How fast water travels through soils?

Subject Area(s) Earth and Space

Associated Unit

Associated Lesson

Header

Image 1

ADA Description: Perspective sight illustrating a dam used to retain water for supplying and/or power purposes

Image file: C:\Users\User\Documents\AMPS\Lessons Summer 2011\1st Lesson- Soil Permeability\dam2.gif

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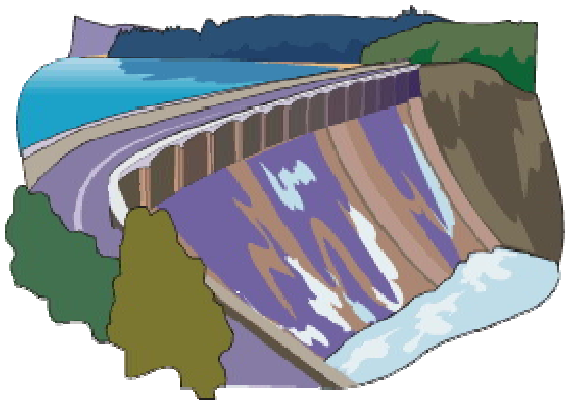
http://idahoptv.org/dialogue4kids/season11/salmon/teachers06.cfm



Grade Level **all grades**

Activity Dependency None

Time Required 240 minutes

Group Size 5

Expendable Cost per Group US$ 0

Summary

Underground water, which is the water located under the ground surface, is of vital importance for human beings since it is a natural resource for drinking and irrigation. Underground water also plays an important role in civil engineering. Water flow within an aquifer, land slope, and earth dam is of interest of engineers to develop accurate designs and optimal constructions. To study water flow inside soil mass the coefficient of permeability, ***k***, should be known.

In soils, ***k*** is the measurement of water ability to flow through them. In other words is the speed of water flow inside soils such as gravel, sand, silt, clay, or a mix of them. This activity is prepared to introduce the concept of soil permeability as one of the key parameters to study seepage or the steady state flow of water. Students will have the opportunity of measuring permeability of different types of soils, compare results, and conclude the importance of size, voids, and density in permeability response.

Engineering Connection

Civil and geotechnical engineers design, build, and sell permeameters to measure ***k*** value of soils in the laboratory as well as in the field. Nowadays, measuring process is done by counting for the volume collected while timing is taken place. Mechatronic tools, such as ultrasonic sensors allow for a better reading of water collected minimizing the measurement error.

Engineering Category = # 2

Choose the category that best describes this activity's amount/depth of engineering content:

1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords

Permeability, soils, civil engineering, slope, landslide, earth dam, permeameter, falling head, ultrasonic sensor, mechatronics, gravel, sand, silt, clay, voids, porosity.

Educational Standards

NYS Science Standards

i. 7.2. d Since the Industrial revolution, human activities have resulted in major pollution of air, water, and soil. Pollution has cumulative ecological effects such as acid rain global warming, or ozone depletion. The survival of livin things on our planet depends on the conservation and protection f Earth resources. (Grades 5-8) (1996)
ii. 2.1. j Water circulates through the atmosphere, lithosphere, and hydrosphere in what is known as the water cycle. (Grades 5-8) (1996)
iii. 2.1. h The process of weathering breaks down rocks to form sediments. Soil consists of sedimen, organic material, water, and air. (Grades 5-8) (1996)
iv. 2.1. d The majority of the lithosphere is covered by a relatively thin layer of water called the hydrosphere. (Grades 5-8) (1996)

NYS Math Standards

i. 5. RP.8 Support an argument through examples/counterexamples and especial cases (Grade 5) (2005)
ii. 5.M.7. Calculate elapsed time in hours and minutes (Grade 5) (2005)

Pre-Requisite Knowledge

Basic number operation skills (addition, subtraction, multiplication, and division)

Learning Objectives

After this activity, students should be able to:

- Measure ***k*** through a basic laboratory model
- Understand the concept of water flow in soils.
- Understand the applications of water flow models in practice engineering.

- Identify variables affecting ***k*** such as particle size, porosity, compaction, density.

Materials List

Each group needs:

- A permeameter device
- Soil sample (Gravel, sand, silt, and or clay)
- Lego Mindstrom NXT Brick
- Lego Ultrasonic sensor
- Watch
- Rules
- Computer
- Paper and markers
- Worksheet
- Soda bottle
- Graduated jar

To share with the entire class:

- Students will watch a Power Point Presentation about Permeability for Kids (see attachment: permeability for kids.ppt

Introduction / Motivation

Let students to think where the water goes when rain falls. Explain them that water is always in constant motion. Mention that some of it travels along the surface to rivers or lakes, some of it is absorbed by plants, some evaporates and comes back to the atmosphere, but the remaining absolutely goes under the ground. Let's imagine pouring water onto a mountain of sand we have built on the beach. Ask them again: where does the water go? And finally come up with an initial conclusion that is the water finds out its way to infiltrate along voids between granular particles.

