

## Lesson 4 – Waste aggregates and material properties

### 1. Background Narrative:

Materials have a wide range of properties that affect how we use them in engineering processes. Materials are often chosen based upon their properties. Properties of a material include strength, hardness, density, appearance, ability to conduct electricity, and resistance to corrosion.

Some major types of material properties include mechanical, optical, thermal, electrical and magnetic properties.

Material properties that are important for determining if a material is suitable for use as an aggregate include:

- Unit weight (bulk density, or how densely the aggregate packs – how much void space there is)
- Specific gravity (material density)
- Particle shape and surface texture (want rough surface with edges, so material will hold together, as opposed to smooth, round surface)
- Shrinkage (will the material shrink as it ages?)
- Absorption, surface moisture (want particles that do not absorb much liquid)
- Resistance to freezing/thawing (obviously we want materials that are resistant)

It is important for students to understand all of these properties so they can make informed decisions about which materials work best for different applications. In this activity, we will examine the properties of a wide range of materials that could be used as aggregates in concrete. Students will learn about making concrete using different waste materials for coarse and fine aggregates. The benefits and burdens of using waste aggregates will be emphasized in this plan. Then the lesson will continue by going over material properties so appropriate choices can be made for the concrete project.

Note that for many of our 8<sup>th</sup> grade students, only a brief overview of material properties is needed. Students need to understand some of the more basic properties and understand the concept that in order to effectively use a material, you need to take into account the properties it has (e.g., need a good electrical conductor if you want to make wire, a good insulator if you want to insulate a house or make a potholder).

### Major concepts

1. Define coarse aggregate as larger aggregate in mix.
2. Define fine aggregate as sand sized aggregate in mix.
3. Coarse aggregates that can be used, examples...
  - a. Stone
  - b. Shredded rubber tire
  - c. PVC
  - d. Wood Chips
  - e. Glass

- f. Paper
  - g. Gypsum
  - h. Anything else, be creative and cautious!
4. Fine aggregates that can be used, examples...
- a. Sand
  - b. White glass (used for pottery)
  - c. Green glass
  - d. Used sand
  - e. Recycled plastic (shredded in manufacturing process – looks like coconut)
  - f. Anything else, be creative but cautious! We went to local manufacturing businesses and found white glass and green glass (that is, fine white powder and tiny glass beads) as well as a waste product from the manufacture of plastic parts – long strings of paper-thin 3/8” wide PVC – looks kind of like old movie reels!

5. Material properties - Vocabulary /Terms:

Brittle	Conductor
Ductile	Elastic
Ferrous	Non-ferrous
Insulator	Plasticity
Thermal	Toughness

Unit weight/bulk density  
 Specific gravity  
 Void space  
 Particle shape  
 Surface texture  
 Shrinkage  
 Absorption  
 Resistance to Freezing/thawing

## 2. Performance Objectives

- Students will be able to identify needs and opportunities for technical solutions from an investigation of situations of social interest.
- Students will be able to formulate ideas on how to incorporate waste in the production of a valuable construction product such as concrete.
- Given a list of material properties, students will be able to explain what those properties mean and give an example of what type of materials might have each property.
- Students will determine which types of properties are exhibited by materials suitable for use as concrete aggregates.
- Based on their material properties, students will be able to define specific waste materials that could be used as aggregates in concrete.

