

CVG 2141
Civil Engineering Materials

Lab 2: Aggregates Lab

Lab Date:

Report Date:

T.A.:

Lab Group:

Lab Partners:

Abstract

Concrete is the most important material a civil engineer will use, as it is not only just used, but can be designed by civil engineers unlike other materials. Aggregates are a large part of the mix design of concrete, so they must be used correctly. In this experiment, the particle sizes of both coarse aggregate and sand are found using sieves. The coarse aggregate goes through a sifter and the sand goes through a sieve shaker. When the percentage passing of each sieve is found and plotted, the curves can be compared to CSA standards to determine if either aggregate meets requirement. The sieve analysis is also used to determine the fineness modulus of the sand. After doing this it can be concluded that the sand meets these requirements, while the coarse aggregate does not. Though, this is a two-part experiment, as some physical properties are found for the sand and coarse aggregate. Analyzing the mass of aggregate in different states allows it to be concluded that both aggregates have average values for specific gravity and moisture content. All of this shows that the sand is good for use in concrete production, and though the concrete has the right physical properties, it does not have a proper particle size distribution and is not safe for concrete production.

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Objective

This report investigates the distribution of different sizes of particles in aggregates. The particle size of sand and coarse aggregate are determined through using sieves to sort the particles by size. When plotted, the results will be compared to CSA standards to further analyze the particle sizes of the aggregates. The specific gravity of aggregate will also be determined from the sieve analysis. Comparing the SDD mass and the oven dry mass will allow specific/bulk density and moisture content to be investigated.

Theoretical background

When the data was recorded for the sieve analysis, only the weight of the sieve and the weight of the sieve and aggregate were taken. A few calculations had to be done in order to attain the percentage passing.

$$\text{Weight Retained} = \text{Weight of Sieve and Aggregate} - \text{Weight of Sieve} \quad \text{Equation 1}$$

$$\text{Percentage Retained} = \frac{\text{Weight Retained}}{\text{Weight of Aggregate}} \times 100 \quad \text{Equation 2}$$

$$\text{Cumulative Percentage Retained}_n = \% \text{ Retained}_1 + \dots + \% \text{ Retained}_n \quad \text{Equation 3}$$

$$\text{Percentage Passing}_n = 100 - \text{Cumulative Percentage Retained}_n \quad \text{Equation 4}$$

The fineness modulus of sand ensures the uniformity of the particle size distribution. It can be found using equation 5.

$$FM = \frac{\Sigma(\text{Cumulative Mass \% Retained})}{100} \quad \text{Equation 5}$$

Specific gravity is a measure of a material that uses the density of water as a reference point. It is essentially the ratio between the density of the material and the density of water. Specific gravity can be found using equation 6.

$$SG = \frac{A}{B+S-C} \quad \text{Equation 6}$$

Where A is oven dried weight, B is the weight of the pycnometer filled with water, S is the SSD weight, and C is the weight of the pycnometer filled with water and aggregate.

Bulk density, or apparent specific gravity, is a measurement similar to specific gravity but does not use a ratio with the density of water. It can be found using equation 7.

$$ASG = \frac{A}{B+A-C} \quad \text{Equation 7}$$

The moisture content found in this experiment can be called absorption, as it is known that the aggregate is originally in SSD. This represents the percentage of the mass of the aggregate in the original condition that was actually water weight. It can be found with equation 8.

$$MC(\%) = \frac{S-A}{A} \times 100 \quad \text{Equation 8}$$

Materials and Equipment

- Sand
- 20mm coarse aggregate
- Scale
- Sieve and sifter
- Pycnometer

Experimental Procedure

1. Weigh the pycnometer filled with water to the reference point
2. Weigh approximately 500g of the provided SSD sand
3. Partially fill the pycnometer with water and pour the 500g of sand into it. Fill the pycnometer back up to the reference point
4. Remove sand from pycnometer and place into a container. Dry sand in oven at about 110 ° C until completely dry. Weigh the oven dried sand
5. Repeat steps 1-4 with 1000g of coarse aggregate
6. Weigh each size sieve and the pan from the sifter (for coarse aggregates) and the sieves (for sand)
7. Measure out 500g of sand and 5kg of coarse aggregate in separate containers
8. Pour the sand in the top of the sieves and place in the sieve shaker for 5 minutes
9. Pour the coarse aggregate in the top of the sifter and allow it to run for 5 minutes
10. Weigh each size sieve with the retained sand/aggregate to determine the percent retained and percent passing

Analysis of Data

Particle Size Analysis

By weighing the mass of each sieve before and after the sand and coarse aggregate passes through it, multiple different aspects can be analyzed. Using just the mass before and after, all the following data was determined.