Introduce the importance o permeability in civil engineering. Give them a brief knowledge of civil engineering main ideas, and projects engineers make such as earth dams, buildings, bridges, land slopes, retaining walls, etc. Next, explain to them the application of water flow analysis in these construction projects.

Figure 1

ADA Description: Panoramic view of a landslide

Caption: Figure 1: ___?

Image file: ___?

Source/Rights: Copyright ©http://qwickstep.com/search/meaning-of-landslide.html

For instance, in landslides and earth dams, the concepts of water flow and permeability are often used. Stability of slopes such as in highways, excavations, and dams mainly depend on the presence of water runoff, infiltration, permeability, and its influence on the overall stability of the project.

The appropriate knowledge of permeability allows engineers to design, calculate and build great constructions, as well as correct and mitigate natural disasters in order to guarantee safe conditions and reduce the risk of damage or collapse.

At this point of the activity, teacher will present his presentation which is called: permeability for kids.ppt.

Figure 2

ADA Description: Permeability for kids

Caption:

Image file: C:\My documents\NYU-POLY\GK-12 FELLOWSHIP\1st Lesson

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Vocabulary / Definitions

Word	Definition
Coefficient of permeability	Measure of the soil's ability to permit water to flow through its pore and voids.
Earth dam	Massive artificial water barrier used to store water for supply and/or power purposes
Landslide	Natural disaster which consist on a wide range of ground movement.
Aquifer	Underground water storage which lies between two low-permeability layers.
Ultrasonic sensor	A sensor used to detect proximity of objects by using dual (transmitter-receiver) ultrasonic signal.
Soil	Natural body consisting of three phases: mineral-water-air. Soil is derived from rocks that have been altered by various chemical mechanical and environmental processes. Different soils such as gravel, sand, silt, and clay as well as their physical differences will be studied.
LEGO Mindstorms NXT	Kit of programmable robotic used for academic purposes owned by LEGO

Procedure

Background

The teacher, in charge of this activity and lesson, must have enough knowledge, previous laboratory experience, and a comprehensive understanding of permeability in soils. Teacher should mention there are different ways to find out permeability value in the field as in the lab.

Before the Activity

- Bring the novel permeameter test to classroom. Introduce it and if possible show them the presentation of permeability for kids. (see the attachment: permeability for kids.ppt)

With the Students

1. Write the following terms on the board and ask students to think about what they mean: soil, groundwater, voids, saturation.
2. Explain students how the novel permeameter works, how to assemble it. Build it up using a natural soil sample. Demonstrate rapidly how water flows through the permeameter.
3. Ask students how fast they think water is going to flow through three different soil types such as gravel, clay, and sand.

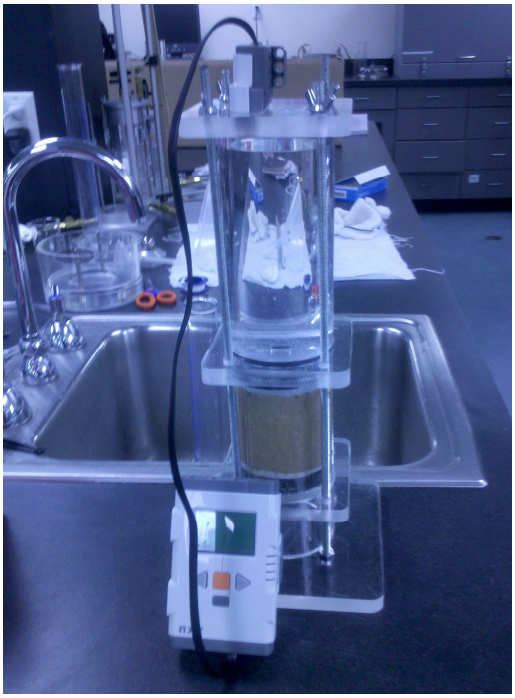
Figure 3

ADA Description: Novel Permeameter test featured with LEGO NXT brick and ultrasonic sensor for measurement

Caption: Figure 1: ___?

Image file: ___?

Source/Rights: Copyright © ___?



Attachments

- How fast water travels through soils.doc
- Permeability datasheet.doc
- Permeability for kids.ppt

Safety Issues

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Troubleshooting Tips

Investigating Questions

Assessment

Pre-Activity Assessment

Basic permeability test

Without any sophisticated permeameter device, students will run their first soil permeability test. It will be done by collecting three samples of different soils (i.e. clay, sand, and gravel). Make three funnel by cutting three two litter soda bottle to pour soil sample inside. In order to collect the water coming out a graduated jar will be used.

