BRIDGE UP!
ENGINEERING

LESSON 5 – GRADE 5

LESSON 5 – GRADE 5: Runoff Management

Big Idea

For the safety of vehicles, pedestrians, and structures, bridge designs include plans that help prevent the pooling or collection of water on bridge decks.

Essential Questions

What are the hazards of water collecting on a bridge deck?

What happens to water on a bridge when it rains, snow melts, or an event like a flash flood occurs?

Can water on a bridge deck be controlled or directed (diverted) somewhere else?

Where does the water go once it is removed from a bridge deck?

Background Information

Water can collect on all types of surfaces including those which are porous, such as soil in fields or impermeable, such as concrete and asphalt. On bridges, which are made of impermeable materials, the ability to control water movement and collection is an important part of the design process to ensure the safety of vehicles, their occupants, and the structure itself. Drainage systems can range from simple to complex; some drainage systems allow excess water to drain out directly below the bridge deck, while others divert water to a collecting pond or other reservoir.

Seasonal changes, as well as catastrophic events like flash flooding, change the amounts of water flowing across surfaces day to day and sometimes minute to minute. Drainage systems need to be able to accommodate those changes so that the rate of flow allows for steady draining of water. Both the drainage system and the catchment system, where diverted water is collected, need to be able to handle the flow of water. Pooling of water can be a problem by causing hydroplaning or ice patches depending on the season.

Not all bridge sites use a drainage system. When they do, the system is kept to a minimum in order to maintain integrity of the bridge structure and to avoid excessive maintenance issues, such as plugging of pipes. Slopes along the bridge deck, from the center to the shoulders, can aid in drainage rates and help keep drainage pipes clear.

Standards & Benchmarks

Minnesota Science Standards

5.1.1.2 Inquiry
Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.

Benchmark: 5.1.1.2.1 Planning Investigations
Generate a scientific question and plan an appropriate scientific investigation, such as systematic observations, field studies, open-ended exploration or controlled experiments to answer the question.

Benchmark: 5.1.1.2.2 Collecting Relevant Evidence
Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in a scientific investigation.

3-5 ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem

3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

Wisconsin Science Standards

A.8.6 Use models and explanations to predict actions and events in the natural world.

B.8.3 Explain how the general rules of science apply to the development and use of evidence in science investigations, model-making, and applications.

C.8.3 Design and safely conduct investigations that provide reliable quantitative or qualitative data, as appropriate, to answer their questions.

C.8.4 Use inferences to help decide possible results of their investigations, use observations to check their inferences.

C.8.6 State what they have learned from investigations, relating their inferences to scientific knowledge and to data they have collected.

C.8.10 Discuss the importance of their results and implications of their work with peers, teachers, and other adults.

C.8.11 Raise further questions which still need to be answered.

G.8.5 Investigate a specific local problem to which there has been a scientific or technological solution, including proposals for alternative courses of action, the choices that were made, reasons for the choices, any new problems created, and subsequent community satisfaction.

Connections with Multimedia Program

Not applicable.

Activity Description

Students will explore how water moves across the surface of a bridge and how it can be directed to a specific place for collection.

Vocabulary

Bridge deck – The surface of a bridge where vehicles and pedestrians travel.

Divert – To change the direction of.

Drainage – The removal of surface water from an area or structure.

Slope – A surface with an incline so that one end or side is higher than the other.

Stormwater runoff – The movement of water over impervious structures that is directed to a specific location.

Materials

Per Group

- 1 strip of cardboard - 1 foot long and 3 inches wide - covered on all sides and ends with duct tape (see preparation section)* have extra covered strips prepared and available in case of leaks or failure during the activity
- 2 wooden blocks or 2 small bricks/pavers
- 4 large (9mm or 10mm diameter) drinking straws
- Strips of duct tape (as needed)
- 1 pair of scissors
- Shallow basin or pan to catch water as activity is conducted (this could also be done outside preventing the need for basins). Examples include water tables, baking sheets or aluminum pans.
- Measuring cup with pouring spout
- Quart container filled with water

Individual Materials

- Science journal
- Pencil

For adult use only

- Very sharp scissors, razor blade, or small awl

Preparation

Cover strips of cardboard along the middle of both sides with a strip of duct tape. On each side, lay a strip of duct tape so that it overlaps the center tape – this will be the top of the bridge deck. Before wrapping the tape over to cover the bottom side, pinch the tape together along the edge so that there is a rim that is about ¼" to ½" in height and then press the rest of the tape edge around to cover the bottom side of the cardboard. You should end up with a rim on both sides of the top of the cardboard creating a small gutter for the bridge deck.

