Bridge the Gap

Unit Summary

Student groups of civil engineering firms design and construct a bridge that will hold the most weight for a given span. In preparation for their project, students build different structures; investigate properties of triangles and rectangles; take a virtual bridge field trip to learn about various types of bridges and examine famous bridges from around the world; and conduct several design and strength tests.

At a Glance
Grade Level: 6-9
Subject(s): Geometry, Civil Engineering, and Physics
Topics: Properties of Shapes; Triangulation; Structural Analysis, Scale Factor
Higher-Order Thinking Skills: Cause and Effect, Problem Solving
Key Learnings: Properties of Polygons, Triangle Inequality, Triangulation and Structural Stability of Designs
Time Needed: 3-4 weeks, 45-minute lessons

Curriculum-Framing Questions

- **Essential Question**
  How can math help me understand my world?
- **Unit Questions**
  Why is geometry important to building structures?
  How can geometry help us build a better world?
  What factors influence bridge strength?
- **Content Questions**
  What is triangulation in geometry?
  How do side lengths determine the shape of a triangle and a quadrilateral?
  What are the basic bridge types?

Assessment Processes

View how a variety of student-centered assessments are used in the Bridge the Gap Unit Plan. These assessments help students and teachers set goals; monitor student progress; provide feedback; assess thinking, processes, performances, products; and reflect on learning throughout the learning cycle.

Things You Need
Assessment
Standards
Resources

Instructional Procedures

Prior to Instruction:
This unit of study makes use of the *Seeing Reason* and *Visual Ranking Tools*.
Examine both the *Seeing Reason* and *Visual Ranking Tools* prior to planning instruction to learn about them and how to use them with students.

Set the Stage (1 day)
Begin the lesson by asking students the Essential Question: *How can math help me understand my world?* Divide students into small groups and have them discuss the Essential Question and record their initial thoughts. Tell the students that they are going to begin a unit about bridges in which they will explore how math, specifically geometry, is an important part of designing and building bridges and structures.

Use the following spaghetti tower task to set the stage for the unit. The objective in setting the stage is to recreate some of the challenges bridge builders face and to introduce the bridge-building unit. Introduce the unit by asking students to complete the following task in small teams:

- Design and build a tower structure using uncooked spaghetti that will support a can that sits 30 cm (about 1 ft) above the floor or the desktop.
    - The base of the structure should be no wider than the diameter of the can. The spaghetti can be cut into any length.
    - The spaghetti can be taped at the top and bottom only.
    - The can must be positioned with the open end facing up so weights can be added to it.
    - The structure must support the most weight possible.

- Have students record the number of noodles used, the number of taped joints, and the maximum weight the structure can support before collapsing.
- Have students stop adding weights when it starts to wobble.
- On a separate sheet of paper, direct students to sketch the design and point out its strengths and weaknesses. Have students identify various geometric shapes in their towers. When done, have students compare their design with others in the class and write down two things they would do to improve their structure.
  Materials needed per team:
    - 75 uncooked spaghetti noodles
    - Masking tape
    - Can
    - Rocks/marbles/other weights

Have groups discuss their towers describing what worked and what didn't. As a class, discuss the following Unit Question: *Why is geometry important in building structures? What did you learn by doing this activity?*

Explore Properties of Polygons (2 days)
In preparation for the following activities, ask students to think about the questions they discussed after the previous activity: *Why is geometry important in building structures? What did you learn by doing this activity?* If they haven't discussed it already, lead students to the fact that certain polygons in geometry are stronger than others. Tell them that they will be exploring properties of polygons during the next few days.

Ask students the following Content Questions: *What is triangulation? How do side lengths determine the shape of a triangle? Or a quadrilateral?* Elicit student ideas about these questions. Tell them that they will explore these questions during today's and tomorrow's lessons. Students will spend one lesson on triangles and one on quadrilaterals to explore the ways that side length determines the shape of polygons.

Triangles Lesson. Students investigate the questions: Suppose you are given three numbers to be lengths of sides of a triangle. *Will it always be possible to make a triangle with those side lengths? Can you make two or more different triangles from the same side length?* Have students use straws and string to explore various combinations of side lengths. They can roll three dice to determine the lengths to use in the triangle. They should sketch and label their results.
Materials needed per team:

- A variety of straws cut into lengths of: 1,2,3,4,5,6 inches
- 3 dice per group
- String
- Scissors

When they have completed the problem, have them look back over their examples and use the straws to explore: *What combinations of side lengths create triangles that you often see in designs and buildings?*

Return to the Content Question posed at the beginning of the lesson and ask students if they have new insights into the questions: *Do side lengths determine the shape of a triangle? What is triangulation?*

Quadrilaterals Lesson. Begin the lesson reminding students of yesterday's lesson, telling them that today they will investigate the Content Question: *Do side lengths determine the shape of a quadrilateral?* Ask students to make conjectures. Students use this lesson to investigate the problem: Suppose you are given four numbers to be lengths of sides of a quadrilateral. *Will it always be possible to make a quadrilateral with those side lengths? Can you make two or more different quadrilaterals from the same side length?* Have students use straws and string to explore various combinations using four dice and sketch and label their results. Have them compare their results to the triangle lesson yesterday. Ask, *How are the results similar and different?*
Materials needed per team:

- A variety of straws cut into lengths of: 1,2,3,4,5,6 inches
- 4 dice per group
- String
- Scissors

When they have completed the problem, have them look back over their examples and use the straws to explore: *What combinations of side lengths create quadrilaterals like those you often see in designs and buildings? How does this compare to what you noticed about triangles yesterday?*

Structures Scavenger Hunt (2 days)
Groups of students go on a scavenger hunt of various structures and use presentation software to teach the class about their findings. Go over Structures Scavenger Hunt handout and discuss the details of the assignment. In brief, groups of students search several pre-determined Web sites that show various building structures and bridges. Each of the eight groups are given different topics: beam and truss bridges, suspension bridges, arch bridges, cantilever bridges, skyscrapers, airports, their school, and stadiums. Research on the structures needs to include:

- its definition
- its characteristics
- the types of polygons used

- combinations of side lengths and structural strengths and weaknesses
- how geometry is part of that structure in the world

This helps students answer the Essential and Unit Questions, *How can geometry help us build a better world?* as well as *How can math help me understand my world?*

Students create a slideshow and teach the rest of the class about their structure. Use this sample student presentation to demonstrate the above elements. Students need to include definitions and visual images of new terms and ideas they encounter on the scavenger hunt such as: truss system, lateral stabilization, and degree of arch curve (these will emerge in various Web sites as they examine the characteristics of the different structures).

Have students take notes during each group's presentation so that they can use the new information in their upcoming bridge experiments. Keep a chart paper of new terms and definitions that emerge from students presentations as a public document for all students to use over the course of the unit. If some important terms and ideas do not emerge from the presentations, introduce them as they relate to the student presentations. This will help prepare students in developing their *Seeing Reason* causal map.

Simple Bridge Experiments (2 days)
In order to investigate the Content Question: *What are some factors that influence bridge strength*?, students use spaghetti to design and test beam and arch bridges to determine which of the two structures holds the most weight.

Testing Beam and Arch Bridges. In brief, students use bricks and cardboard to build a beam and arch bridge and determine which of the two structural designs holds the most weight.
Each group will need:

- 2-4 bricks
- Cardboard
- Weights
- Lab procedures handout

Redesigning the Spaghetti Tower. Have students design and build a tower structure using uncooked spaghetti that supports a can that sits 30 cm (about 1 ft) above the floor or the desktop. This task requires students to use what they have learned so far about triangulation and structure strength. It gives them a chance to go back and redesign the tower they built on the first day of the unit and to try out and test new ideas about structural design and strength. Students should use the following specifications to redesign their tower:

- The base of the structure should be no wider than the diameter of the can.
- The spaghetti can be cut into any length.
- The spaghetti can be taped at the top and bottom only.
- The can must be positioned with the open end facing up so weights can be added to it.
- The structure must support the most weight possible.

