

Aggregate

Lecture - 2

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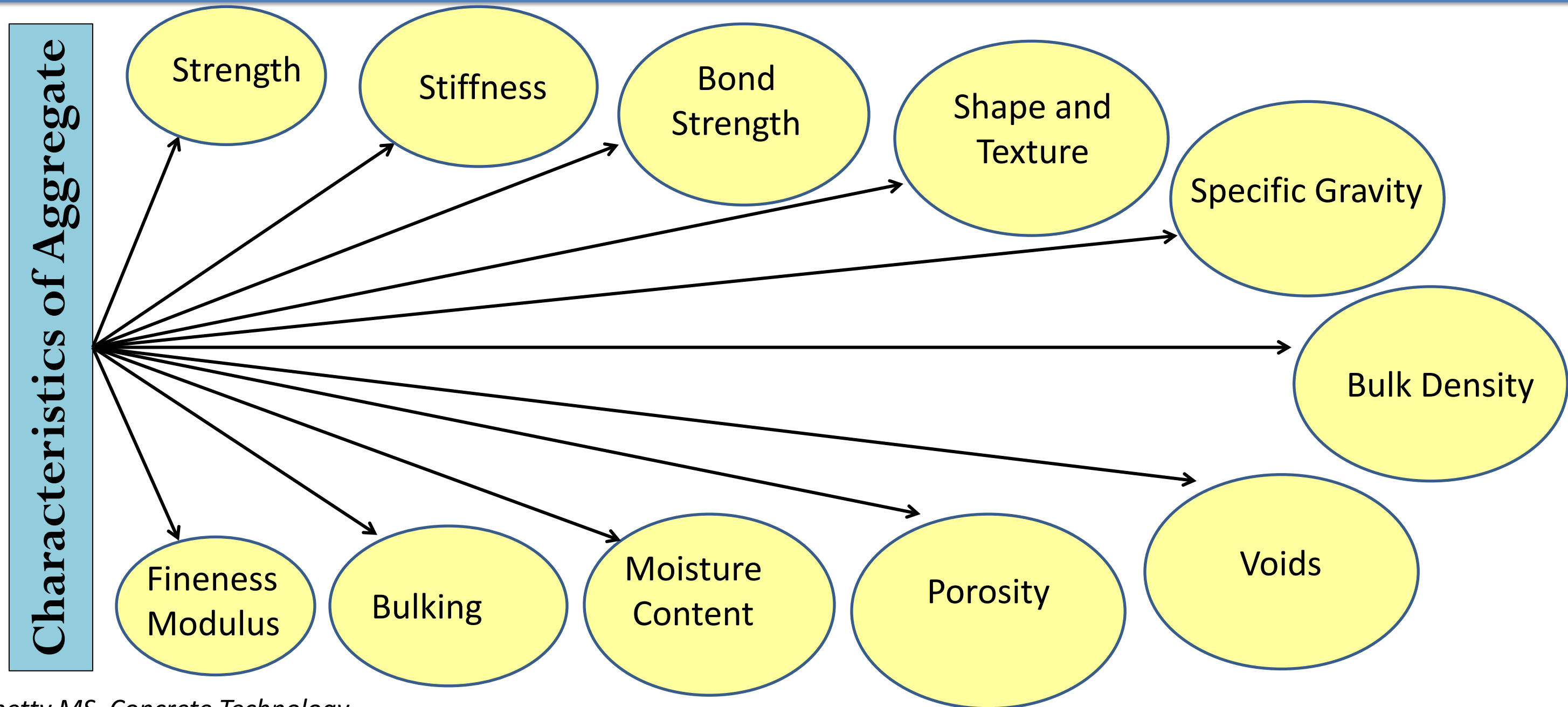


Angular Aggregates

Elongated Aggregates

Paste Phase

Characteristics of Aggregates



Characteristics of Aggregates



Bond Strength

A *rougher texture* result in a **greater adhesion** or *bond* between the **particles** and the **cement matrix**. Likewise, the **larger surface area** of more **angular aggregate** provides a **greater bond**.