### 3. Standards:

- NYS Integrated 4.3, 4.7, 5.2
- US Science 2.2
- US Technology 1.3, 2.2

### 4. Resources

- Samples of all Coarse and Fine Aggregates listed above (plus others as appropriate)
- Samples of waste materials for Material Properties Worksheet – use materials that students can handle, stretch, tap, feel, etc. For example:
  1. shredded rubber, and some rubber bands
  2. shredded plastic samples, and plastic milk jugs or bottles (note number on bottom of sample, match object to correct sample of shredded plastic!)
  3. shredded PVC and a piece of PVC pipe
  4. ground glass and glass bottles
  5. shredded newspaper and several pieces of newspaper, whole
  6. ashes from a wood stove – no real large sample available, provide an open container and spoon so students can test density and examine with magnifying glass
  7. wood chips or saw dust, and a block of wood
  8. shredded aluminum or metal, and a few waste metal containers (tin cans)
  9. aluminum foil – shredded and whole
- Beaker of water (to test density and surface absorption)
- Magnifying glass (to examine surface texture and shape)
- Teacher resources: Information about concrete
- PowerPoint – see “Teacher resource – concrete used a construction material with pictures” and “Teacher resource – Overview of Aggregate Properties”
- Material Properties Vocabulary Worksheet
- Aggregate Material Properties Definition Sheet
- Properties of Aggregates Worksheet (2 versions provided)

## 5. Vocabulary

Brittle	Conductor
Ductile	Elastic
Ferrous	Plasticity
Insulator	Toughness
Void Space	Absorption
Shrinkage	Bulk Density

## 6. Instructional Plan

- 1. Introduction: (2 minutes)** Begin with a skit of a fictitious phone call with one person trying to describe a new material. Can use cell phones to make it more realistic, but ask teacher.

Sample:

Person one: (answering phone) Hello?

Person two: Madam! We have just discovered this brand new material, it's awesome and we are going to build rocket ships out of it.

Person one: So tell me about this material, what are its properties.

Person two: It's great. Better than all the rest.

Person one: Well is it **Ductile**?

Person two: It's better than ductile; this will fly better than any duck.

Person one: Well is it **ferrous**?

Person two: Of course, this material is ferrous, ferrous good.

Person one: Then is it **elastic**?

Person two: Sir I'm building rocket ships, not sweat pants.

Person one: Well is it **conductive to electricity**?

Person two: Let me check (yelps) Very well sir.

Person one: What about its **thermal properties**?

Person two: This material is hot!

Person one: Can it be **infiltrated**?

Person two: There will be no covert operations here!

Person one: Well, you really haven't told me anything. In fact, I'm scared about this rocket ship. Where are you building it?

Person two: In your backyard.

Explain to students that to effectively communicate material properties there are some vocabulary terms they need to become familiar with.

After the skit begin today's lesson: ( 5 min.) Remember yesterday. You learned about concrete, ingredients in concrete, (cement, water, sand and gravel – cement and water critical for making “concrete,” sand and gravel really just fillers to reduce the cost.) Today, we need to figure out how to add non-biodegradable waste materials to the mix, both to recycle the waste materials and to create strong and durable concrete.

**Note:** *this lesson contains 2 versions of material properties definitions and worksheets. One is for a basic technology curriculum (‘material properties vocabulary and worksheet’) and the other is more geared to properties of concern when making concrete (‘physical properties of aggregates, definitions and worksheet’). Use the one that suits the needs of the particular class. Either way, conduct the class in the same manner – brainstorm/possible waste aggregates, go over the definitions to make sure students understand, do the activity - look/feel waste materials and examine properties of each, then regroup to discuss the suitability for using as concrete aggregate and why.*

*You may want to briefly discuss the importance of material properties to selecting a suitable waste material (or any material to use in any project – give examples), then distribute the definitions worksheet and fill in as a class, then split into groups and distribute the waste aggregates and have groups complete the back side of the worksheet. In other words, skip the brainstorm. Could also set up stations around the room with the different waste aggregates and have students circulate with their worksheets.*

## **2. Material Properties Overview(5 min)**

- a. Explain to the students that the properties of aggregates are critically important for creating a strong and durable concrete product.
- b. Divide students into groups. Hand out the appropriate version of the Material Properties definitions worksheet, and have transparency up on board (if doing material properties, provide additional red information, but not examples – have students fill in examples as homework or during extra time in class).

## **3. Activity ( 15 min)**

*Note: depending on the time available and the class size, this activity could be done in 2 possible ways – one would be to set up stations around the room with the different materials and have kids rotate among the stations and fill in their worksheets. Another way would be to split the kids into groups and give a few samples to each group, then have them report back to the class about their materials and a recommendation as to whether the material would make a good waste aggregate.*

- a. Properties of Aggregates (use one of the 2 worksheet versions provided, depending on what you have for materials). Do either as stations or by groups, as described above. (10 min)
- b. Have students identify the material properties of each of the samples they examine and complete the worksheet.
- c. Save time at the end to go over all samples together as a class.