Have students record the number of noodles used, the number of taped joints, and the maximum weight the structure can support before collapsing.

- Have them stop adding weights when it starts to wobble.
- On a separate sheet of paper, direct students to sketch the design and point out its strengths and weaknesses. Ask students to compare their new designs with their initial designs and write about the improvements they made.
- When done, have students compare their design with others in the class and write down two things they would do to improve their structure. Ask them to reflect on the following questions:
    - *Why is it important to redesign?*
    - *How can past designs improve future designs?*

Materials needed per team:

- 75 uncooked spaghetti noodles
- Masking tape
- Can
- Rocks/marbles/other weights

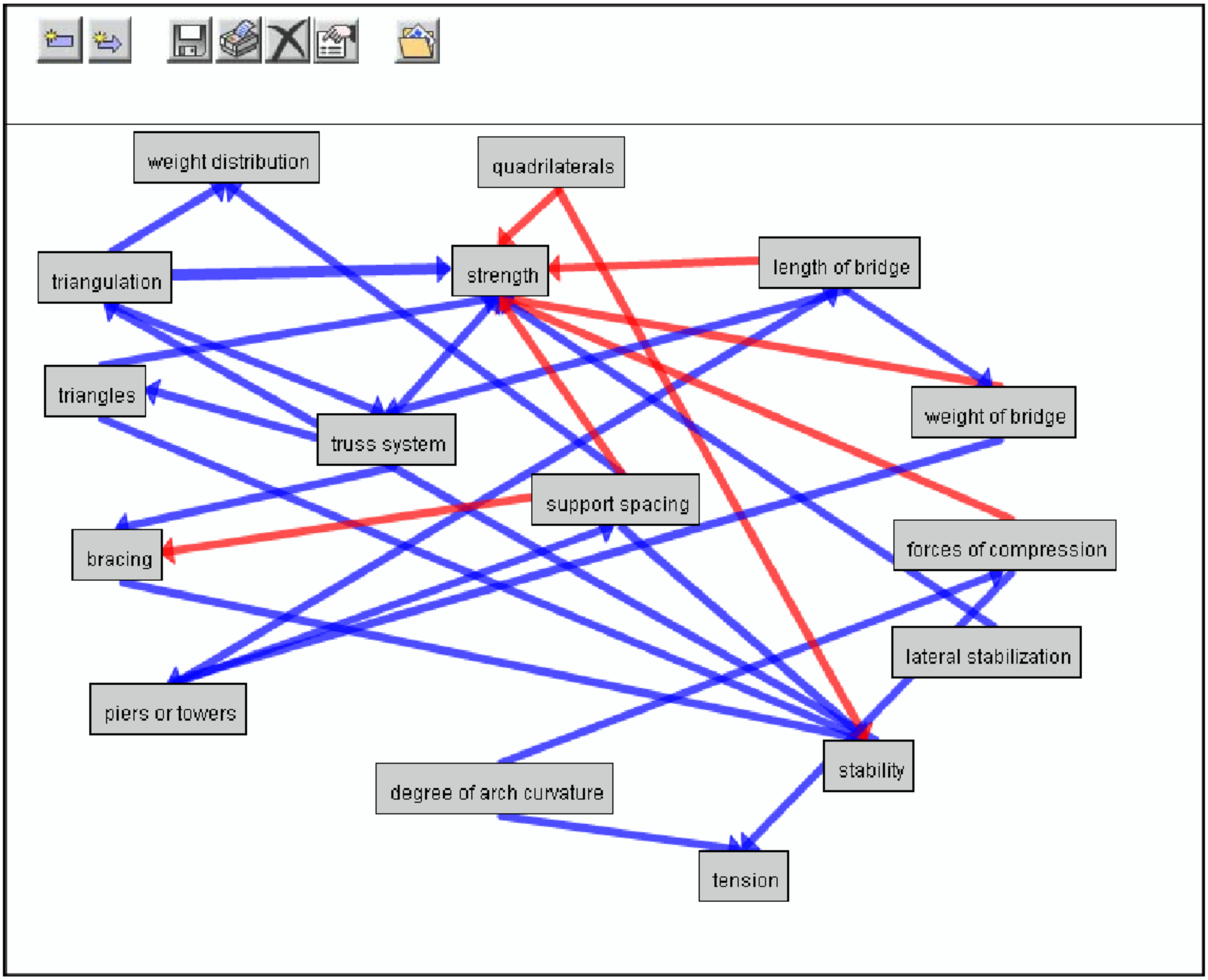
Discuss as a class the characteristics of strong and weak towers. Have students identify and discuss what they know about shapes and relate how those shapes have affected the towers they built.

Use Seeing Reason to Study Factors that Influence Bridge Strength (2 days)
Before proceeding with the next activity, click here to set up the Bridges project in your workspace. Place students in groups and ask them to use *Seeing Reason* to respond to the Unit Question: *What factors influence bridge strength?* Students need to include data from previous work in this unit to support relationships and factors such as those shown in the following map. Encourage them to use the description feature of the tool to explain their thinking and the relationship between factors. This activity serves as a midpoint unit performance assessment, whereby readiness for the bridge building task can be determined. Use the midpoint scoring guide to determine students' readiness.

Examine the Seeing Reason Activity
The *Seeing Reason* space below represents one team's investigation in this project. The map you see is functional. You

can roll over the arrows to read the relationships between factors, and double-click on the factors and arrows to read the team's descriptions.

Project Name: **Bridges** **(Click here to set up this project in your workspace)**
Question: **What factors influence bridge strength?**



*If students need more experiences, ask students to look back over their notes and work on the previous lessons: polygons activities, structures scavenger hunt, and bridge experiments to look for relationships between bridge design and strength. Discuss the characteristics of strong and weak bridges. Ask them to re-evaluate their maps and adjust factors, relationships, and descriptions to fit anything new they have learned.

Bridge Building Task
Provide the following scenario to the students:
Your civil engineering firm has been hired to design and build a model of a bridge to replace the old bridge in your city. Your task is to design the bridge, build a model, and create a portfolio to present before the town council for approval. As a first task, each team needs to decide on your civil engineering firm's name.

Your model will be tested for strength and must meet the following specifications:

1. *You can only use spaghetti noodles and masking tape to build your bridge*
2. *The bridge must have a span of at least 30cm long*
3. *A roadbed of at least 5 cm wide and a clearance of at least 10 cm in height*
4. *The distance between the bridge supports should be at least 10 cm apart, unless the bridge has only one tower or support structure*

In addition to presenting your model, your portfolio to the town council needs to provide clear and convincing evidence for your choice of design, blueprints of your model bridge, and other supporting documentation such as: concept webs, graphs, charts, and photos.

Distribute the presentation scoring guide to the students to help them understand the expectations for the project.