Table 1: Sieve Analysis for Coarse Aggregate

Sieve Analysis for Coarse Aggregate - 5.06kg						
Size (mm)	Weight of Sieve (kg)	Weight Retained (kg)	Percentage Retained (%)	Cumulative Percentage Retained (%)	Percentage Passing (%)	
20	8.08	0.88	17.4	17.4	82.6	
10	10.64	3.6	71.1	88.5	11.5	
5	7.64	0.54	10.7	99.2	0.8	
2.5	6.82	0	0	0	0	
1.25 (pan)	6.08	0	0	0	0	

Table 2: Sieve Analysis for Sand

Sieve Analysis for Fine Aggregate - 500.5g						
Size (mm)	Weight of Sieve (g)	Weight Retained (g)	Percentage Retained (%)	Cumulative Percentage Retained (%)	Percentage Passing (%)	
4.75	515.0	4.5	0.9	0.9	99.1	
2.36	586.0	95.0	19.0	19.9	80.1	
1.18	523.0	95.5	19.1	39.0	61.0	
0.6	488.0	84.0	16.8	55.8	44.2	
0.3	458.5	128.5	25.7	81.5	18.5	
0.15	428.0	78.5	15.7	97.2	2.8	
0.01	374.5	6.0	1.2	98.4	1.6	

To find the particle size curve, the percentage passing is plotted against the sieve mesh size.

Equations 1, 2, 3, and 4 were used to find the percentage passing. To achieve a proper curve, the data must be plotted on logarithmic axes. On the same graph, the CSA A23.1 standards are plotted so the size distribution can be visually inspected to see if the sand or coarse aggregate meets CSA standards.

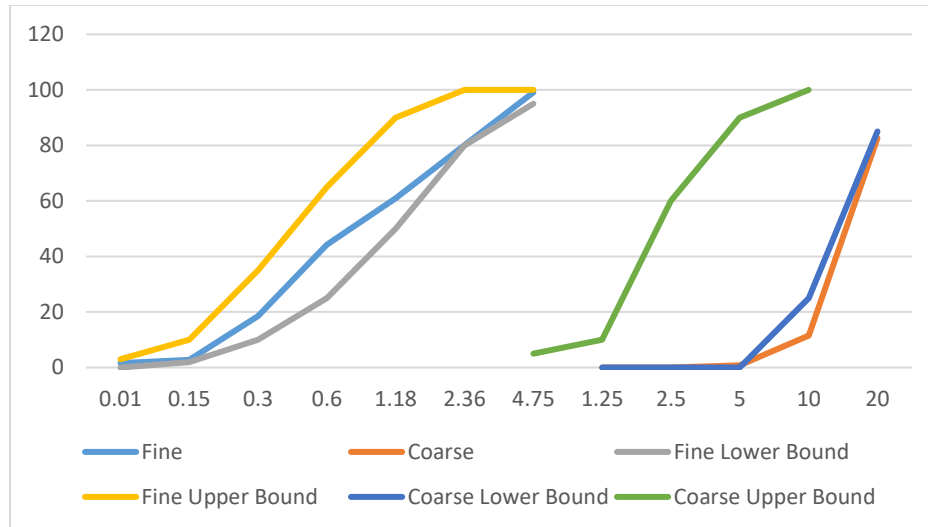


Figure 1: Particle Size Analysis & CSA Standards

Fineness Modulus of Sand

Using **equation 5**, the fineness modulus of sand can be determined by finding the average cumulative percent mass retained by each sieve.

$$FM = \frac{\Sigma(\text{Cumulative Mass \% Retained})}{100}$$

$$FM = \frac{(0.9\% + 19.9\% + 39.0\% + 59.8\% + 81.0\% + 97.2\%)}{100}$$

$$FM = 2.983$$

Relative Density

Using **equation 6**, the specific gravity of the oven dried state sand/aggregate can be determined by exploring the relationships between different measurements.

$$SG_{OD-Sand} = \frac{A}{B + S - C}$$

$$SG_{OD-Sand} = \frac{492.5g}{1448.5g + 500.0g - 1762.0g}$$

$$SG_{OD-Sand} = 2.641$$

$$SG_{OD-Coarse} = 2.690$$

Using **equation 7**, the bulk density of the sand/aggregate can be determined by using a similar equation to **equation 6**, except not using the SSD state mass.

$$ASG_{Sand} = \frac{A}{B + A - C}$$

$$ASG_{Sand} = \frac{492.5g}{1448.5g + 492.5g - 1762.0g}$$

$$ASG_{Sand} = 2.751$$

$$ASG_{Coarse} = 2.746$$

Actual Moisture Content

Using **equation 8**, the moisture content of the SSD sand/aggregate can be calculated. This is done by finding the difference in mass between the SSD and oven dried states and finding the percent of the total mass that is.

