12 Modeling Cliff Erosion

MODELING

Jayden visits his friend who lives on Seaside Cliff. As he walks toward the cliff to see the ocean, he notices some gullies. He thinks the gullies must have been caused by runoff that eroded the top edge of the cliff near the parking lot. He then remembers seeing topographic maps showing how the cliffs have eroded more rapidly in the past 25 years. When he looks out at the ocean, he thinks that those big powerful waves must also be causing erosion on the face of the cliff.

Water flowing down a slope due to gravity is not the only way water can cause erosion and deposition. For example, in a coastal area, ocean waves hitting the shore can move earth materials from one place to another. In this activity, you will use a model to investigate what happens when a large system of ocean waves hitting sea cliffs, such as those in Boomtown. You will then be given a set of engineering criteria and constraints to use as you build, test, and redesign erosion-control model structures to mitigate the effect of waves on sea cliffs.

Ocean waves eroded the cliff base of these houses until the support columns were revealed.

GUIDING QUESTION

How can we reduce the effects of ocean waves on coastal areas?

MATERIALS

For each group of four students

Parts A and B

- 1 plastic box with line
- 1 plastic cliffmaker
- 1 wavemaker holder (with slot)
- 1 wavemaker paddle
- 1 river model catch basin
- 1 graduated cup (30-mL)
- 1 spoon
- 1 plastic cup (9-ounce)
- supply of moist sand
- supply of water

Additional Materials for Part B

- 2 mesh sleeves of small rocks
- 9 building bricks

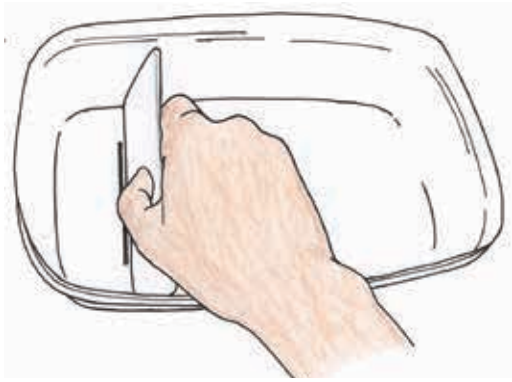
For each student

- 1 Student Sheet 12.1, "Evaluating Designs: Cliff Erosion"

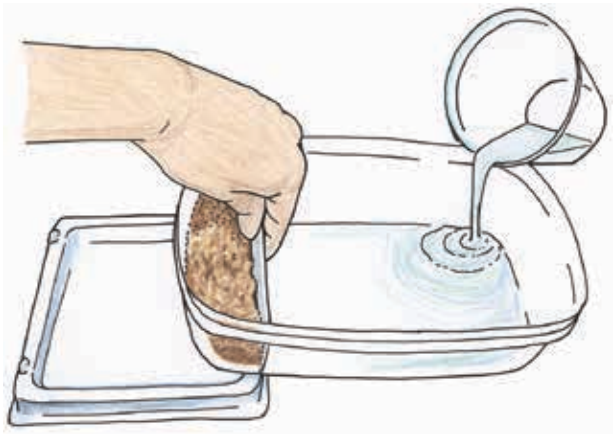
PROCEDURE

Part A: Modeling Cliff Erosion

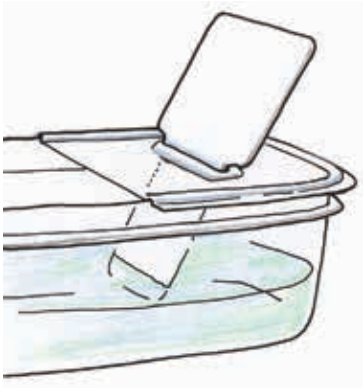
1. Place the plastic cliffmaker in the plastic box at the line marked on the box. Hold it so that it makes a vertical wall in the box, as shown below:



2. Use the 30-mL graduated cup to fill the smaller portion of the box with 150 mL of moist sand. Level the top of the sand with the spoon.
3. Slide the catch basin from the river model under the sand-filled end of the box. This will create a gentle slope.
4. While holding the cliffmaker in place, gently pour water into the edge of the box opposite the sand until it just touches the bottom of the cliffmaker, as shown below:



5. Complete the model cliff by carefully removing the cliffmaker. Do this by slowly lifting the wall straight up out of the box. Sketch the model cliff in your science notebook.
6. Place the wavemaker holder on the side opposite the model cliff. Insert the wavemaker paddle into the slot, as shown below:



7. At the rate of 1 wave per 3 s, move the wavemaker paddle back and forth along the bottom of the box 5 times. Sketch and record your observations in your science notebook. Don't forget to record what is happening at the bottom of the box.

