Faculty of Engineering and Technology

Civil Engineering Department

Construction Materials Laboratory

ENCE215

Experiment # 2

" Aggregate: Sieve analysis, L.A abrasion test "

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- **Introduction**

Background information

Aggregates as a component of concrete have the highest percentage (both in volume and mass) usually ranging between 60 % to 75% of normal concrete mixes, thus a lot of the mix's properties are affected by those of aggregates.

The sieve analysis test is a test that is performed on both, coarse and fine aggregates to determine the particle size distribution of a given sample. By performing this test, a clear idea is taken about the gradation of particle sizes, which is very helpful in determining the suitability of some type of aggregates to a certain application or project.

The basic principle of this test is to pass a sample of aggregates through a sieve series, which are ordered such that they are decreasing in their openings size moving downwards, and to know how much of the aggregate has retained on each sieve. In general aggregates are categorized into two groups, coarse aggregates which are the aggregates retained on sieve NO.4 and fine aggregates which are capable of passing the NO.4 sieve, and for each category of the previous two there is a standard sieve series.

In engineering applications, it is vitally important to determine the gradation of aggregates or the grain size distribution, it is effortless to obtain them from plotted graphs using the results of the sieve analysis test. It is conventional to plot a graph relating the percentage of aggregates passing (percentage retained could be used) each sieve and the corresponding sieve size. In most of the cases, one of three curves could appear. First, well graded aggregates curve which is a smooth curve that extends covering a reasonable area of sizes, this type indicates that the aggregate sample contains a satisfying variation of particle sizes from finest to coarsest, in other words voids between large aggregates are filled with the smaller aggregate particles, thus void content in a mix produced by these aggregates is minimalized, thus less cement is required to fill the voids which makes it the most economical type of grading. this grading of aggregates is usually suitable for mixes demanding high strength and compactabillity such as Foundation works and Full compacted concrete works. Second, poorly graded aggregates curve, this steep curve represents a lack in variation of the particles sizes, which means that all particles have more or less the same size, which leads to a higher requirement of cement to fill the voids and in sequence even more water to maintain workability affecting the economic factor could be used in pavements that need drainage. Third, gap graded aggregates curve, in this gradation type several sizes are absent, it is usually used for architectural and aesthetic purposes.

An important index usually obtained from the sieve analysis test is the Fineness modulus (F.M), it is a factor defined as the sum of the cumulative percentages retained on the sieves of thestandard series, divided by 100. The value of the fineness modulus gives an indication of how fine is the sample of aggregates, it could be useful to detect slight variations in aggregates from the same source, which could have an impact on concrete's workability. It is worth mentioning that higher values of (F.M) indicate coarser aggregates.

Another very important characteristic that should be tested when dealing with coarse aggregates is hardness. Hardness could be generally defined as the material's ability to resist wearing when rubbed or scratched by another material. A very common test used for determining hardness of aggregates is the Los Angeles abrasion test. In this test aggregates are exposed to abrasive forces (crushing) using steel balls that are randomly moving in the L.A's rotating drum. The difference in the samples weight before and after the crushing expressed as a percentage of the original weight gives a value that is called the 'abrasion value'. This test is so beneficial for structures or projects were aggregates are prone to degradation and disintegration such as for roads and pavements were frictional forces are always affecting aggregates. It is worth mentioning that higher L.A values indicate weaker abrasion resistance.

For fine aggregates:

- $Fineness\ modulus\ (F.M) = \frac{\Sigma\, cumulative\ (\%retained)}{100}$

For coarse aggregates:

- $Fineness\ modulus\ (F.M) = \frac{\Sigma\, cumulative\ (\%\ retained)+500}{100}$
- It is important to apply correction to the retained masses due to error, using these formulas:

-Sieving error = (W(before sieving) - W(after sieving)) / W(before sieving)*100%

-Correction = $W_{retained}$ + (Error * $W_{retained}$)

- Abrasion value = $\frac{W_b - W_a}{W_b} * 100\%$

  Where:

  W_b: the initial weight of aggregates before crushing.

  W_a: the final weight of aggregates after crushing (and sieving the resulting fines).