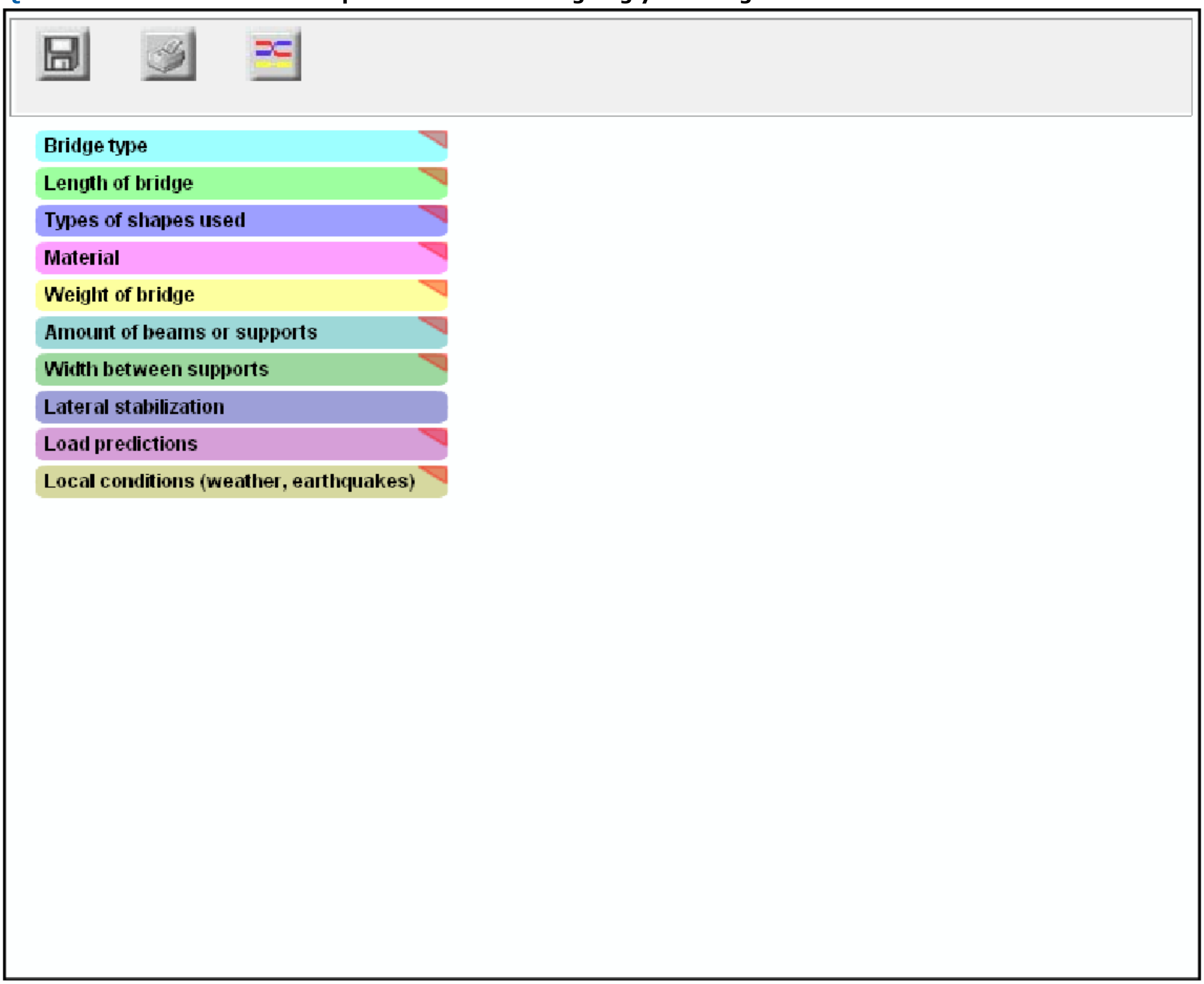
Review and answer any questions they might have. Ask students to refer to the scoring guide as they work on the project.

Use Visual Ranking to Rank the Most Important Factors in Designing Your Bridge (1 day)
Introduce the *Visual Ranking Tool* using the demonstration space at Try the Tool. Before proceeding with the next activity, click here to set up the Designing Bridges project in your workspace. Show students how to rank and compare lists, and how to describe items and explain their relative merit using the comments feature. Point out the meaning of the correlation coefficient (the degree to which rankings agree or disagree). A coefficient of 1.0 is perfect agreement, and a coefficient of –1.0 is a perfect disagreement.

- Have students log in to their *Visual Ranking* team space. Point out the prompt that guides their ranking: *What is the most important factor in designing your bridge?* Have each civil engineering firm rank the items with this in mind, and explain the relative merit of each item using the comments feature of the tool. As students sort their lists, listen to their discussions and ask questions to help groups negotiate, make choices, and express their thinking.
- Once the groups have finished ranking and commenting, have them compare their lists with the lists that were ranked by the other firms. They should read each other's comments about the relative merit of each factor. Have students discuss why their lists are alike and different. Suggest that they identify the firms that ranked items most and least like they did. Have similar and dissimilar firms meet to discuss their rankings and rationale behind the order. Some firms may want to revise their thinking based on the things they learn from other firms.

Examine the Visual Ranking Activity
The *Visual Ranking* space below represents one team's ranking on this project. The view you see is functional. You can roll over the red triangle to see the firm's comments and click the compare button to see how different firms ranked the items.

Project Name: Designing Bridges (Click here to set up this project in your workspace)
Question: What is the most important factor in designing your bridge?



Inform and Persuade Others

Once firms are finished ranking and discussing, have the firms reflect on the process by answering some of the following questions:

1. *What was it like defending your group's point of view? Was it difficult? Why?*
2. *What was the biggest obstacle to settling on a compromise within your firm? What obstacles do civil engineering firms in general face when they are trying to get things done?*
3. *What are other similar situations where there are different groups with competing interests?*

Meet again as a large group and discuss these same questions. Using a projector system and networked computer display the lists and discuss general themes that appear. Ask students to consider: *Is any factor consistently in the top of the ranking? At the bottom of the ranking? What about those factors relate to design decisions in building a model bridge?*

Ask students to reflect in their journals about the most and least important features to consider when building a bridge. Read the entries to assess for understanding before moving on to the design phase of the project.

Decide on Bridge Type, Design, and Create a Blueprint (1-2 days)
Have students draw the side, top, and end view of the bridge they have chosen along with the support structure according to specifications. Be sure to have them include measurements and scale factor on their drawing. Make sure they keep track of the number of noodles they will use, the length of the noodles needed, and the amount of taped joints. This will serve as their firm's blueprint to use in constructing the model. Review the blueprints and offer suggestions as needed.

Bridge Building (5-6 days)
Give students five or more days to build their bridge models during class. The time allotment will vary by the type of bridge they are building. As students build their bridges, circulate through the teams asking questions and taking notes about group processes, conceptual understanding, and thinking skills such as problem solving and analysis.

Final Presentation to the Town Council (1-2 days)
Use the presentation scoring guide to assess the final presentation, blueprints, and portfolio. As a part of each firm's presentation, they will test the maximum weight the structure can support before collapsing. The students will test the strength of the bridge by placing a can on top of the bridge (in the middle) and adding weights until it starts to wobble.

Summarize the unit work by asking students to respond in writing to the Essential and Unit Questions, *How can math help me understand my world?, How can geometry help us build a better world?,* and *Why is geometry important to building structures?* Remind students to use this opportunity to showcase what they have learned about structures and strength as they answer the questions.

Prerequisite Skills

- Measuring
- Drawing scale models
- Familiarity with multimedia presentation software

Differentiated Instruction

Resource Student

- Make modifications as dictated in the student's IEP
- Provide visual aids and examples (documents, photos, and examples from this Unit Plan can be helpful)
- Supply an outline of the tasks and timeline for the project (including milestones)
- Select group best suited to work with this student
- Provide extra time as needed to complete individual assignments

Gifted Student

- Have students keep a budget of the firm's bridge expenses, acting as the accountant for the firm; researching materials costs; deciding upon what lumber (noodles) cost per foot, what braces (masking taped joints) cost, how much material was used and the amount of waste; using a spreadsheet keep a running record of expenses incurred and an estimated beginning budget.