8. Make 5 more waves, and record your observations in your science notebook. Make 2 more sets of 5 waves. Sketch and record your observations.
9. Summarize your observations by answering the following:
   - What happened to the cliff?
   - What happened at the bottom of the model?
   - What earth processes did you observe in action?
10. Use the cliffmaker to push the sand back up into the upper end of the box. Carefully drain out any remaining water in the box.

Part B: Mitigating Cliff Erosion

11. Read the following criteria and constraints for designing a system that will reduce erosion in the model. As a class, clarify or add any relevant criteria or constraints to the design challenge.

    Design Criteria

    The design must

    - cause less erosion to the cliff than if there was no erosion-control system in place.
    - have maximum effectiveness when subjected to 5 waves at the rate of 1 wave per 3 s.

    Design Constraints

    The design is limited by using the materials provided.

The hard surfaces of the large rocks mitigate the erosion of the land between the house and the water.

12. Obtain the erosion-control materials from your teacher. Talk among your group about the different ways you could use the materials provided to prevent erosion along the cliff. Choose what you think is the best design to test using the cliff model.
13. Rebuild the cliff as in Steps 1–5. If the sand is too wet to form the cliff, mix a little dry sand into it until it is the right consistency. Once the sand cliff is packed so that it can stand on its own, carefully remove the cliffmaker.

14. Build and properly position your prototype erosion-control structure.
15. Gently pour water into the edge of the box opposite the sand until it just touches the bottom of your structure. Make a clearly labeled "before waves" sketch of the model cliff with your structure in place.
16. Repeat Steps 6–9, and make a clearly labeled "after waves" sketch of the model.
17. Discuss with your group how effective your structure was at reducing erosion. What were its strong points? What were its weak points?
18. Based on your results, work with your group to redesign your erosion-control structure to optimize erosion control.
19. Prepare a new cliff, and then repeat Steps 14–17.
20. Compare the effectiveness of your re-engineered structure with your original structure, and make suggestions for further improvements.
21. Follow your teacher's instructions for presenting your final design to the class. Complete Student Sheet 12.1, "Evaluating Designs: Cliff Erosion" to compare erosion-control designs.

ANALYSIS

1. In Part A, what did the waves do to the cliff model? Explain in terms of energy, erosion, and deposition.
2. Think about the different designs for reducing cliff erosion.
   a. Explain how they reduce erosion.
   b. Are there any drawbacks to building structures to protect cliffs? Explain your reasoning.
3. Do you think you could improve your cliff-erosion structure if you had
   a. more of the materials provided? Explain using evidence from your investigations.
   b. different materials than those provided? Explain using evidence from your investigations.

4. Imagine two identical cliffs, one next to an ocean and one far away from any water. Compare the erosion at these two locations if both locations receive the same amount of rainfall and
   a. both cliffs are made from the same type of rock. Explain your reasoning.
   b. the rocks on the inland cliffs are made of a softer type of rock than the coastal cliff. Explain your reasoning.
5. Imagine two identical cliffs, one with stores and a parking lot built close to its edge and the other undeveloped. Compare the erosion at these two locations if both receive the same amount of rainfall. Explain your reasoning.
6. What other design criteria or constraints do you think should apply for the building of the new school and fields on the cliff?
7. Consider a real city that wants to build a new school. The city is located in a hot, urban climate in an area prone to hurricanes.
   a. What additional criteria and constraints might the city have in building their new school?
   b. How could the additional criteria and constraints you described help ensure a successful building design?
   c. What determines which technology is used in the design?
   d. What are the consequences for the people and the environment in using natural resources for the building?

Name_____ Date_____

STUDENT SHEET 12.1

EVALUATING DESIGNS: CLIFF EROSION

Group	Meets criteria to reduce erosion	Meets criteria for 5 waves (1 wave/3 s)	Design strengths	Design weaknesses	Evaluation
1					
2					
3					
4					
5					
6					
7					
8					