# STEM FOR STUDENTS
## DRIVE IT HOME

# STEM in TRANSPORTATION

## Lesson 4: **Aggregates**

Grade Level: 4-8

VDOT
Virginia Department of Transportation

# Aggregates

## Background Knowledge

Aggregates is a broad term for many course materials used in construction such as sand, gravel, crushed stone, and slag. In many applications, a binding material is added to aggregates to help them attain higher engineering properties such as strength or wear-resistance. By selecting the right type of aggregates and cementing material, departments of transportation can provide the public with a transportation infrastructure that will last for decades. Using the wrong materials for construction will reduce the life of roadways, bridges and tunnels necessary for the transport of goods that are vital to our economy.

Most aggregates that are used for road and construction purposes are sourced from the earth. Different parts of the country and world have varying natural resources, so understanding the properties of the aggregates available in different areas helps engineers plan and design the strongest and most efficient structures. In this lesson, students will learn about aggregates, how they are used in transportation infrastructure, and what properties are important when selecting road materials.

STANDARDS OF LEARNING

SCIENCE: 4.8, 5.8, ES.4, ES.5, ES.6, ES.9, PS.2

**Objective**

Students will:

- Investigate various types of aggregate
- Understand the different materials used in asphalt mixes
- Utilize household food items to make their own asphalt mix

**Materials**

- Household food items

## Procedure

1. Introduce students to engineering uses of aggregates and which of these natural resources are available within their state.
    - In Virginia, limestone, dolostone, sandstone, quartzite, granite, gneiss, basalt, greenstone, aplite, slate, and marble are all quarried for use as crushed stone.
    - Anything made of concrete use aggregates, so most buildings, roads, and bridges have aggregates as a base material.
    - The Virginia Department of Mines, Minerals, & Energy has additional information about crush stone use, quarries, and industry data. https://www.dmme.virginia.gov/dgmr/crushedstone.shtml

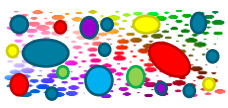
2. Have students discuss what engineers must consider when they are deciding on the type of material to use for a road or other transportation structure.
    - Amount of traffic
    - Types of vehicles using the road (light versus heavy commercial vehicles)
    - Climate
    - Cost of road materials
    - Soil structure
    - Maintenance/ long-term costs (Asphalt is easier to repair than concrete but needs repair more frequently. While both asphalt and concrete crack, asphalt tends to deteriorate faster due to its softer consistency.)

3. Discuss the properties that make aggregates good for construction and/or road surfaces.
    - Toughness
    - Soundness
    - Durability
    - Abrasion resistance
    - Availability

    Show the short video about aggregate characteristics and the testing equipment used to measure them. (https://www.youtube.com/watch?v=9JNiqoYkbAs "The Physical Characteristics of Aggregates: Toughness, Durability, and Abrasion Resistance" by the Gilson Company.) If you'd like to skip the equipment descriptions, stop playing the video at 2:13 min.

4. Aggregates typically make up over 90% of an asphalt mixture and 70 – 80% of concrete. The amount of binder (the black asphalt) in a mixture is very important and determines how well the aggregate particles stay together and how the road surface wears over time and in different weather conditions. Discuss how adding different aggregates to a mixture can provide a better performing road than just using one type of aggregate.
    - light-weight expanded clay or shale = increased skid resistance
    - too much clay however, can impact how well the asphalt binder sticks to aggregates
    - Cubical, rough-textured aggregates provide more strength than rounded, smooth-textured aggregates (Figure 1-3). Cubical aggregate particles tend to lock together resulting in a stronger mass of material. Instead of locking together, rounded aggregate particles tend to slide by each other. Because natural sands tend to be rounded, with poor internal friction, the amount of natural sand in a blend is often limited.

Cubical Aggregate



Rounded Aggregate

- granite & quartzite are good strong aggregates
- limestone is strong, but when particles rub together, it will create a fine dust that is water-soluble. When water mixes with the left over minerals from the dust, it creates a "glue" that binds larger particles together.


