

Sort It Out! Processing Aggregates



LEARNING OUTCOMES

Students will learn the meaning of and use of the terms: resource, aggregate, crushed stone, sand, gravel, and construction materials, as these terms are used in the construction industry.

Students will understand how raw aggregates are found, evaluated, and produced and/or processed for use in the construction.

Students will understand how these products are used and why this is important to their way of life and for the needs and future of our communities and society.

MATERIALS NEEDED

- Access to the Internet and projection/display equipment to use the video, “Virtual Tour: Aggregate Processing Facilities,” from the Ohio Aggregates & Industrial Minerals Association, which is available at <https://vimeo.com/392234189>.
- Some samples of aggregates such as crushed stone, gravel, sand, and pieces of broken Portland cement concrete and/or asphaltic concrete from a sidewalk, street, or parking lot surface repair job.
- Magnifying glasses, scales or rulers, and paper plates for examination of samples. Small containers to hold desk samples of the aggregate samples. Paper and pencil. Eye protection.
- Handheld device – cell phone, tablet, Chromebook, etc.
- Go to <https://mineralseducationcoalition.org/esw/> for more information about the Sort It Out! Unit, including the accompanying *Sifting Stones* activity.

INTRODUCTION

Crushed stone, gravel, and sand may be gathered from local contractors or concrete plants, from landscape suppliers and/or contractors, or from hardware stores’ lawn and garden section. A courteous approach to the manager of any of these potential sources may result in gifts of the 10 to 15 pounds needed. A check with your school district facilities maintenance department might yield these aggregates as well as some broken Portland cement concrete and asphaltic concrete. Conversation with your local ready-mix concrete supply company management or a local sand and gravel or crushed stone supplier or quarry might result in an offer of samples and possibly even a professional engineer, geologist, or marketing manager to come to your classroom and help conduct this lesson.

Once these aggregate samples have been collected, inspect the samples for dust and other foreign materials. Washing might be needed so that your students can see the actual colors, shapes, and composition of the particles and to see the aggregate pieces in the samples of Portland cement concrete and/or asphaltic concrete.

PROCEDURE

Part A – View the first minute and 20 seconds of the video, stopping when it moves to the frame that shows “Mineral Extraction” in print. Stop here and discuss briefly what was shown in this part of the video:

- What facilities were shown in this part of the video?
- Describe the scenes in the video; what did you see?
- Discuss the safety of visitors and workers at one of these aggregate production sites.

Then, have students examine the aggregate sample materials that you have provided, then work to explore for answers to these questions:

1. What is the meaning of the term aggregate or aggregates?
2. Why are aggregates important to you and your community?
3. What kinds of rocks are used in your community to make aggregates?
4. Examine the samples of aggregates that your teacher has provided. Describe the pieces of rock in each sample – colors, sizes, shaped, edges smooth or rounded, etc.
5. Why do you think that the pieces are shaped as you see them? (Remember that some have been crushed by a machine, large mechanical rock crushers, while others may have been broken and rounded by natural processes then rolled and moved by flowing water before being deposited where they were found and produced.)
6. Describe how the pieces in each sample are about the same size. How might this sorting have been achieved?
7. Using available sources of information such as Internet sites, possibly calling and interviewing sales people for local contractors, ready-mix concrete or hot mix asphalt plants, find and record the meaning of the terms on the vocabulary worksheet (next page).

AGGREGATES VOCABULARY WORKSHEET

| TERM | MEANING | SOURCE |
|------------------------|---------|--------|
| crushed stone | | |
| gravel | | |
| sand | | |
| (rock) chips | | |
| coarse aggregate | | |
| fine aggregate | | |
| rock crusher | | |
| natural gravel | | |
| stock pile | | |
| construction materials | | |
| Portland cement | | |
| asphalt | | |

8. What safety training and personal protective equipment (PPE) are required of workers who work at facilities that produce crushed stone, sand, gravel and any other construction materials? Below is a picture of safety equipment used in some mines. Would miners in aggregate quarries likely need all or some of these items?



Miner Safety



www.MineralsEducationCoalition.org

9.

Part B – Continue to view the video forward to the 2:00 mark, stopping where the frame shows “Blasting” in print. Stop here and discuss what was shown in this part of the video:

- How does this part of the video show the recovery of raw aggregate materials from the Earth?
- How are these raw aggregate materials initially taken from the Earth and processed?
- How is water in these raw aggregate materials managed?
- What machine is used to remove, that is “produce,” these aggregate materials from the water body? A dredge may also be used. How is it different from the machine shown in the video?

Then, have students consult information sources on the Internet using key words from these questions and develop a written description of how sand and gravel are recovered from a water body – lake or river.