English Language Learner

- Provide visual aids and examples (documents, photos, and examples from this Unit Plan can be helpful)
- Use example structures from student's native culture in an effort to link the unit to student's prior knowledge and experiences
- Utilize the geometric shapes in creating tables (use images of triangles with side lengths labeled on charts to represent combinations that do and do not make triangles)

Credits

A teacher participated in the Intel® Teach Program, which resulted in this idea for a classroom project. A team of teachers expanded the plan into the example you see here.

Assessment Plan

Assessment Plan

Before project work begins

- Reflect on Essential Question

- Spaghetti Tower Pre-Activity

Students work on projects and complete tasks

- Informal Observation
- Feedback
- Spaghetti Tower Post-Activity
- *Seeing Reason* Maps

- Midpoint Scoring Guide
- *Visual Ranking* comments
- Reflections

After project work is completed

- Presentation Scoring Guide

- Reflections

Use both informal and formal methods for checking student understanding. Informal: Monitor and listen carefully to student thinking, ask probing questions such as *How do you know that works?*, review drafts, and give students feedback as they work through project activities. Have students check work with their firm members. Formal: Assess students' understanding and readiness for the bridge building project by using the midpoint scoring guide and re-teach ideas if necessary. Provide the presentation scoring guide to students and explain the expectations before they start working. Assess students' final portfolio presentation, which includes the model bridge using the presentation scoring guide. Ask students to reflect on their learning by answering the Essential and Unit Questions.

Content Standards and Objectives

Targeted Content Standards and Benchmarks

NCTM Content Standards:

Geometry Standard for Grades 6-8

In grades 6-8 all students should:

- Precisely describe, classify, and understand relationships among types of two- and three-dimensional objects using their defining properties
- Understand relationships among the angles, side lengths, perimeter, areas and volumes of similar objects
- Draw geometric objects with specified properties, such as side lengths or angle measures
- Use two-dimensional representations of three-dimensional objects to visualize and solve problems such as those involving surface area and volume
- Use geometric models to represent and explain numerical and algebraic relationships;
- Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life

Problem-Solving Standard for Grades 6-8

In grades 6-8 instructional programs should enable all students to:

- Solve problems that arise in mathematics and in other contexts
- Build new mathematical knowledge through problem solving
- Apply and adapt a variety of appropriate strategies to solve problems
- Monitor and reflect on the process of mathematical problem solving

Connections Standard for Grades 6-8

In grades 6-8 instructional programs should enable all students to:

- Recognize and use connections among mathematical ideas
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
- Recognize and apply mathematics in contexts outside of mathematics

Student Objectives

Students will be able to:

- Learn about triangulation
- Understand that side lengths determine the exact shape of a triangle (Side-Side-Side Congruence Theorem), as long as the sum of the lengths of any pair of sides is longer than the length of the third side (this is known as the triangle inequality: $a+b>c$ in order for it to make a triangle
- Understand that for quadrilaterals, side lengths can be arranged in a variety of shapes.
- Understand that the sum of the lengths of any three sides of a quadrilateral is greater than the length of the fourth side
- Understand that the triangle is a stable figure and keep their shape under stress, whereas quadrilaterals can wobble into many unstable shapes and become distorted under stress
- Examine the strengths and weaknesses of structures
- Create procedures for constructing and testing components of a structure
- Compare the strengths of different components of a structure
- Learn about bridge types and their structural design
- Provide arguments related to principles and to evidence for ideas and choices expressed
- Use measurement and scale factor to draw accurate scale models

Resources

Materials and Resources

Printed Materials

- Books or magazines on structures and bridges (optional)

Supplies

- Spaghetti noodles
- Masking tape
- Cans for each group (about 4" or 10 cm in diameter and 5" or 12 cm in height)
- Weights of some kind for each group such as: marbles, rocks, or fishing weights
- Straws
- String
- Rulers

Internet Resources

- Bridge from *Fact Monster*
  www.factmonster.com/ce6/sci/A0808901.html*
  This introductory site provides some basic information about bridges.
- Basic Bridge Types from *Matsuo Bridge*
  www.matsuo-bridge.co.jp/english/bridges/index.shtm*
  This site has lots of introductory information about different bridge types.
- Bridge Basics: A Spotter's Guide to Bridge Design
  http://pghbridges.com/basics.htm*
  This Web site has diagrams and descriptions of a wide variety of kinds of bridges.
- Bridge Building Information from Brantacan
  www.brantacan.co.uk/bridges.htm*
  This site has a comprehensive collection of links about bridges.
- Geometry of Bridge Construction
  www.faculty.fairfield.edu/jmac/rs/bridges.htm*
  This site has a variety of diagrams and pictures of bridges described from a geometrical perspective.
- Bridge Pros
  http://bridgepros.com/*
  This comprehensive bridge-site is dedicated to the engineering, history and construction of bridges. *Not-To-Be-Missed Section:* Bridge Projects from around the world past, current and future.
  http://bridgepros.com/projects/index.html*
- Super Bridge from *PBS NOVA Online*
  www.pbs.org/wgbh/nova/bridge/*
  Learn about the four major types of bridges and then test your knowledge by matching the right bridge to the right location.
- Building Big: All About Bridges from a *Related PBS Website:*
  www.pbs.org/wgbh/buildingbig/bridge/index.html*
  This site includes a Forces Lab in which students can explore forces, loads, materials and shapes.
- Bridge Builder
  www.pbs.org/teachersource/mathline/concepts/architecture/activity3.shtm*
  This site has a simulation that guides students through building a bridge with the fewest number of bricks possible.
- Design and Build a Virtual Bridge Truss.
  www.jhu.edu/~virtlab/bridge/truss.htm*
  Use the program at ***Bridge Designer*** to design trusses. Once a truss is drawn in the program, a click on "Calculate" will check your design. Another click will generate a complete force diagram showing compression/ tension forces in each of the members and reactive forces at the support nodes.
- Spaghetti Bridges: 11th Annual Spaghetti Bridge Contest
  www.jhu.edu/news_info/news/audio-video/spaghetti.html*
  Pictures of spaghetti bridges from John Hopkins University

Other Resources

- List kits
- Equipment
- Film

- Video
- CD-ROM or DVD resources
- Field trip sites
- Experts

Technology – Hardware

- Computer for creating presentations
- Printer for handouts
- Projector for presenting and *Visual Ranking* activity
- Internet connectivity for research and using the thinking tools

Technology – Software

- Presentation software for creating presentations
- Word processing software for writing reflections
- Internet Browser for research

MIDPOINT PERFORMANCE ASSESSMENT SCORING GUIDE

CATEGORY	4	3	2	1
Mathematical Understanding	Explanations in description show understanding of the mathematical concepts used to support the relationships.	Explanations in description show a majority of understanding of the mathematical concepts used to support the relationships.	Explanations show some understanding of the mathematical concepts used to support the relationships.	Explanations show very limited understanding of the underlying mathematical concepts needed to support the relationships OR are not written.
Content	Content from previous activities is thoroughly and accurately incorporated into the relationship explanations.	Content from previous activities is incorporated into the relationship explanations.	Some content from previous activities is incorporated into the relationship explanations.	Minor content from previous activities is incorporated into the relationship explanations OR there are several factual errors.
Causal Mapping	Maps represent accurate causal relationship between factors. Thorough and accurate explanations are given for relationships.	Maps are adequate and do not distort the causal relationship between factors, but interpretation of the explanation is somewhat difficult.	Maps distort the causal relationship between the factors somewhat and interpretation of the explanation is somewhat difficult.	Maps seriously distort the causal relationship between factors making interpretation almost impossible. Little or no explanation is given.
Requirements	All requirements are met and exceeded.	All requirements are met.	One requirement was not completely met.	More than one requirement was not completely met.
Weighting & Scoring		Content & Understanding (Double weighted) 8 6 4 2	Causal Mapping & Requirements (Single weighted) 4 3 2 1	Overall /24

