Revised 6/00

Lesson #12

Retaining Walls

Grade Level: 3-4
Can be extended to 5-6

Teachers, this is a basic lesson plan that you may modify at your discretion.

Modifications to video: There have been several changes to the lesson plan since the video was made. This lesson plan reflects the latest changes made as a result of suggestions from teachers who have presented the lesson during the daytime program. Because of time constraints, the activity of measuring piles of sand was changed to a demonstration format. Please continue to send us your ideas!

Overall educational objectives: Students will be able to name the properties of sand as related to the properties and the building of retaining walls. They will build a retaining wall and state how retaining walls are used.

Associated Standard CORE objectives:

3040-05 Students will explore and classify soils.
3030-0202 Investigate the impact of technology on resources.

Materials list:

6 - Pictures of retaining walls
6 - Tubs of sand
6 - Dowel pieces for boxes
6 - Plastic scoops
- String, tape, paper
1 - Section of rebar
6 - Retaining wall boxes
6 - 7” x 10” Compacting boards
3 - Dust pans and brooms
- Tarps (Floor cover)

Teacher provides:

1 - Adult helper
- scissors
- poster board (optional)

Lesson activities:

1. Begin with these thought questions: How is sand formed? Where does sand fit in the rock cycle? How would retaining walls help prevent erosion? How do retaining walls affect the environment?
2. To explore the properties of sand, demonstrate measuring the height of sand piles. All of the piles will be about the same height. There is only a certain height you can attain with a given quantity of sand because there is nothing there to keep it from sliding.

3. Pile the sand against a board and see what happens. You should see about the same result because there is only one side holding up the sand. The angle formed at the slope and the horizontal is called the angle of repose.
4. Use the retaining wall pictures to demonstrate how retaining walls support roads and bridges. Have the students point out the critical features.
5. Divide the class into 6 teams. Each team will now be challenged to build a wall (using the provided boxes, paper, and string) that will hold 16 inches of sand without failing. A wall is considered failed if it collapses or if there is a deflection of 5 degrees or more (marked on the box) when the end board is removed.
6. Start by having each team construct a retaining wall from a 11" x 17" sheet of paper, masking tape, and string. Demonstrate how this is done:
   a.) Fold right-angle flaps (about 1 1/2") on the sides and bottom of the paper by laying it over the end board from a box and forming flaps around the board edges.
   b.) Using pre-cut pieces of 12"-14" string, tape the ends of 2-4 pieces along a horizontal line approximately 2" above the bottom flap of the paper. This is the first line of "rebar." Repeat this arrangement upward 4 or 5 times along the paper. Students should be allowed to decide the number and spacing of both the "rebar" strings and the lines of "rebar."

   The paper flaps will be put against the end board that is held in place by a dowel. Be sure that the bottom and side flaps of the paper are flat against the walls and that the sand covers them. Add sand up to the first reinforcements, then compact the sand. Extend the strings to the back of the box. Take care to compact each layer before laying down the next row of string. Compaction is a critical factor in building retaining walls. The better the sand is compacted the more weight the wall will hold. Continue this process up to the top line, making sure that the top of the paper is folded over and covered with sand.
7. Carefully pull back on the end board and remove the dowel. Then carefully wiggle the board from side to side until you are able to remove it. Check the end of the box to see if there is any deflection. Deflection is a deviation from the desired angle. The wall is a success if there is less than 5 degrees of deflection or if it does not collapse when weight is put on it. Have a student carefully stand on top of the sand. If the wall doesn't fail, have another student stand on the sand. If the wall still holds, have one of the students carefully jump up and down until the wall fails.
8. Have the students write a paragraph summary about retaining walls and why their wall was successful or why it failed.

Background information:

- Retaining walls are an important part of erosion control, dam construction, and road construction. They are effective tools in providing support for a variety of needs.

- Sand is often used because it is a relatively inexpensive resource.

- Sand is a loose, incoherent mass of mineral materials in a finely granular condition, usually consisting of quartz, with a small proportion of mica, feldspar and other resistant materials. It is the product of chemical (rain) and mechanical (wind) disintegration of rocks under the influences of weathering and abrasion.

- Erosion, one of principle mechanisms for sand formation, is considered to be the natural, physical, and chemical processes by which the soil and the rocks of the earth's crust are continuously abraded and corroded. Most erosion results from the combined activity of several factors, such as heat, cold, gases, water, wind, gravity, and plant life. In some regions one cause may be predominant, as wind in arid countries.

- Kinds of erosion may be grouped into two major divisions: geological erosion, which affects rocks as well as soil; and soil erosion.

Class organization: Because this is a group activity, it may require more than one supervisor while the students are creating a retaining wall (especially with the students in the younger grades). Be sure that all members of each group are allowed to participate and learn from the activity. It might be a good idea to have cleaning supplies available, such as a vacuum cleaner, broom, and dustpan.

Teacher tips:
- The children will need at least 25 minutes to build an effective wall.
- String can be wound around your arm from elbow to thumb and cut at both ends to provide the appropriate lengths. This can be done before class.
- If the sand is dusty, moisten slightly.

Extensions:
Discuss the different kinds of soil (especially soils in your region) and the importance each kind of soil plays directly in our lives. Divide the students into small groups, giving each group a set of magazines to look for pictures in which soil and sand play an important role. Create a collage on poster paper from the pictures.