Sample concrete & asphalt core samples

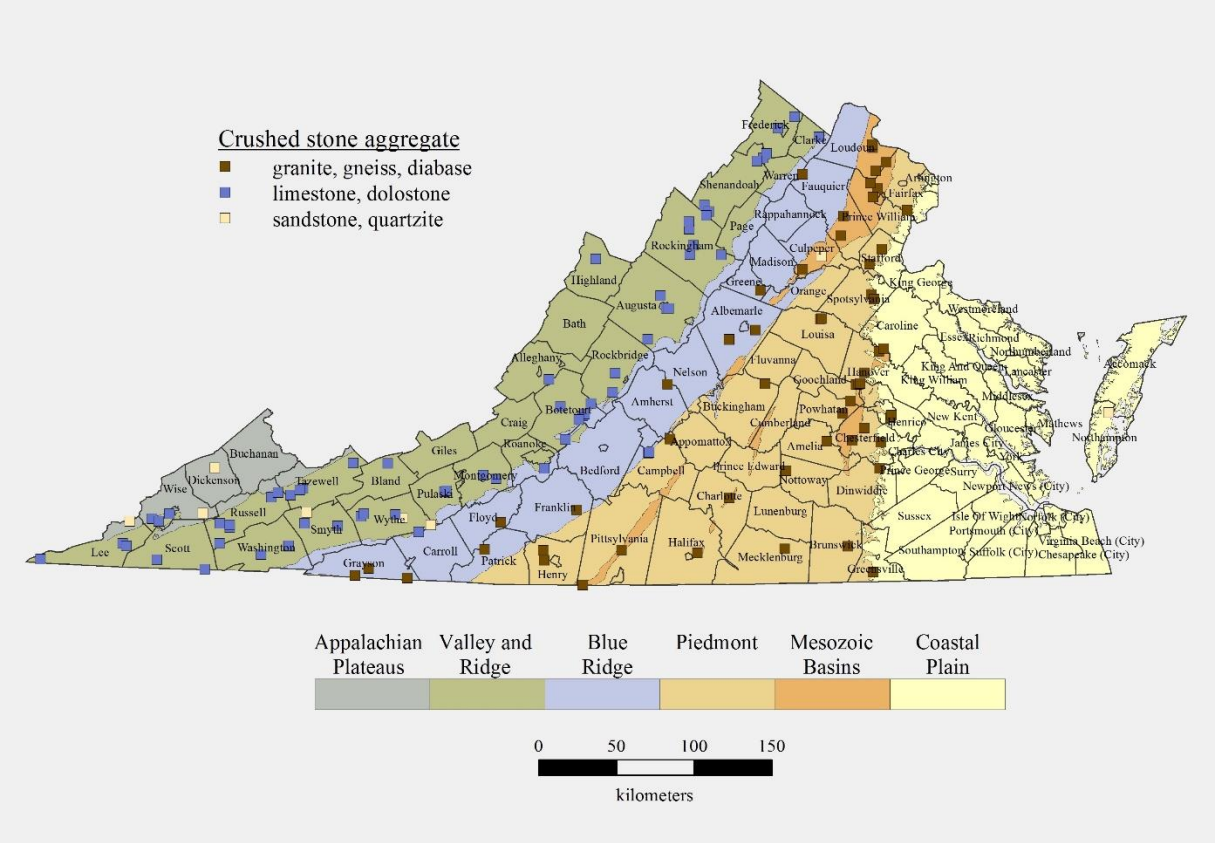
5. Have students read the article about how roads are built. The article includes a link to a virtual asphalt plant tour. https://wonderopolis.org/wonder/how-do-you-build-a-road (2:56 min.) For a longer, more detailed video of asphalt plant operations and aggregate use, watch How an Asphalt Plant Works - YouTube (7:45 min.).