FINAL PRESENTATION SCORING GUIDE

CATEGORY	4	3	2	1
Portfolio (Group)	Our portfolio to the town council provides clear and convincing evidence for our choice of design, accurate and detailed blueprints of our model bridge, and other supporting documentation including a concept web, graphs, charts, and photos.	Our portfolio to the town council provides evidence for our choice of design, accurate blueprints of our model bridge, and some supporting documentation such as a concept web, graphs, charts, and photos.	Our portfolio to the town council provides minimal evidence for our choice of design, blueprints of our model bridge with errors, and one other supporting document: either, a concept web, graph, chart, or photo.	Our portfolio to the town council does not provide evidence for our choice of design, accurate blueprints of our model bridge, or other supporting documents.
Content	Our presentation and portfolio cover all elements relating to the bridge design in depth with details and examples. Our subject knowledge is excellent.	Our presentation and portfolio include essential knowledge about the bridge design. Our subject knowledge appears to be good.	Our presentation and portfolio include essential information about the bridge design but there are 1-2 factual errors.	The content in our presentation and portfolio is minimal OR there are several factual errors.
Understanding (Individual)	I effectively demonstrate a thorough understanding of the importance of geometry in the modern world by providing an insightful explanation with many detailed examples drawn from my work in the unit.	I accurately provide details about the importance of geometry in the modern world.	I provide a few examples about the importance of geometry in the modern world.	I demonstrate severe misconceptions about the importance of geometry in the modern world.
Organization of Presentation	My content is well organized using headings and subheadings effectively to convey relationships among ideas. My bullets summarize my main points.	My content is well organized using headings or bulleted lists to group related material.	My content is logically organized for the most part.	I do not use a clear or logical organizational structure, just lots of facts.
Persuasiveness	My key points are detailed and clear with excellent visuals to support details. I completely persuade the audience to agree or side with my proposal.	My key points are clear but lack detail. My visuals support my points. I am able to persuade most of the audience to agree or side with my proposal.	My key points are a little difficult to understand, but I have included critical components. It is hard to see the connection between my visuals and the key points. The audience is somewhat persuaded but has lots of questions.	My explanation is difficult to understand and is missing several components OR is not included. My visuals do not relate. The audience is not persuaded to agree or side with me.

Presentation	My presentation is well-rehearsed with smooth delivery that holds the audiences attention – slides are constantly referred to and enhance the presentation.	My presentation is rehearsed with fairly smooth delivery that holds audiences attention most of the time – slides are often referred to and enhance presentation.	My delivery is not smooth, but I am able to maintain interest of the audience most of the time – slides are rarely referred to.	My delivery is not smooth and I often lose the audiences attention – slides are not referred to at all.
Check: ☐ Blueprint ☐ Bridge ☐ PowerPoint	Content and Understanding (Double weighted) 8 6 4 2	Presentation, Persuasiveness, and Organization (Single weighted) 4 3 2 1	Overall /28	

Structures Scavenger Hunt

Structures Scavenger Hunt

Find your group topic below and go on a scavenger hunt of structures! Your group will be responsible for teaching the rest of the class about your topic using presentation software. Your presentation needs to include the following:

1. The definition of your type of structure (if applicable)
2. Visual examples from around the world, noting the characteristics that make them your type of structure
3. One visual example of a structure that illustrates:
    - Types of polygons that are seen most often within your structure's design
    - Combination of side lengths that make up those polygons (using your exploration of polygons activities from the past two days)
4. Strengths and weaknesses of this type of structure
5. How shapes factor into the strengths and weaknesses
6. What shapes are missing from your structure and why you think this is
7. What you think would improve your structure's strength
8. How math helps in the design of structures
9. How math helps me understand my world

Beam and Truss Bridges

Explore the Web sites below to find out about beam and truss bridges:
http://science.howstuffworks.com/bridge1.htm*
www.pghbridges.com/basics.htm*
www.pennridge.org/works/brbeam.html*
www.ce.ufl.edu/activities/cdrom/civil/sample.html*
www.pbs.org/wgbh/buildingbig/bridge/basics.html*
www.faculty.fairfield.edu/jmac/rs/bridges.htm*

Suspension Bridges

Explore the Web sites below to find photos and information about suspension bridges:
www.pbs.org/wgbh/buildingbig/bridge/basics.html*
www.pghbridges.com/basics.htm*
http://science.howstuffworks.com/bridge1.htm*
www.faculty.fairfield.edu/jmac/rs/bridges.htm*

Arch Bridges

Explore the Web sites below to find photos and information about arch bridges:
www.pbs.org/wgbh/buildingbig/bridge/basics.html*
www.pghbridges.com/basics.htm*
http://science.howstuffworks.com/bridge1.htm*
www.faculty.fairfield.edu/jmac/rs/bridges.htm*

Cantilever Bridges

Explore the Web sites below to find photos and information about cantilever bridges:
www.richmangalleries.com/cantilever_bridges.htm*
www.brantacan.co.uk/cantilever.htm*
http://en.wikipedia.org/wiki/Cantilever*
www.faculty.fairfield.edu/jmac/rs/bridges.htm*

Skyscrapers

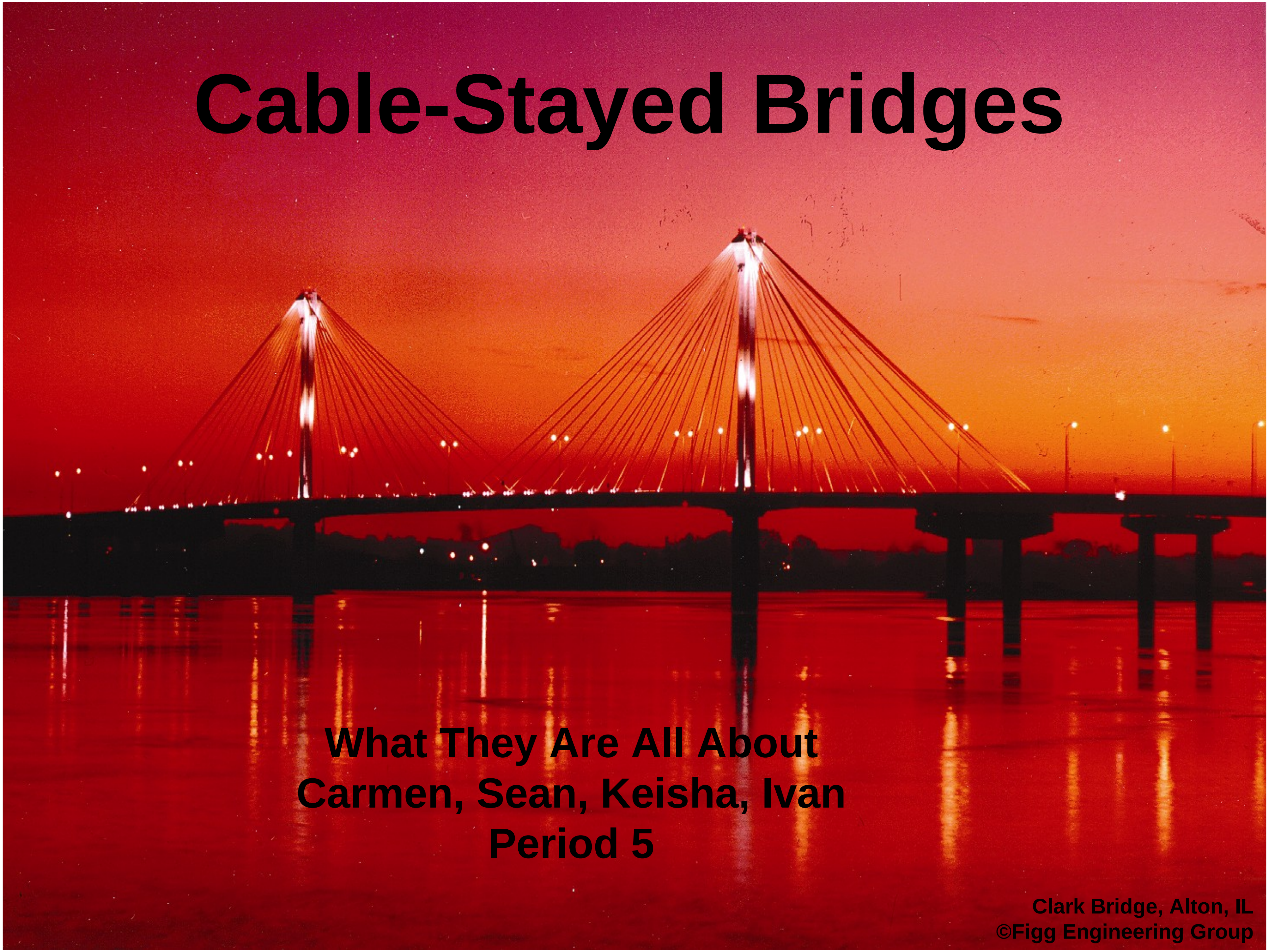
Explore the Web sites below to find photos and information about skyscrapers:
www.pbs.org/wgbh/buildingbig/skyscraper*
www.howstuffworks.com/skyscraper.htm*
www.greatbuildings.com/types/types/skyscraper.html*
www.emporis.com/en/bu/*