In addition, a watch or chronometer should be utilized to control the time for filling the jar.

Figure 4

ADA Description: Basic Permeability test

Caption: Figure 1: ___?

Image file: ___?

Source/Rights: Copyright © http://4.bp.blogspot.com/_M4RFltFUe5Q/SBYBiYS6SxI/AAAAAAAAANY/7jeHTaczbaE/s1600-h/Soils_permeability_image.jpg

Activity Embedded Assessment

This hand-on activity is being split out in three parts: a) Introduction to Permeability test, which is the adaptation of kids with permeameter, b) Permeability test without using ultrasonic sensor, where kids run tests taking volumes and timing analogically, and c) Permeability test with using ultrasonic sensor, which is the point where children are able to minimize measurement error by using of technological tools such as mechatronic components.

Introduction to Permeability test

Take a soil mass directly from soil bag or container to the permeameter chamber.

Fill the upper chamber with water and open valve to allow water to flow through soil. Wait until all air bubbles disappear. It indicates the soil sample is fully saturate.

Close the valve and marking out in the water chamber the initial and final water level to be monitored. Once the test is ready to run open the valve and simultaneously starting timing.

Close the valve again and stop timing when water level is reached the second (lower) level.

Calculate the velocity of water flow dividing the volume of water, which is the result of cross sectional area times the different in head, by time.

Permeability test without using ultrasonic sensor

Take a soil mass, weight and pour it within a known volume in the permeameter chamber. Compact it in such way that soil correctly fits in the assigned volume. It ensures a similar compaction level.

Fill the upper chamber with water and open valve to allow water to flow through soil. Wait until all air bubbles disappear. It indicates the soil sample is fully saturate.

Close the valve and marking out in the water chamber the initial and final water level to be monitored. Once the test is ready to run open the valve and simultaneously starting timing.

Close the valve again and stop timing when water level is reached the second (lower) level.

Calculate the velocity of water flow dividing the volume of water, which is the result of cross sectional area times the different in head, by time.

Permeability test using ultrasonic sensor

Take a soil mass, weight and pour it within a known volume in the permeameter chamber. Compact it in such way that soil correctly fits in the assigned volume. It ensures a similar compaction level.

Fill the upper chamber with water and open valve to allow water to flow through soil. Wait until all air bubbles disappear. It indicates the soil sample is fully saturate.

Close the valve, make sure both water levels (initial and final) are marked up, and make sure ultrasonic sensor is connected to both the NXT brick and the upper cap of water cell.

Figure 5

ADA Description: second grade kids playing with permeability test

Caption: Figure 5: ___?

Image file: ___?

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Make the LEGO Mindstorm code for reading the proximity of water and timing this process.

Once the test is ready to run open the valve and simultaneously starting NXT brick.

Stop NTX bricks when water has reached the lower or second level. Automatically it will give the distance between both water levels, as well as the time for water to reach lower level.

Calculate the velocity of water flow dividing the volume of water, which is the result of cross sectional area times the different in head divided by the time.

Post-Activity Assessment

Question and Answer: Ask students the following questions. Have the students write their answers down on a piece of paper first, but stress the answer will not be graded. After everyone has had a chance to write an answer down, call on a student to answer the question. Did everyone get the same answer?

- What is permeability? (Answer: Soil or permeable rock that is saturated with water.)
- Why is permeability important in construction and engineering?
- What is ground water table?
- Where does rainfall water go after get on soil surface?
- Why do groundwater travels slower than a river?
- List at least three cases where permeability is used in civil engineering?
- Why do you think data collected from a test is more accurate if sensors and mechatronics tools are used?
- Which are the elements that may change the value of permeability?

Activity Extensions

Activity Scaling

- For lower grades: For 4th and 5th grade use less technical vocabulary
- For upper grades, use technical vocabulary

Additional Multimedia Support

- Permeability for kids.ppt
- Permeability video for kids

References

- http://aegsrv2.esci.keele.ac.uk/earthlearningidea/PDF/Permeability_of_soils_Final.pdf
- http://classic.globe.gov/tctg/passthrough.pdf?sectionId=102&lang=EN

Other

Redirect URL

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Supporting Program

This activity is developed under the project Applying Mechatronics to Promote Science (AMPS) conducted by the Department of Mechanical Engineering of Polytechnic Institute of New York University and supported by the National Science Foundation. The contributors of this activity thank the Mechatronics Lab and the Soil Mechanics Lab of NYU-POLY.