Have students bring in closed jars with samples of soil from their neighborhood.

After a discussion of erosion, create a model in a tray of a hillside using sand and soil. Pour water on the model and let the students describe what happens. Several activities are outlined in *The Comprehensive Water Education Book*, lesson 31.

Safety precautions: If a child jumps on the sand in the box to cause the retaining wall to fail (as shown in the video), have someone ready to steady him or her. Take care in lifting heavy sand containers.

References:

Country Journal v24, Jan/Feb '97, p.37-46 "Retaining Walls for Function and Beauty"
A guide to building retaining walls and contains information on preparing a retaining wall site dealing with drainage and building stone and timber retaining walls.

Sunset v184, Mar'90, p.180-1 "Retaining Walls to the Rescue"
Describes how a landscape architect designed a series of retaining walls to redefine a slope into two levels for planting.

Please make your students aware that this lesson relates to the following:

Career Fields: SCIENCE, TECHNICAL, SCIENCE-HUMANITARIAN

Occupations: * Architectural and Building Construction Technicians: Help architects and engineers plan and design structures. They test materials, build and transport, store, inspect, and use all types of construction materials.

Education: Several years experience as manager, supervisor, or craft worker. May have to pass a civil service examination.

Civil Engineer: Plan, design, and oversee the construction and maintenance of roads, railroads, airports, bridges, harbors, channels, dams, irrigation projects, pipelines, power plants, and water supply and sewage systems. They may work in areas of design, research, construction, or teaching.

Education: Bachelor's Degree

*** Contractor:** Coordinate and manage an entire construction project and assume full responsibility for its completion at a time frame and cost specified agreement in the contract. There are four main types of contractors: building contractors, heavy industrial construction contractors, municipal utilities contractors, and highway contractors.

Education: Bachelor's Degree

Geologist: Study the physical aspects and history of the earth. They identify and examine rocks, study information collected by remote sensing instruments in satellites, conduct geological surveys, construct maps, and use instruments to measure the earth's gravity and magnetic field. They analyze information collected through seismic studies. They also search for oil, natural gas, minerals, and ground water.

Education: Bachelor's Degree

*** Landscape Architect**: Design residential areas, public parks and playgrounds, shopping centers, golf courses, parkways, and industrial parks. They plan the location of buildings, roads, and walkways and arrangement of flowers, shrubs, and trees. They create detailed plans indicating new topography, vegetation, walkways, and other such landscaping details as fountains and decorative features.

Education: Bachelor's Degree

*** Taken from Occupational Outlook Handbook 1998-1999.**

Review Questions:

1. What is sand? How is it formed?

2. Why do you need rebar to construct a retaining wall?

3. What are some important uses of retaining walls?

4. Did your retaining wall fail? If so, why?

5. What are the benefits of retaining walls that justify their cost and work?

Junior Engineering, UMC 3735, Utah State University, Logan, UT 84322-3735
Phone: (435) 797-8000 **Fax:** (435) 797-8005
E-mail: jreweb@ext.usu.edu **URL:** juniorengineering.usu.edu

Picture captions

1. Find the men in the picture and compare their height to the size of the wall. How high do you think this wall is? (40-50 feet high.) How high can retaining walls be built? (35 feet is common, and many walls have been built higher than that —75 feet is very high for a retaining wall)

   This wall is made from concrete, sand, and reinforced steel materials. Looking at the attractive concrete face, it is hard to realize that on the other side is compacted sand, gravel, and steel strips.

   A retaining wall is attractive. Also, a sloping grade doesn't need to be used, so it saves space. It is strong; the lateral supporting structure of the bridge can be placed at the edge of the wall.

2. Retaining walls save on space and save on materials. This picture shows the backside of the panels and how the fill materials are compacted to strengthen the retaining wall during the construction process. Steel straps are used in this particular wall for reinforcement. Other retaining walls may use metal grids or plastic materials. Note the connection to the wall panel. Large equipment is used to compact the granular fill. No large compacting equipment is allowed within 3 feet of the wall. Why? (The top panels may be forced over by the pressure, so lightweight equipment is used next to the panels)

   The wall is built from the bottom up as metal reinforcing strips are connected to the concrete facing, then a layer of sand and gravel is compacted by the heavy equipment. The process is repeated many times.

3. The concrete, interlocking, pre-fabricated panels are ready to attach to the reinforcing metal strips. Look closely and you can see the temporary wooden shims that were placed in between the panels to provide proper alignment. What would happen if these were not removed? (A hole would be left when they deteriorate or rot away. It would weaken the wall.)

4. What do you think would cost more: a long bridge or a short bridge? This bridge can be much shorter and the structure take less room because the retaining wall can be built vertically. Large loads can be applied close to the wall face.

5. This is the finished bridge. Note the finished corner sections. The retaining wall is strong and attractive. Engineers call this a MSE or mechanically stabilized earth wall.

6. All six of these pictures are of the Reinforced Earth Company's wall system. The final surface can be smooth or raised and have different textures or colors. There are many other versions of retain ing walls.

   Besides the large retaining walls that you might see on a freeway or supporting a bridge, you may have seen a small retaining wall supporting a garden plot or the yard of a home. Have you ever seen a retaining wall in your neighborhood?