Airports
Explore the Web sites below to find photos and information about airports:
www.GreatBuildings.com/types/types/airport.html*
www.kdmodels.com/Airport_structures.htm*
www.architecturalfabrics.com/ch11.html*
www.flysfo.com/about/press/as_min_presskit_new_photo.asp*

Stadiums
Explore the Web sites below to find photos and information about stadiums:
www.worldstadiums.com/*
www.cadinfo.net/editorial/sydney2k.htm*
www.bjghw.gov.cn/forNationalStadium/indexeng.asp*
www.tjhsst.edu/~kdomina/CAD02/dngsui/*

Your School
Explore your school's structure. Use a digital camera to take photos of the structural design of your gym, the cafeteria, the office, the front of the school, etc.

Cable-Stayed Bridges



What They Are All About
Carmen, Sean, Keisha, Ivan
Period 5

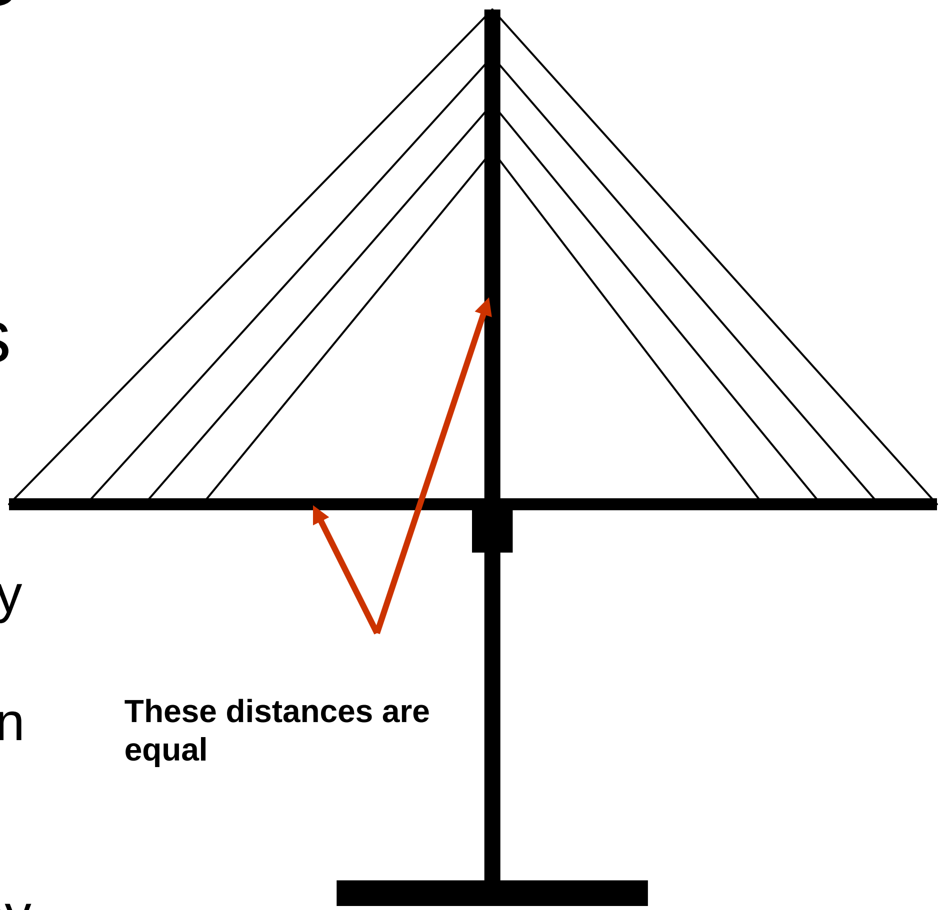
Clark Bridge, Alton, IL

What is a Cable-Stayed Bridge?

- A cable-stayed bridge, one of the most modern bridges, consists of a continuous strong beam (girder) with one or more pillars or towers in the middle
- Cables stretch diagonally between these pillars or towers and the beam
  - These cables support the beam
- The cables are anchored in the tower rather than at the end

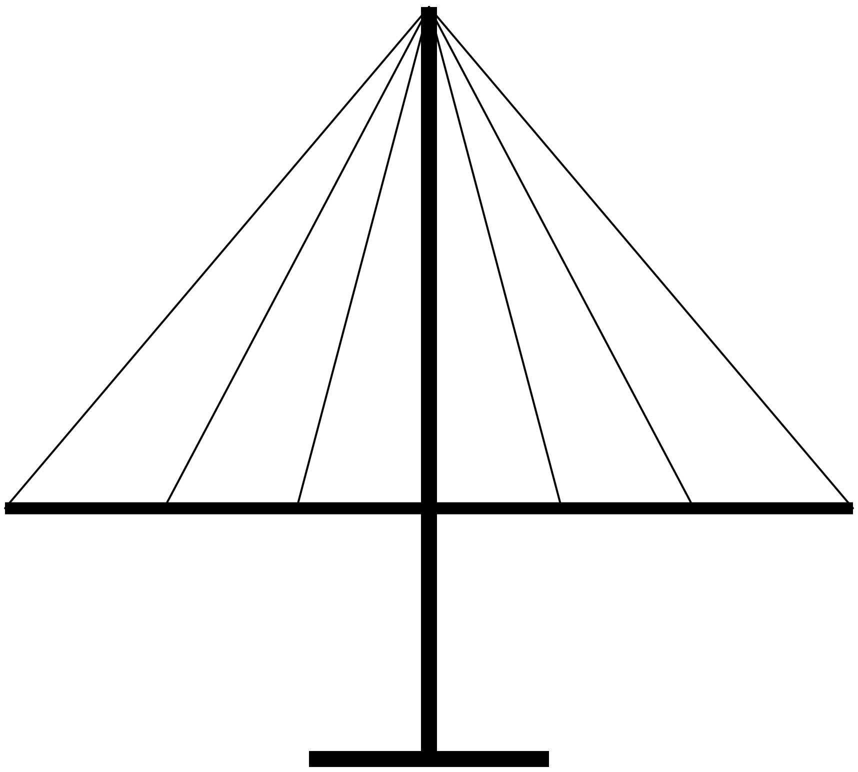
Two Major Classes of Cable-Stayed Bridges

- Different based on how the cables are attached to the pillars
  - **parallel attachment design**
    - cables are made nearly parallel by having the height of attachment on the pillar be similar to the distance from the pillar along the roadway



Two Major Classes of Cable-Stayed Bridges

- Different based on how the cables are attached to the pillars
  - **Radial attachment design:**
    - the cables all connect to or pass over the top of the pillar.