1. These sites where sand and gravel are recovered are generally called “sand and gravel pits.” Write a paragraph describing what makes up such a site.
2. Describe why these aggregate resources naturally occur in the locations where they are found. Hint: Look up topics like “glacial sand,” “river gravel or sand,” “glacial deposits.”
3. How is the water managed that is taken from the lake or stream with the raw aggregate materials?
4. *Out of class extended learning assignment:* Check your state department of natural resources Internet site to learn what permits the operator of the sand and gravel pit must acquire and maintain in order to recover the raw aggregate materials, how this operator must monitor and maintain water quality, and how the site must be reclaimed once all of the resource is recovered.

Part C – Continue to view the video forward to the 3:04 mark, through the blasting and loading/hauling of the blasted rock, stopping before the narrator finishes the sentence about conveyors and before the narrator starts to describe the use of screens and the image is of a screen-surface with holes over which the rock pieces are passing. Have a class discussion supplemented by student use of their hand-held devices to answer these questions:

- What is the meaning of blasting or rock blasting in this use of the technology?
- Why is blasting used to loosen the rock rather than other mechanical means such as you may have seen on construction sites around your school where trenches or basement excavations are dug?
- What is the goal of the blasting phase of this part of recovering rock to make into aggregates? Why do you suppose this is important and what might determine the size of the largest rock that the blaster wishes to produce from the blast?
- What are conveyors or conveyor belts and how are they used? Check your school cafeteria to see if the used plates, flatware, and drinking glasses are moved to the dishwasher by a conveyor belt system.

Then, have students consult information sources on the Internet using key words from these questions and develop a 1-2 page long written report to answer these questions:

1. How are drilling and blasting used to loosen solid rock from the Earth’s crust?
2. What is meant by the “drilling” part of this activity? How does this enable the blast to be set up and executed? What substances are used in the drill holes to break the rock loose and make smaller pieces?
3. What is the designed outcome of the blast?
4. How does a conveyer belt move materials?

Out of class extended learning assignment: Check your state department of natural resources or licensure boards Internet sites to learn what training and permits/licensures the blaster must have in your state. What safety rules govern the blaster’s work?

Part D – Continue to view the video forward to the 4:28 mark, through the screening/sizing, stock-piling, and marketing of the finished aggregate materials.

The students should re-examine the samples and describe the sizes of the particles in each sample – what is the largest size, what is the smallest size, how are the pieces distributed between the largest and smallest, and what are the shapes of the particles (rounded, angular)?

Have a class discussion supplemented by student use of their hand-held devices to answer these questions:

Discuss/describe the screens that are used to separate the aggregate particles by size.

- How do the screens separate the aggregate particles into different ranges of sizes? (Looking at the sample with the largest particles, what do you think was the size of the holes in the screen through which all particles passed and the size of the screen through which none of them passed?)
- Relatively speaking, what size particles are taken out of the mass of the crushed or natural aggregate materials first? What sizes are collected last at the end of the screening process?
- What are stockpiles? What part do they play in the production and sales of the aggregate materials? How are stockpiles like warehouses in the distribution of groceries to your local grocery store? Why?

Examine the pieces of broken Portland cement concrete and/or asphaltic concrete.

- What aggregate pieces do you see in the broken surfaces or finished surfaces of these?
- How do pieces of aggregate in the broken samples compare to the samples that your teacher provided? How are they different?

General questions:

- What are the uses of aggregate in our country?
- How do you depend upon aggregates daily?

Outside of class assignment: What kinds of aggregates are produced in your area? How are these mixed to make Portland cement concrete? What part does the Portland cement itself play in the making and use of Portland cement concrete? Combine the answers for these questions into a 1-2 page report suitable to share with your parents and relatives to educate them about how the concrete upon which they depend is made.

Part E Continue the video to its end. Encourage the students to take notes of the uses of the aggregate production site after all the aggregate materials have been removed and used. Discuss these postproduction (or reclaimed) uses of the site. The students should write a short report that clearly describes what reclamation means in concept and what it means in the use of the land after the aggregate resources have been removed. State reclamation requirements that were learned in the work above regarding the permitting process may support this writing.

- Make a list of the work that might be necessary to reclaim a quarry or sand and gravel pit site.
- Make a list of the potential land uses for such a reclaimed site as a result of a good reclamation plan and program.

- Contact your county zoning board or similar government body and learn about how the quarries and/or sand and gravel pits in your community have been reclaimed and about the postproduction/reclamation land uses of the sites.