- **Purpose**

The sieve analysis test is used in this experiment to determine the grain size distribution of coarse and fine aggregates samples, in order to determine the suitable engineering application according to gradation curves. Also to calculate the fineness modulus from the sieve analysis results. Finally, to determine the abrasion value of aggregates by means of L.A abrasion test.

- **Hypotheses**

The fineness modulus for fine aggregate is usually between 2.3 and 3 for fine aggregates, and 7.3 to 8 for coarse aggregates according to American specifications hence are values should be within that range. By visual inspection our aggregate samples seemed to be of uniform size, hence it is expected to see a poorly graded curve when plotting. Also for the L.A test we expect that the abrasion value should be less than the maximum one since no apparent visual problems were observed.

- **Procedure**

a) Sieve analysis test:

1. Four samples of aggregates were prepared (two coarse samples and two fine samples).
2. Samples were weighed to get the total weight of each sample.
3. The fine aggregate sample was sieved through sieve #200 by washing method.
4. The coarse aggregate sample was put inside the coarse sieve series (on the top), with being careful not to overload the sieves.
5. The sieve series was carefully mounted to the shaker, and vibrated for 3 minutes.

6. After the shaking was finished, for each sieve each retained amount was weighed using the balance.
7. The same procedure was followed for the other coarse sample.
8. After the coarse samples were done, the first fine sample was secured and shaken for five minutes using the shaker.
9. After shaking, each sieve's fine content was weighed, in order to avoid error, the brush was used to assure not leaving any fines stuck on the sieves.
10. The second fine sample was treated with the same procedure of the first one.

b) L.A abrasion test:

1- An amount of coarse aggregates was sieved using the shaking sieve.

2- A sample of five kilograms (W_b) was obtained by taking 2.5 kg of 12.5mm sieve and 2.5 kg of the 9.5mm sieve.

3- The five kilogram sample was placed inside the L.A machine.

4- All of the 11 steel balls were put inside the machine along with the aggregates.

5- The machine was calibrated to complete 500 revolutions (which are nearly equivalent to 15 minutes), and in anticipation of any problems we set 15 minutes on the timer.

6- After the 500 revolutions were complete we emptied the crushed sample in the steel tray beneath the drum..

7- The crushed sample was manually sieved using the #12 (1.7 mm) sieve.

8- The aggregates passing the sieve were tossed away while the retained was preserved and weighed to obtain W_a.