Building A Cable-Stayed Bridge

- Many things to think about mathematically:
  - Horizontal distance from tower to point of attachment
  - Height of point of attachment above bridge level
  - Stretched length of cable
  - Angle between cable and tower
- Experiments to consider:
  - Cable needs to be tested to see how its stretch varies with the angle to the vertical
    - an experiment to determine how much a length of cable stretches when it supports a mass

Building A Cable-Stayed Bridge

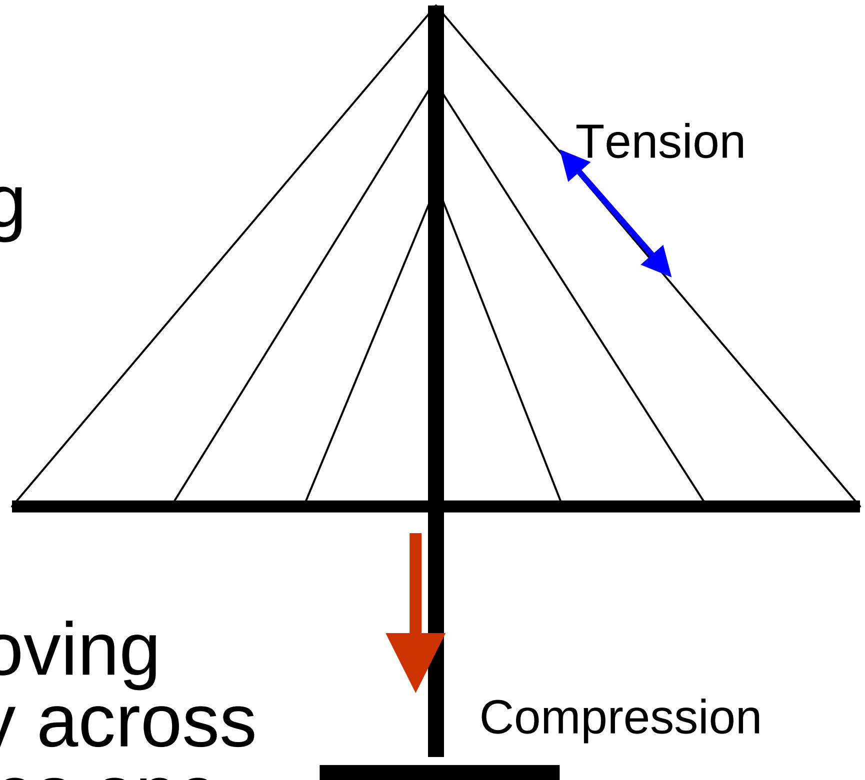
- The tower of the bridge forms the vertical side of the right triangle
  - The distance between the points of attachment of preceding cables on the tower should be equal
  - Likewise, the points of attachment of the cables on the beam of the span should be equidistant.
- You can calculate the length of the remaining cables after the first cable has been installed by applying the proportionality concept or the Pythagorean theorem

Building A Cable-Stayed Bridge

- When building a cable-stayed bridge, to figure out how long the cables need to be, engineers either use scale drawings or Pythagoras and trigonometry to find the required length of cable for each section and the angle between the cable and the vertical

Tension and Compression – Important!

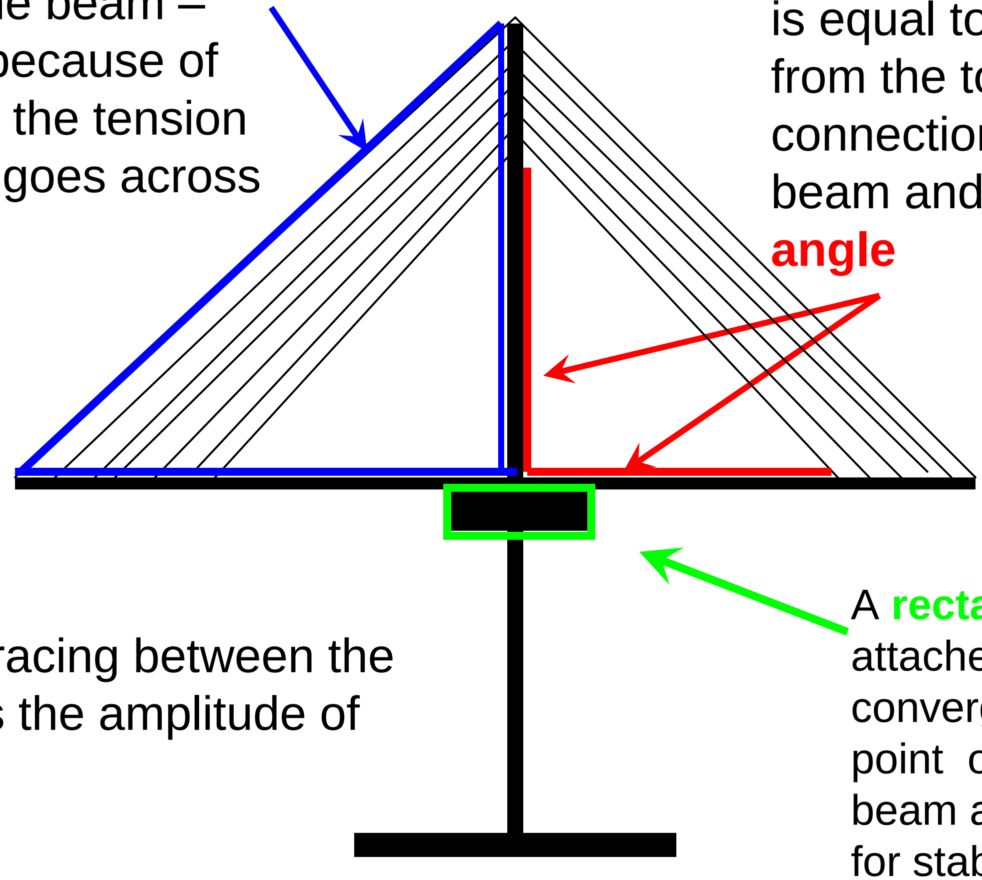
- The tower is responsible for absorbing and dealing with compression forces
- Tension occurs along the cable lines
- This works because a moving load is not applied evenly across the bridge, and as it moves one set or the other of the diagonals will find itself in tension



Let's Look at Shapes

Triangles are one of the shapes used by the attachment of the cables and the beam – this shape is used because of its ability to transfer the tension as the moving load goes across the bridge