THOUGHT QUESTIONS

1. What kinds of rock may be crushed and used to make aggregates?
2. What kinds of rock or minerals are not used to be crushed to make aggregates? Why?
3. What is the aggregate product called “rip rap” and how is it used? Look around your community for examples of the use of rip rap. Is rip rap composed of large or small pieces of broken rock? Why? (If you visit with a producer or contactor, this product might be called “channel liner.”)
4. Most sand is made by natural processes of breaking rock to smaller particles sizes without the crushing of the rock mechanically. Can sand be made by crushing rock mechanically?
5. How do the aggregate industry and engineers designate aggregate ranges of sizes for uses, *e.g.*, what is the usual reference name/number of the coarse aggregate used in Portland cement concrete?
6. What kinds of rock crushers are used to break larger pieces of rock into smaller pieces to be screened (sorted) into groups of specified size ranges?
7. In your area, what are the market prices of aggregates in dollars per ton?
8. What are the “standard” particle sizes for aggregates that are used to make Portland cement concrete? To make hot mix asphalt?

Much thanks to the Ohio Aggregates & Industrial Minerals Association (OAIMA) for their collaboration on this educational unit.

Appendix 1

VOCABULARY: Some common names and terms (for teacher preparation and background)

Asphalt refers to the “heavier” and “thicker” part of crude oil that is processed to make a cementing material which is heated to temperatures of 340 to 380 degrees F (Fahrenheit), mixed with sand and crushed stone making what is called “hot mix” to spread and compact over the prepared base while hot. When the “hot mix” is compacted and cools, it forms the “asphalt” pavement or asphaltic concrete for streets, driveways, parking lot surfaces, etc.

Crushed stone refers to a product that has been made by crushing larger pieces of rock into smaller pieces – an accelerated and “manmade” form of physical weathering. The kind of rock that is crushed may be limestone, sandstone, granite, basalt or any other hard and very durable rock that does not take on water and resists wear and further breaking.

Gravel generally refers to pieces of rock that have been broken and to some extent rounded by the natural mechanical weathering processes in nature then transported and deposited in a location of enough volume to provide a supply for construction uses, generally a deposit of a few hundred thousand tons.

Portland cement concrete refers to the combination of coarse aggregate, gravel or crushed stone, sand, Portland cement and water which is mixed, possibly with some additives in very small amounts, and placed in forms to cure into the durable product for sidewalks, driveways, highways, building walls, etc.

Portland cement is a product made by heat treatment of crushed limestone, shale or clay, some iron and other trace volume additives. These ingredients are processed at temperatures above 2,000 degrees F in rotary kilns producing what is called “clinkers” which are then cooled and crushed to a fine powder for the making of Portland cement concrete and other uses. (The Romans used a volcanic material, pozzolan, which preformed just as Portland cement.)

Sand refers to a material, either naturally-occurring or made by crushing rock, with a particle size range from ¼” (6.35mm) down to dust.

Appendix 2

HELPFUL REFERENCES

United States Geological Survey – National Industrial Minerals, crushed stone, etc.:
<https://www.usgs.gov/centers/nmic/crushed-stone-statistics-and-information>.

U.S. Department of Transportation, Federal Highway Administration, YouTube video, “Concrete Clips: Aggregates for Concrete Paving Mixtures,” <https://www.youtube.com/watch?v=4xIHawZgJiQ>.

National Stone, Sand, and Gravel Association, NSSGA, (<https://www.nssga.org/about/>). NSSGA is the leading voice and advocate for the aggregates industry. The members – stone, sand and gravel producers and the equipment manufacturers and service providers who support them – are responsible for the essential raw materials found in every home, building, road, bridge and public works project.

Portland Cement Association, PCA, (<https://www.cement.org/cement-concrete-applications/concrete-materials/aggregates>). Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete. The Portland Cement Association (PCA), founded in 1916, is the premier policy, research, education, and market intelligence organization serving America’s cement manufacturers.

National Asphalt Pavers Association, NAPA,
(https://www.asphaltpavement.org/index.php?option=com_content&view=article&id=199&Itemid=332). Making asphalt pavement is like baking a cake. You measure all the right ingredients, mix them up and heat them for the final product.
(https://www.asphaltpavement.org/index.php?option=com_content&view=article&id=14&Itemid=33). Asphalt pavement is one of America’s building blocks. The United States has more than 2.7 million miles of paved roads and highways, and 94 percent of those are surfaced with asphalt.

State Producer Association Internet sites that will be helpful in finding background information and for students to examine for information (most every state has such an organization; these are examples):

Ohio Industrial Aggregates and Industrial Minerals Association,
(http://www.oaima.org/aws/OAIMA/pt/sp/home_page).

Missouri Limestone Producers Association (http://www.oaima.org/aws/OAIMA/pt/sp/home_page).

California Construction and Industrial Minerals Association (<https://www.calcima.org/links>).

Indiana Mineral Aggregates Association (<https://indmaa.org/>).

Your community is served by a producer or producers of crushed stone, sand, and gravel as well as ready-mix Portland cement concrete and hot-mix asphalt. These companies are valuable sources of information that is quite local to the area of your school. Contact with their marketing or engineering division will provide local information and contact in the industry to add to the success of the use of this lesson.