   Roads are not constructed with just one layer of aggregate mixture. The ground or subgrade must be prepared to support several layers of aggregate and asphalt concrete that will make up the completed road structure. Figure 1 shows an example of how a road or parking lot might be constructed using various layers of aggregates and asphalt mixes.


Figure 1: Typical low volume pavement section

6. Have students research asphalt plants in their area and locate them on maps. You can also have students map quarries in their areas. Does there seem to be any correlation between quarry locations and asphalt plant locations?

   A good reference for researching crushed stone quarries in Virginia is the Department of Mines, Minerals, & Energy. Virginia Geological Survey - Crushed Stone




**Aggregate quarry locations in Virginia**
Map from Virginia Geological Survey - Crushed Stone website, 08/17/2021

**7.** For a yummy "asphalt" treat, the following recipe can be made in class in a crockpot or at home with a microwave.

## Tasty "Asphalt" recipe

**Ingredients:**

1 cup semi-sweet chocolate chips
¾ cup crushed graham crackers
1 1/3 cup Cheerios or other cereal

**Tip:** Crush the graham crackers in a plastic zipper bag. Particles can be of varying sizes (some crumbs, all pieces ¼" or smaller.

Melt chocolate in the microwave on low or in a crock pot. Mix in the graham cracker pieces/crumbs and the cereal. Stir until coated well. Spoon mixture into cups to serve.

**Alternate ingredient:**
Substitute ½ cup of sweetened coconut flakes for the graham crackers.

**Careers to Explore**

- Geologist
- Mining engineer
- Reclamationist
- Materials scientist or engineer
- Surface miner
- Civil engineer

You can play some of the audio interviews on this site to help students learn more about careers associated with mining and geology: https://mineralseducationcoalition.org/

## Terminology

**Aggregate**: A hard inert material of mineral composition such as sand, gravel, slag, or crushed stone, used in pavement applications either by itself or for mixing with asphalt binder. They are classified by size with varying fine-to-course classifications.

**Mining**: the extraction of valuable minerals or other geological materials from the Earth.

**Concrete**: a compact and rigid material commonly used for building. It forms when a mixture of cement, gravel, sand, and water thoroughly dries.

**Geology**: the study of the Earth, the materials of which it is made, and the processes acting upon them.

**Materials Science**: The study of material characteristics. It helps us understand limits of materials, identify the best applications of use, and how to combine materials to improve the overall properties for a certain use.

**Limestone**: A sedimentary rock commonly used as a material for building. It can also used as the base layer in asphalt paving systems. It is the primary stone component for many asphalt materials.

**Asphalt Pavements:** Pavements consisting of a surface course of asphalt concrete over supporting courses such as asphalt concrete bases, crushed stone, slag, gravel, Portland Cement Concrete (PCC), brick, or block pavement.

**Ductility:** The ability of a substance to be drawn out or stretched thin

**Durability**: The property of an asphalt paving mixture that represents its ability to resist disintegration from the environment and traffic.