Procedure

Introduction

- Discuss the basic structure of a bridge and the surface on which vehicles or people can move across it (bridge deck).
- Ask students to identify weather conditions and seasonal changes that occur in their region and how water plays a part in these conditions.
- Tell students they will be exploring how water moves on bridge decks.

Activity description

- Introduce materials. The strip of cardboard covered in duct tape will represent a bridge deck and the two blocks or bricks/pavers will act as support for the simple bridge they are testing.
- Ask student groups to set up their bridges so that the cardboard strip lays across the blocks or pavers. If indoors, this will be done in the basin or pan provided. If outdoors, blocks can be set on a level surface.
- Direct students to pour water onto the cardboard strips using the spouted measuring cups in multiple ways and observe what happens. *Students are looking for where the water is flowing and how it moves across the surface of the bridge deck.*
- Can the water be controlled just by pouring? Does the flow rate (how fast or slowly the water is poured) make a difference? Does it matter where the water is poured (one end or in the middle)? Allow time for groups to test different ways of pouring water, remind them to empty their basins as needed.
- How does this relate to a bridge deck? *Seasonal precipitation, water is landing on or moving along the bridge deck and it ends up somewhere else.*
- Ask students what happens when there is a larger volume/amount of water on the bridge deck (flash floods or very heavy rains)?
- Why might there be problems with water just overflowing from bridge decks into the river or land below the bridge? *Pollutants can be washed into surrounding waterways, erosion can occur where water continually drains at either end of the bridge, vehicles on the bridges could slide, hydroplane, or lose control.*

- Discuss drainage systems and how they might work on a bridge deck to help manage water when unusual levels occur as well as during regular seasonal water flow amounts. *This would include the idea of pooling water collecting during steady rains that may not overflow the bridge deck edges.*
- Allow time for groups to sketch a plan for a drainage system in their science journals and collect materials (straws, duct tape, scissors) with the goal of directing water to at least one specific site. Does the slope of the system matter? *Would the bridge be at a slope or would the drainage system have a slope to it?*
- Groups will come to consensus on the plan to use and then add the drainage system to their bridge deck. *Students can cut holes along the straw and/or punch holes (with help of teacher using an awl or other instrument) into the cardboard strips depending on where their drainage system is to be placed. Drainage can be along the sides or down through the bridge deck. Duct tape can be used to connect the drainage systems to the bridge decks.*
- Student groups will test their designs by pouring water on their bridges, noting what works and what could be improved. *Did the water flow where you wanted it to? Why or why not? What would you do to change or improve your design?*
- Groups will share their designs with the class either by demonstrating each design or by walking around the room or area to see what other groups have designed.
- Students reflect on what they learned in their science journals, noting improvements they would make to their original designs.
- As an exit slip, ask students: Why is controlling water on a bridge important? *Health of local water and ecosystem, managing erosion, safety for vehicles and people using bridges, managing the amount of water that is allowed to remain on the bridge at any given time, response to seasonal changes.*

Assessment

Science journal sketches and responses completed or exit slip responses.

Extensions

Research local bridges to determine how water is moved away from the bridge deck.

Other Resources

Bridge Deck Drainage

http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/bridge-memo-to-designer/page/Section%2018/18-1m.pdf

http://www.iowadot.gov/bridge/policy/584DeckDrainJu11.pdf

http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hec/hec21.pdf

Stormwater Runoff

http://water.epa.gov/polwaste/npdes/stormwater/index.cfm

http://nc.water.usgs.gov/projects/bridge_runoff/overview.html