$$MC_{Sand}(\%) = \frac{S - A}{A} \times 100$$

$$MC_{Sand}(\%) = \frac{500.0g - 492.5g}{492.5g} \times 100$$

$$MC_{Sand}(\%) = 1.5\%$$

$$MC_{Coarse}(\%) = 0.76\%$$

Discussion of Results

After analyzing the data obtained from the lab, conclusions in reference to the CSA A23.1 standards can be made. Both the coarse aggregate and sand have ranges for percent passing that occurs through each sieve. The CSA ranges have been plotted on **figure 1**, that has the actual percentage passing on it as well. From visually analyzing the graphs, it is clear that the sand remains within the bounds of the standards in every sieve. However, the coarse aggregate is below the lower bound of the size range for every sieve. This means that the coarse aggregate does not meet the standards put out by the CSA. If the first sieves were to retain less of the sample, the coarse aggregate would have a better dispersion amongst the sieves.

According to the CSA A23.1 standards, the fineness modulus of sand must be in the range of 2.3 to 3.1 for the type of sand that was used. From the information that was gathered in the lab, the fineness modulus was calculated to be 2.983, which falls well within the standards. This means that the sand is considered usable by these standards.

From the lecture notes, the range of values in which the moisture content of coarse aggregates should fall between is 0-4%, and 0-2% for sand. From the calculations, the values of 1.5% for

sand and 0.76% for coarse aggregate show that the materials fall within the proper range. These ranges can be used in this case because since it was established that both materials were in SSD condition before the experiment, the moisture content calculation is technically finding the absorption. The lecture notes also provide a range of values in which the specific gravity of each material should fall between. For both types of materials, the value should fall between 2.4 and 2.9. Using the data collected in the lab, the specific gravity of sand was found to be 2.641, and the specific gravity of coarse aggregate was found to be 2.690. Both of these values fall within the range. The other value that was calculated in the data analysis is the bulk density, or apparent specific gravity. This value is very much dependent on the specific situation in which the measurements are taken. The oven dried mass is used to calculate this value which shows that it is completely relative to whatever state the aggregate is in.

Conclusion and Recommendations

Based on the results of the data analyzed it can be concluded that the coarse aggregate is not suitable for use in concrete production. The CSA lays out clear standards for the particle size of grading of the coarse aggregate, and the sample used does not meet these requirements. Although, through analysis of the sand in reference to the CSA standards, it is found that it does meet requirements. Unlike the coarse aggregate, the sand has a good dispersion of particle size throughout the sample, and each sieve had a percentage passing within the range found in CSA A23.1. The sand also meets the requirements that are in place for the fineness modulus it has. The fineness modulus checks the uniformity of particle size and gives a measure to the grading fineness. This means that if one were to put together a mix design for concrete, the sample of sand used would work very well, and the coarse aggregate would not.

After going through the analysis of the data collected and further understanding it, it is obvious that the errors found can not be result of an improper procedure. The procedure is well designed and is standard for particle size analysis, which means the problem must be found somewhere else. Too much of the larger sized particles were found through the sieve analysis. To meet the requirements, the aggregate sample would need to have more particles pass through the first and second sieve.

References

- CVG 2141 Aggregates (1)
- CVG 2141 Aggregates (2)
- CVG 2141 Lab 2 Aggregates Lab Manual

Appendices

Example of Equation 1

Weight Retained = Weight of Sieve and Aggregate – Weight of Sieve

$$\text{Weight Retained}_{\text{coarse-20mm}} = 8.08\text{kg} - 7.20\text{kg}$$

$$\text{Weight Retained}_{\text{coarse-20mm}} = 0.88\text{kg}$$

Example of Equation 2

$$\text{Percentage Retained} = \frac{\text{Weight Retained}}{\text{Weight of Aggregate}} \times 100$$

$$\text{Percentage Retained} = \frac{0.88\text{kg}}{5.06\text{kg}} \times 100$$

$$\text{Percentage Retained} = 17.4\%$$

Example of Equation 3

$$\text{Cumulative Percentage Retained}_n = \% \text{ Retained}_1 + \dots + \% \text{ Retained}_n$$

$$\text{Cumulative Percentage Retained}_2 = 17.4\% + 71.1\%$$

$$\text{Cumulative Percentage Retained}_2 = 88.5\%$$

Example of Equation 4

$$\text{Percentage Passing}_n = 100 - \text{Cumulative Percentage Retained}_n$$

$$\text{Percentage Passing}_2 = 100 - 88.5\%$$

$$\text{Percentage Passing}_2 = 11.5\%$$