Featured State Standards (Missouri):

Schools from across the country are invited to join in the program. Missouri state standards are provided for Missouri schools since funding for this program comes from various Missouri organizations.

Show-Me Knowledge Standards (Science)

In Science, students in Missouri public schools will acquire a solid foundation which includes knowledge of:

2. properties and principles of force and motion

Missouri Grade Level Expectations**Strand 2 Force and Motion**

Laws of Motion

Work and Simple Machines

Force, Motion, and Work

Interactions between Energy, Force, and Motion

Participant Preparation:

1. Participants should come to the program with an interest in bridges, engineering, math or science.
2. Participants should utilize preparatory materials provided for the program and other resources of their own to better understand the context of the program's subject and to think in advance of questions they wish to ask the experts. Any questions determined in advance, can be e-mailed to us prior to the program at roundtrips@clayton.k12.mo.us.
3. Participants should have pencil and paper ready to use during the program to jot down ideas and additional questions as they come to mind.

Pre-Program Activity Suggestions:

1. Students should explore the Missouri Department of Transportation website dealing with building the new Glasgow Bridge. That website can be found at <http://www.modot.mo.gov/northcentral/glasgowbridgeproject.htm>. The site includes information about the original bridge, plans for the new bridge, and a web cam showing current work on the bridge. Students should develop questions about what they read to ask during the program or to send to us in advance of the program at roundtrips@clayton.k12.mo.us. Teachers might want to divide the class into groups and have each group investigate a specific part of the website to explore in depth. Students can then share their learning with the rest of the class and present the questions they have developed to ask of the program's experts.
2. Have students explore the PBS website <http://www.pbs.org/wgbh/nova/bridge/build.html> and play the game to build the bridge they believe is best for the locations shown. What questions do they have for engineers based on this experience?
3. Have student investigate examples of bridge collapses by looking at websites provided in the Bridge Failures Web Resources handout included with this program's preparatory materials. What questions do they have for engineers based on their research?

Post-Program Activity Suggestions:

1. As a follow up to this program and as a lead in to the other programs in the upcoming series, have students create a list of questions they have about "what happens next" in the construction of the new bridge. Send those questions to us at roundtrips@clayton.k12.mo.us for MODOT experts to answer and reply to your students.
2. Have students share what they found most interesting and potentially frustrating about the careers they saw today. What would they like or dislike about being an engineer or bridge builder?
3. Have students return to the websites provided in the Bridge Failures Web Resources handout included with this program's preparatory materials. What do they understand now that they did

not understand before? What additional questions now come to mind they'd like to e-mail the engineers at roundtrips@clayton.k12.mo.us.

Vocabulary:

Tension—In physics, tension is the magnitude of the pulling force exerted by a string, cable, chain, or similar object on another object.

Compression—Physical compression is the result of the subjection of a material to compressive stress, resulting in reduction of volume. The opposite of compression is tension.

Bending—In engineering mechanics, bending (also known as flexure) characterizes the behavior of a structural element subjected to an external load applied perpendicular to the axis of the element. A structural element subjected to bending is known as a beam. A closet rod sagging under the weight of clothes on clothes hangers is an example of a beam experiencing bending.

Torsion—In solid mechanics, torsion is the twisting of an object due to an applied torque.

Shear—A shear stress is defined as a stress that is applied parallel or tangential to a face of a material, as opposed to a normal stress which is applied perpendicularly. In other words, considering that weight is a force, hanging something from a wall creates a shear stress on the wall, since the weight of the object is acting parallel to the wall, as opposed to hanging something from the ceiling which creates a normal stress on the ceiling, since the weight is acting perpendicular to the ceiling.

Arch Bridge--The main supporting structure in an arch bridge is one or more curved elements. The dead and live forces that act on the arch bridge are transmitted along the curved line of the arch into abutments or supporting structures at either end. These abutments are sunk deep into the ground, into bedrock if at all possible.

Beam Bridge--The simplest type of bridge consists of a single piece of material that stretches from one side of a barrier to the other side. That piece of material—called a beam or girder—rests directly on the ground on each side or is supported on heavy foundations known as piers.

Suspension Bridge--In a suspension bridge, thick wire cables run across the top of at least two towers and are anchored to the shorelines within heavy abutments. In some cases, the roadway is supported directly by suspenders from the cables. In other cases, the suspenders are attached to a truss, on top of which the roadway is laid. In either case, the dead and live loads of the bridge are transmitted to the cables, which, in turn, exert stress on the abutments. That stress is counteracted by attaching the abutments to bedrock.

Cable-Stayed Bridge—A cable-stayed bridge is a bridge that consists of one or more columns (normally referred to as towers or pylons), with cables supporting the bridge deck.

Live Load--The force exerted on a bridge as a result of the traffic moving across the bridge.

Dead Load--The force exerted by a bridge as a result of its own weight.

Dynamic Load--The force exerted on a bridge as a result of unusual environmental factors, such as earthquakes or strong gusts of wind.

Truss--A structure that consists of a number of triangles joined to each other.

Cantilever--A cantilever bridge is a variation of the simple beam bridge. A cantilever is a long arm that is anchored at one end and is free to move at the opposite end. A diving board is an example of a cantilever.

Substructure--The understructure support of the bridge including foundation, piers, bents, caps, columns, footings, etc.

Abutment-- Point of contact between two objects or parts

Scour—the removal of sediment such as sand and rocks from around bridge abutments or piers. Scour, caused by swiftly moving water, can scoop out scour holes, compromising the integrity of the bridge.

Series Information:

This program is the fifth of a ten part series of programs dealing with the Missouri Department of Transportation building a new bridge over the Missouri River at Glasgow, Missouri. Schools may sign up for one program or any combination thereof. More information about the entire series of programs, including archived versions of previous programs in the series can be found at: <http://mobrbridge.more.net>.