- **Instruments:**

fig.1: Coarse aggregates

fig.2: Fine aggregates

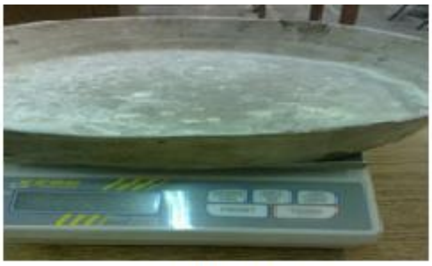


fig.3: Digital balance

ig.4: Mechanical shaker

fig.5: Coarse aggregate sieves

fig.6: Fine aggregate sieves

fig.7: L.A machine

fig.8: Mechanical sieves

fig.9: Brush

- **Data & Calculations:**

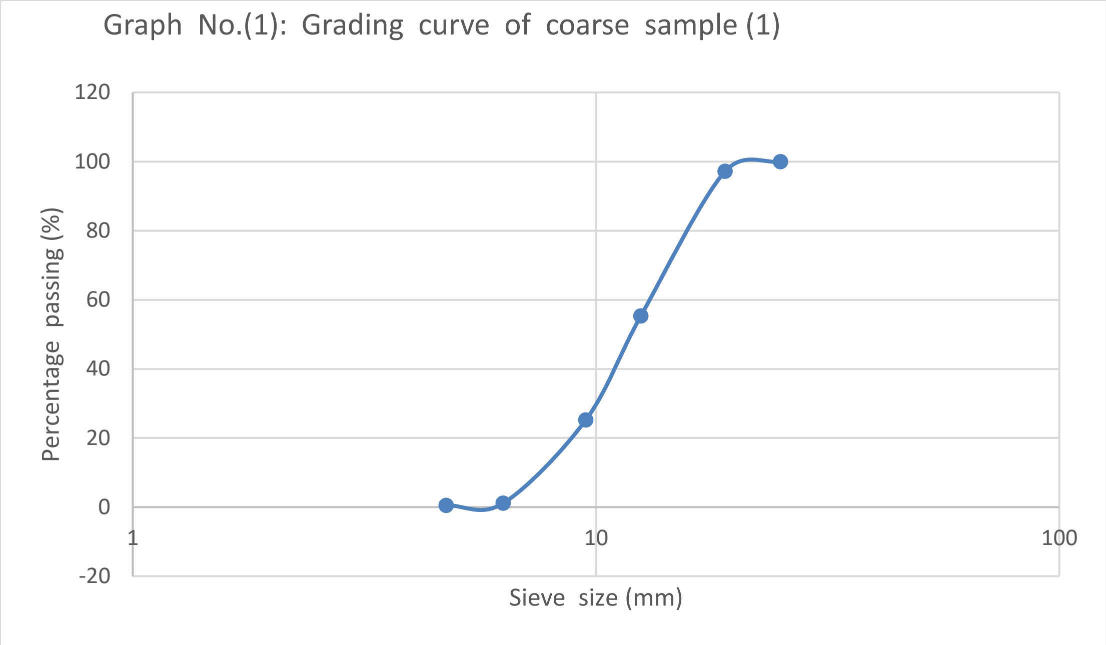
Coarse sample one:

Total weight before sieving = 887.04 g

Error = $\frac{887.04 - 888.27}{887.04} * 100 = -0.139\%$

Table No.(1): gradation on coarse aggregate sample (1)						
Sieve size (mm)	Individual mass retained (g)	Corrected mass retained (g)	Individual percent retained (%)	Cumulative Percent Retained (%)	Cumulative percent passing (%)	Reported percent passing (%)
25.0	0	0	0	0	100	100
19.0	25.09	25.06	2.83	2.83	97.17	97.2
12.5	371.53	371.01	41.83	44.66	55.34	55.3
9.5	267.73	267.36	30.14	74.8	25.20	25.2
6.3	214.02	213.72	24.09	98.89	1.11	1.1
4.75	4.57	4.56	0.51	99.5	0.50	0.5
Pan	5.33	5.32	0.60	100	0	0
	Σ = 888.27	Σ = 887.03		Σ = 320.68		

F.M = (320.68 + 500) / 100 = 8.2068 ≈ 8.21



Coarse sample two:

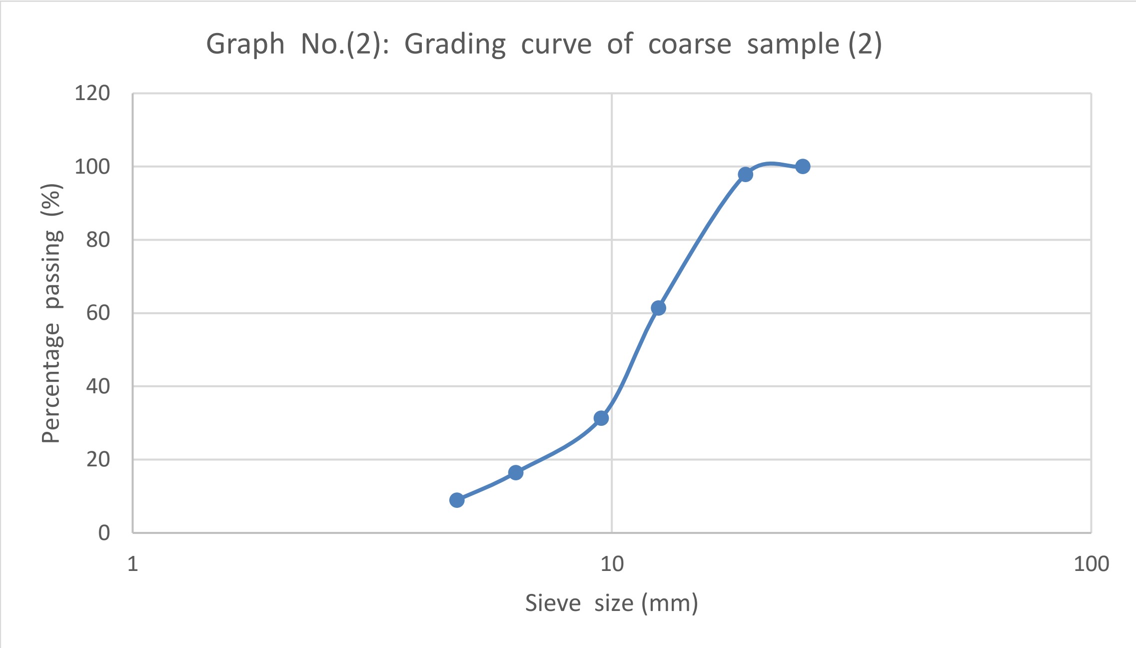
Total weight before sieving = 1243.00 g

Error = $\frac{1243.00 - 1242.26}{1243.00} * 100 = 0.043\%$

Table No.(2): gradation on coarse sample (2)						
Sieve size (mm)	Individual mass retained (g)	Corrected mass retained (g)	Individual percent retained (%)	Cumulative Percent Retained (%)	Cumulative percent passing (%)	Reported percent passing (%)
25.0	0	0	0	0	100	100
19.0	26.48	26.49	2.13	2.13	97.87	97.9
12.5	453.39	453.58	36.49	38.62	61.38	61.4
9.5	373.28	373.44	30.04	68.66	31.34	31.3
6.3	184.84	184.92	14.88	83.54	16.46	16.5
4.75	93.18	93.22	7.50	91.04	8.96	9.0
Pan	111.29	111.34	8.96	100	0	0

	Σ = 1242.46	Σ = 1242.99		Σ = 283.99	

F.M = (283.99 + 500) / 100 = 7.8399 ≈ 7.84



Fine sample one:

