Stage 4-5

Scrambled Science: Arch Strength

Lesson Overview

The following activity guide is for use by high school students and educators looking to explore and expand on the concept of **arch strength** both in the classroom and at home. The guide presents an overarching challenge for students to respond to and some supporting activities to integrate cross-curricular priorities and help structure their understanding by providing depth and richness within the learning. There is an extension task to encourage students to apply their understanding to new situations and encourage further thinking.

Eggs have a fascinating shape that has been replicated through architectural structures across history for a particular reason; the immense strength of the **arch shape**. Students will investigate the effect of different forces on a range of arches and apply their knowledge to real world problems.

Lesson Intentions

- Understand some basic architectural principles
- Understand how arches contribute to the structural integrity of a building
- Design a structure using mechanical engineering concepts and understanding

Teachers Notes

Year 8 Outcomes:

Science Understanding
- Energy appears in different forms, including movement (kinetic energy), heat and potential energy, and energy transformations and transfers cause change within systems (**ACSSU155**)

Science Inquiry Skills
- Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (**ACSIS139**)
- Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (**ACSIS140**)
- Measure and control variables, select equipment appropriate to the task and collect data with accuracy (**ACSIS141**)

Design and Technologies
- Generate, develop, test and communicate design ideas, plans and processes for various audiences using appropriate technical terms and technologies including graphical representation techniques (**ACTDEP036**)

Year 10 Outcomes:

Science Understanding
- Energy conservation in a system can be explained by describing energy transfers and transformations (**ACSSU190**)
- The motion of objects can be described and predicted using the laws of physics (**ACSSU229**)

Science Inquiry Skills
- Formulate questions or hypotheses that can be investigated scientifically (**ACSIS198**)
- Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (**ACSIS199**)
- Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (**ACSIS200**)

Design and Technologies
- Develop, modify and communicate design ideas by applying design thinking, creativity, innovation and enterprise skills of increasing sophistication (**ACTDEP049**)

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Main Challenge

Super Structures

Investigate the characteristics of a building that would help make it resistant to extreme wind, storms or an earthquake. Design a new skyscraper for your city using the shape of an egg as inspiration and incorporate the arch shape within its architecture to ensure it will withstand a range of extreme conditions. Use CAD software to design a 3D representation of your new skyscraper.

Tips:

- Investigate the arch strength of an eggshell. What is its load capacity? How will you test this?
- Investigate architectural elements that can influence the resistance of buildings. What makes one building stay standing while others crumble to the ground?
- Investigate how buildings can be designed to be stronger and safer. Use construction materials such as building blocks, or CAD software to reconstruct famous or familiar buildings. These could be towers, bridges, hotels, monuments or even your own house. Consider the shapes used in the structure of these buildings.
- Recreate extreme conditions to test your buildings' strength and structure. Try recreating hurricane, tornado, tsunami or earthquake conditions. What happens to your structure?
- Investigate why architects might choose to use an arch instead of a triangle to bear load. Consider the different types of arches used for different purposes; i.e. a semicircular arch versus a pointed arch.
- Investigate how a building's foundation plays a part in its strength. What happens to buildings with less of a foundation? Equate this to the shape of an egg; how does the shape of an eggshell influence its strength?
- What can we tell about the architectural techniques of civilisations across history by looking at their structures?
- What do you notice about the relationship between the size of a building's footprint and height, and its ability to withstand the impact of extreme conditions?
- Take photos and record accurate measurements during your investigation.
- Present your investigation and findings using a digital medium.

Investigate arch structures around the world with the following examples:

1. Colosseum, Rome, 70 - 80 AD
2. Tintern Abbey, Wales, 1131 - 1536
3. Gaudi's Catenary arches, 19th - 20th century
4. Forest Pavilion by nArchitects, Taiwan, 2011
5. Pont du Gard, France, 40 - 60 AD
6. Koyunbaba Bridge, Turkey, 1484 - 1489
7. Stari Most, Bosnia and Herzegovina, 16th century
8. Taq-i Kisra (Arch or Ctesiphon), Iraq, 540 AD

Supporting Activities

Hold a raw egg in your hand, positioning your fingers at either 'end'. Investigate how much force is needed to break the shell. Try this activity with eggs of different sizes. Does the size of an egg influence its strength?

Explore how other architectural structures have incorporated or been inspired by natural shapes. Hypothesise why these shapes or structures have been chosen for their role.

Set a carton of a dozen eggs out on the floor. Without shoes, walk across the tops of the eggs. Investigate how much downward force the eggs can take before breaking. Discuss the meaning of the phrase 'walking on eggshells' and its link to your findings.

Extension Opportunity

Structural designs and various materials are other important factors to consider when testing building resistance. What other factors would be important to investigate?

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