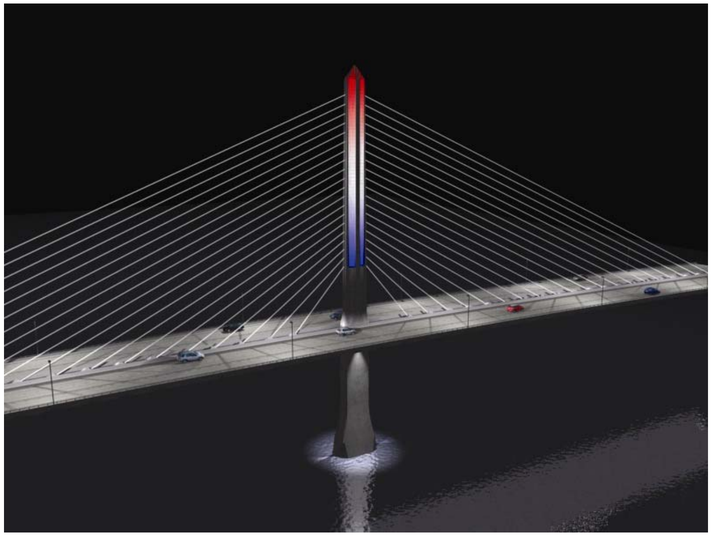
In this bridge, the distance of the cable up the tower is equal to the distance from the tower to connection point on the beam and is a **90 degree angle**



Triangulated bracing between the cables reduces the amplitude of oscillations

A **rectangle** is attached at the convergence point of the beam and tower for stability

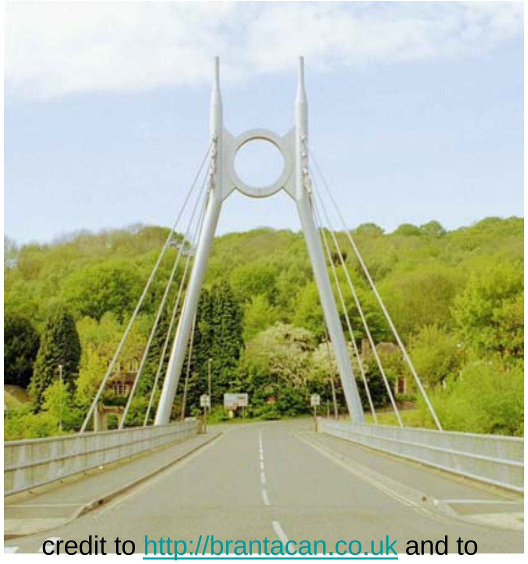
Visions of Cable-Stayed Bridges



Maumee River Bridge, Toledo, OH

© Figg Engineering Group

Cable Stayed Bridge, Kiev, Ukraine



credit to http://brantacan.co.uk and to Derek Locke.

Jackfield Bridge in Coalbrookdale

Visions of Cable-Stayed Bridges

The Sunshine Skyway Bridge over Tampa, FL

Winner of 17 design awards

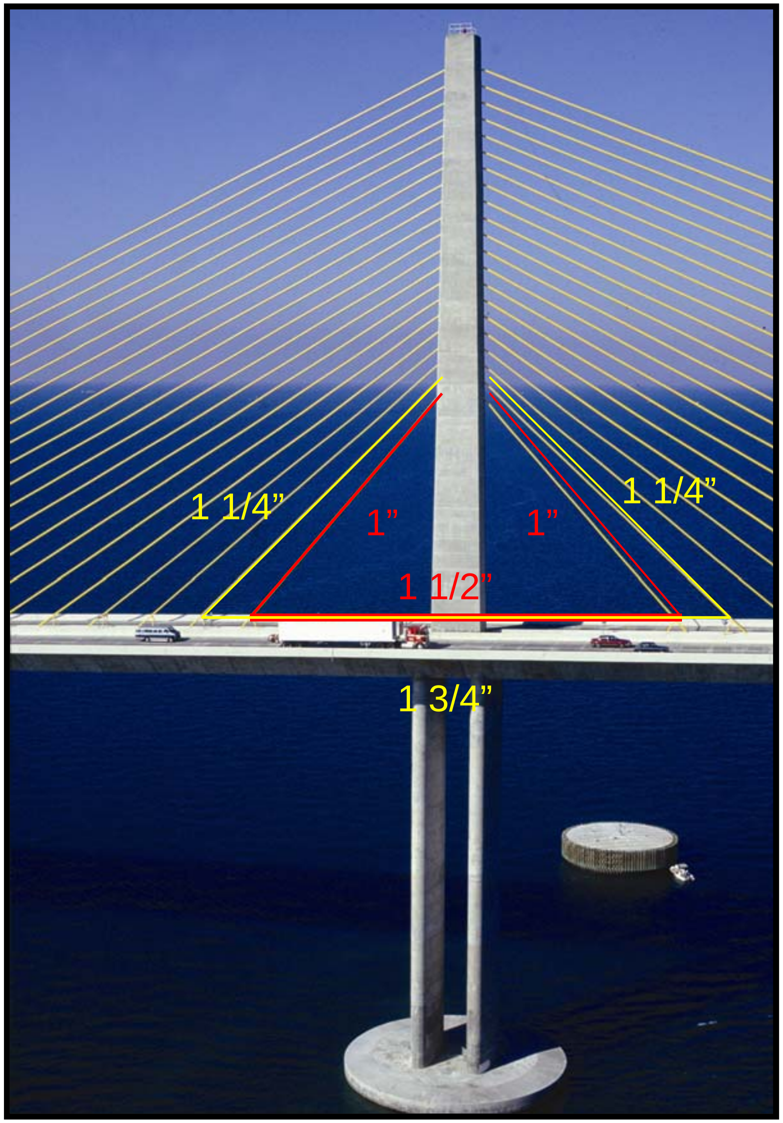
Let's Look at Combinations of Side Lengths

• The red triangle has two sides of 1" and one side of 1 1/2". If you use what we learned about triangles,

a + b > c; 1+1 > 1 1/2.

•The yellow triangle has two sides of 1 1/4" and one side of 1 3/4". So, 1 1/4 + 1 1/4 > 1 3/4

•Both triangles are very close to an equilateral triangle with all sides being equal. This is the strongest triangle.



Strengths of Cable-Stayed Bridges

- Uses a single support only
- Well-balanced
- Cables can be fabricated separately
- Horizontal loads are contained within the structure
  - Ideal for use when the river banks are fragile
    - For example if the banks are alluvial mud
- The cables disperse a load across more area easily
  - Cables from nodes on tower to road is variant of a triangle
- Greater inherent rigidity of the triangulated cable-stayed bridges

Math - Helping Me Understand My World

- Civil engineers need to use a combination of geometric shapes to build the strongest structures
- Extremely important for engineers to carry out the technical calculations necessary to plan a bridge project
  - If the specifications are not correct, the bridge could collapse
- For medium length spans between 500 and 2,800 feet, cable-stayed is fast becoming the bridge of choice
  - Modern looking – geometric shapes (eye pleasing as well as necessary for strength)
  - Cost effective

Testing Beam and Arch Bridges Lab Procedures

Materials needed for each group:

- 2-4 bricks
- Corrugated card board
- Weights

Procedures:

1. Place two bricks 20 cm apart.
2. In order to make a higher structure, place the second set of bricks on top of the first layer of bricks.
3. Place a piece of corrugated cardboard between the two bricks.
4. Gradually place weights in the center of the cardboard until it begins to sag in the middle.
5. Record the amount of weight the bridge held before it began to sag.
6. Rebuild your bridge as stated in steps one and two above.
7. Place an arch between the two bricks by carefully bending a piece of corrugated cardboard in the form of an arch. Make sure that it fits snugly between the bricks that are 20 cm apart.
8. Place a piece of cardboard on top of the arch between the two bricks.
9. Gradually place weights in the center of the cardboard until it begins to sag in the middle.
10. Record the amount of weight the bridge held.

Observations:

1. What type of bridge did you build at the beginning of the activity?
2. What type of bridge did you build the second time?
3. What effect did adding the arch to the bridge have, if any?
4. Which bridge would you rather cross? Why?