**Fatigue Resistance:** The ability of asphalt pavement to resist cracking caused by repeated flexing.

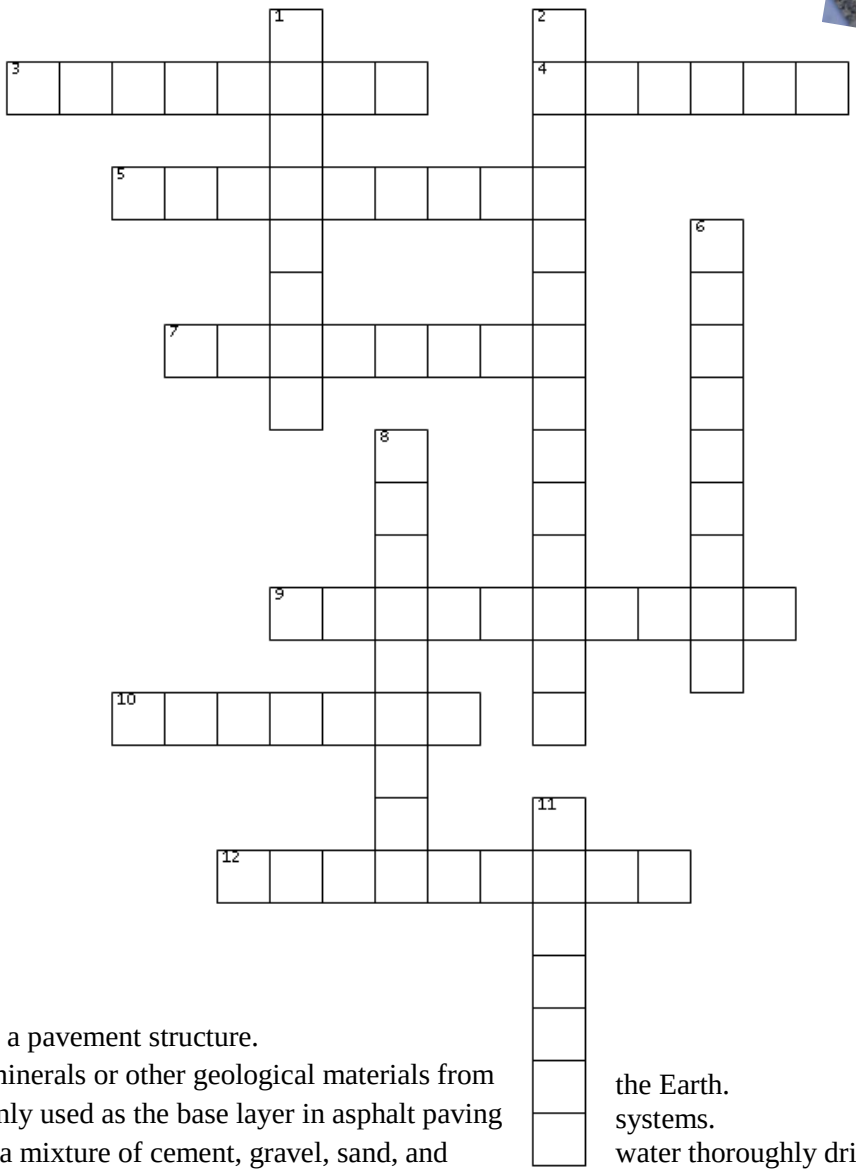
**Impermeability:** The resistance an asphalt pavement has to the passage of air and water into or through the pavement.

**Subgrade:** The soil prepared to support a pavement structure.

# Aggregates in Roads

**WORD BANK**

aggregate
asphalt
pavement
materials
ductility
permeability
fatigue
durability
geology
concrete
mining
subgrade



**ACROSS**

3. The soil prepared to support a pavement structure.
4. The extraction of valuable minerals or other geological materials from the Earth.
5. A sedimentary rock commonly used as the base layer in asphalt paving systems.
7. A material that forms when a mixture of cement, gravel, sand, and water thoroughly dries.
9. The property that represents a pavement's ability to resist disintegration from the environment and traffic.
10. The study of the Earth, the materials of which it is made, and the processes acting upon them.
12. _____ Science helps people understand the limits of materials and identify the best applications of use.

**DOWN**

1. Asphalt _____ consists of a surface course of asphalt concrete over supporting courses such as asphalt concrete bases, crushed stone, slag, gravel, etc.
2. The resistance an asphalt pavement has to the passage of air and water into or through it
6. The ability of a substance to be drawn out or stretched thin.
8. A material such as sand, gravel, slag, or crushed stone, used in pavement applications either by itself or for mixing with asphalt binder.
11. _____ resistance is the ability of asphalt pavement to resist cracking caused by repeated flexing.

**RESOURCES:**

https://www.acplm.net/glossary-asphalt-paving-terms/ (accessed 15 July 2021)

http://www.asphaltinstitute.org/engineering/glossary-of-terms/ (accessed 15 July 2021)

https://geology.com/articles/what-is-geology.shtml (accessed 15 July 2021)