#### 4. Closure/ wrap-up (10 min)

- a. Answer the questions on the worksheets as a class.
- b. Summarize what was learned (share information from the activity, share opinions about which materials would be good waste aggregates) – waste materials used as aggregates, material properties are important, many wastes have suitable material properties to be used as aggregates.
- c. Ask students – based on what they did, which aggregates do they think will work best and why. How can we choose the best among these possibilities? Answer: we need to do some testing!!
- d. **Important** – tell students to brainstorm at home about waste materials that they want to try, encourage them to bring in a sample (about 1 cup) of a waste material, ready to mix into concrete (e.g., cut up milk jugs, shredded newspaper, wood stove ashes, coffee grounds, etc...)

Name: \_\_\_\_\_

Date \_\_\_\_\_

## Material Properties Vocabulary Worksheet

Property	Definition/description	Examples
Ductile materials	Materials that can bend and be deformed without breaking.	
Brittle materials	A brittle material will not deform without breaking.	
Elastic materials	An elastic material can be bent and it will return to its original shape.	
Plasticity	Plastic materials can be bent and they will stay bent.	
Strength	Strength refers to the materials ability to retain its own shape while a force is being applied.	
Toughness	Toughness is a materials ability to absorb energy without breaking.	
Hardness	Hardness is a materials ability to resist being scratched or dented.	
Conductivity	Conductive materials do not resist the flow of electricity, or offer very little resistance.	
Insulating	Insulating materials resist the flow of electricity. They are good for preventing heat loss from a building or protection from a conductor.	
Magnetic	Magnetic materials can be attracted to a magnet. Most can be magnetized or made to act as a magnet.	

## Material Properties Vocabulary Worksheet (teacher version)

Ductile materials	Materials that can bend and be deformed without breaking. <b>Any material that can be pressed, twisted, or bent into shape has a high ductility.</b>	<b>mild steel, gold, fiberglass.</b>
Brittle materials	A brittle materials will not deform without breaking. <b>opposite of ductile</b>	<b>window glass</b>
Elastic materials	An elastic material can be bent and it will return to its original shape.	<b>Rubber bands, springs, and fishing rods</b>
Plasticity	Plastic materials can be bent and they will stay bent. <b>The material we know as plastic gets its name from that characteristic.</b>	<b>Modeling clay, metals</b>
Strength	Strength refers to the materials ability to retain its own shape while a force is being applied. <b>Strong materials are very difficult to bend, or shape.</b>	
Toughness	Toughness is a materials ability to absorb energy without breaking	<b>Animal leather, nylon, high density polymers, metals</b>
Hardness	Hardness is a materials ability to resist being scratched or dented.	<b>Diamonds, High carbon steel, tungsten carbide</b>
Conductivity	Conductive materials do not resist the flow of electricity, or offer very little resistance. <b>Most good conductors are metals</b>	<b>The very best is silver</b>
Insulating	Insulating materials resist the flow of electricity. They are good for preventing heat loss from a building or protection from a conductor. <b>opposite of conductive</b>	<b>Wood, plastic, ceramic</b>
Magnetic	Magnetic materials can be attracted to a magnet. Most can be magnetized or made to act as a magnet. <b>These materials must have iron in them or be ferrous.</b>	<b>steel</b>

Name: \_\_\_\_\_

Date: \_\_\_\_\_

## Worksheet: Material Properties of Aggregates

**Directions:** List the materials you have available as aggregates in the left hand column. For each material, place a check in the box of the properties that describe the material, using the terms from the definitions page. Feel free to examine the materials and ask questions.

Aggregates	Ductile	Brittle	Elastic	Plasticity	Strength	Toughness	Hardness	Conductivity	Insulating	Magnetic

### Questions:

Which properties would best suite a concrete aggregate?

Which of the above materials contain these properties?