Total weight before washing = 200 g

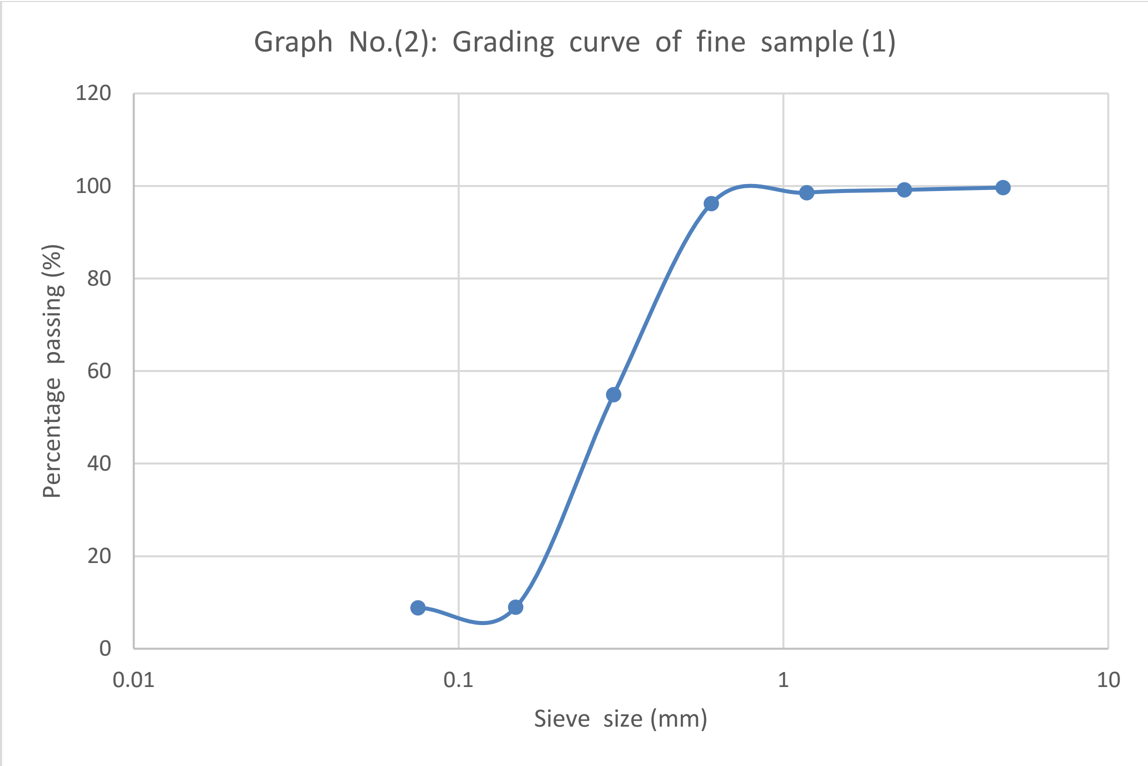
Total weight before sieving = 182.73 g

W(total retained on pan) = 0.32 + (200 - 182.73) = 17.59 g

Error = $\frac{200 - 199.43}{200} * 100 = 0.285\%$

Table No.(3): gradation on fine aggregate sample (1)						
Sieve size (mm)	Individual mass retained (g)	Corrected mass retained (g)	Individual percent retained (%)	Cumulative Percent Retained (%)	Cumulative percent passing (%)	Reported percent passing (%)
4.75	0.68	0.68	0.34	0.34	99.66	99.7
2.36	0.98	0.98	0.49	0.83	99.17	99.2
1.18	1.21	1.21	0.61	1.44	98.56	98.6
0.6	4.71	4.72	2.36	3.8	96.20	96.2
0.3	82.37	82.60	41.30	45.1	54.90	54.9
0.15	91.55	91.81	45.91	91.01	8.99	9.0
0.075	0.34	0.34	0.17	91.18	8.82	8.8
Pan	17.59	17.64	8.82	100	0	0
	Σ = 199.43	Σ = 199.98		Σ = 233.7		

F.M = 233.7 / 100 = 2.337 ≈ 2.34



Fine sample two:

Total weight before washing = 200 g

Total weight before sieving = 196.27 g

W(total retained on pan) = 0 + (200 - 196.27) = 3.73 g

Error = $\frac{200 - 199.95}{200} * 100 = 0.025\%$

Table No.(4): gradation on fine aggregate sample (1)						
Sieve size (mm)	Individual mass retained (g)	Corrected mass retained (g)	Individual percent retained (%)	Cumulative Percent Retained (%)	Cumulative percent passing (%)	Reported percent passing (%)
4.75	2.36	2.36	1.18	1.18	98.82	98.8
2.36	0.93	0.93	0.47	1.65	98.35	98.4
1.18	1.41	1.41	0.71	2.36	97.64	98.6
0.6	18.08	18.08	9.04	11.4	88.6	88.6
0.3	84.88	84.90	42.45	53.85	46.15	46.2
0.15	85.08	85.10	42.55	96.4	3.60	3.6
0.075	3.48	3.48	1.74	98.14	1.86	1.9
Pan	3.73	3.73	1.87	100	0	0
	Σ = 199.95	Σ =199.99		Σ = 264.98		

F.M = 264.98 / 100 = 2.6498 ≈ 2.65

W_b = 5.000 kg

W_a = 3.390 kg

Abrasion value = [(5.000 - 3.390) / 5.000] * 100 = 32.2

- **Results & Conclusion**

Coarse sample (1): F.M = 8.21

Coarse sample (2): F.M = 7.84

Fine sample (1): F.M = 2.34

Fine sample (2): F.M = 2.65

Abrasion value = 32.2 %

All of the gradation curves are very steep and extend only for a narrow range of sizes which is consistent with the properties of the poorly gradation curve, this means that most of the particles are of uniform size, and that there is a lack of size variety, according to that this aggregate is proper for using in pavements and for special types of foundation design.

The fineness moduli of the fine aggregate samples are within the range of 2.3 and 3, also the fineness moudli are almost within the range of 7.3 to 8, which indicates that the results are accurate to an accepted agree.

The abrasion value obtained is 32.2% which is accepted by referring to (AASHTO T 96), which suggests that the maximum value is 40%. Thus, our results are supporting the hypothesis.

Source of error:

1. Loss of some aggregates during the weighing process.
2. Some of the fine sample was still stick on the sieves.
3. Systematic error of the balance.
4. Error in shaking time.

5. Poor manual sieving for the crushed aggregates.

- **References**

1. Matls. I.M. (2002) Aggregate Sampling Methods and Determination of Minimum Size of Samples for Sieve Analysis. Office of materials. IOWA Department of Transportation.
2. Newman J. and Choo B. S.(2003). Advanced Concrete Technology: Constituent Materials. Butterworth-Heinemann, An imprint of Elsevier: Oxford