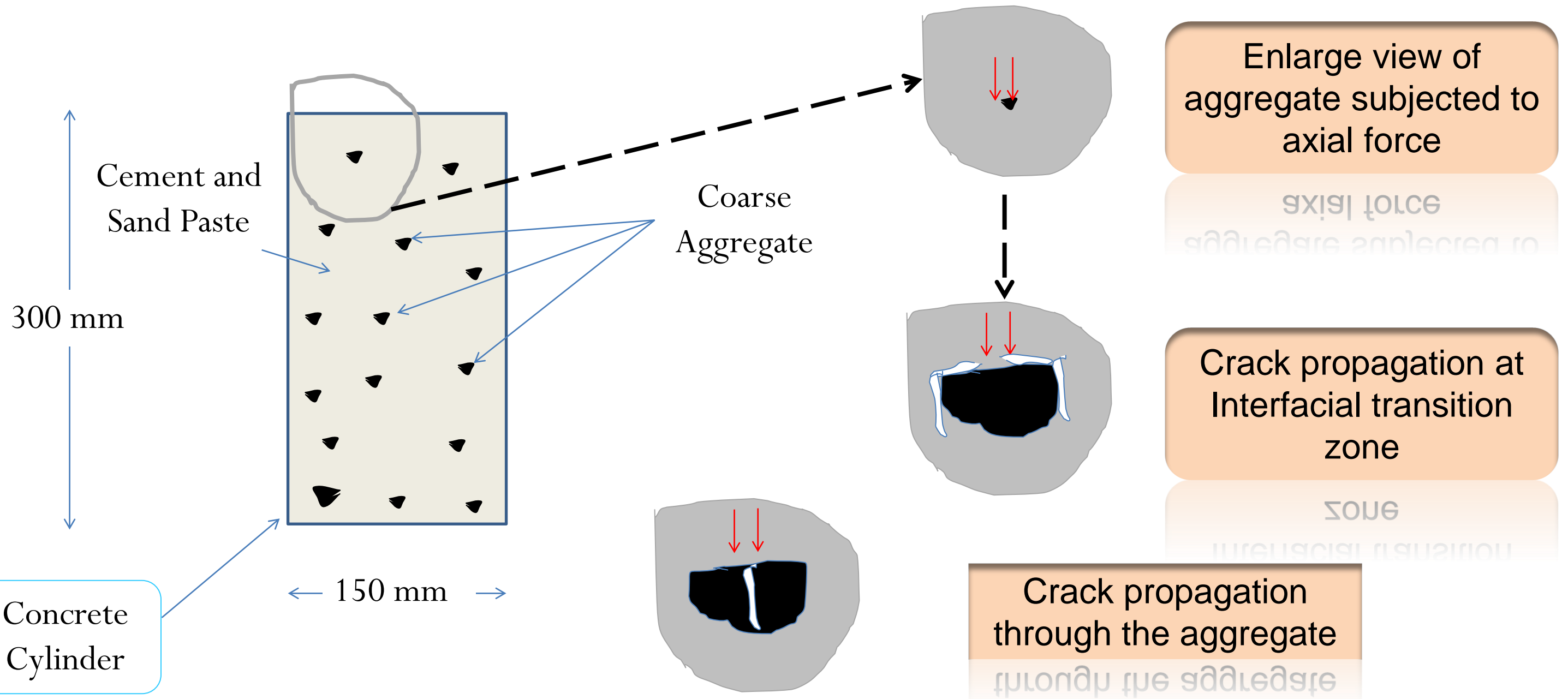
Under increasing external load, these cracks spread along the interfaces before extending into the paste or aggregate particles. The strength of the bond between aggregate and cement paste thus has an important influence on the strength of concrete.

Duggal SK, Building Materials

Neville AM & Brooks JJ, Concrete Technology

7/27/2020

Failure in Concrete Cylinder



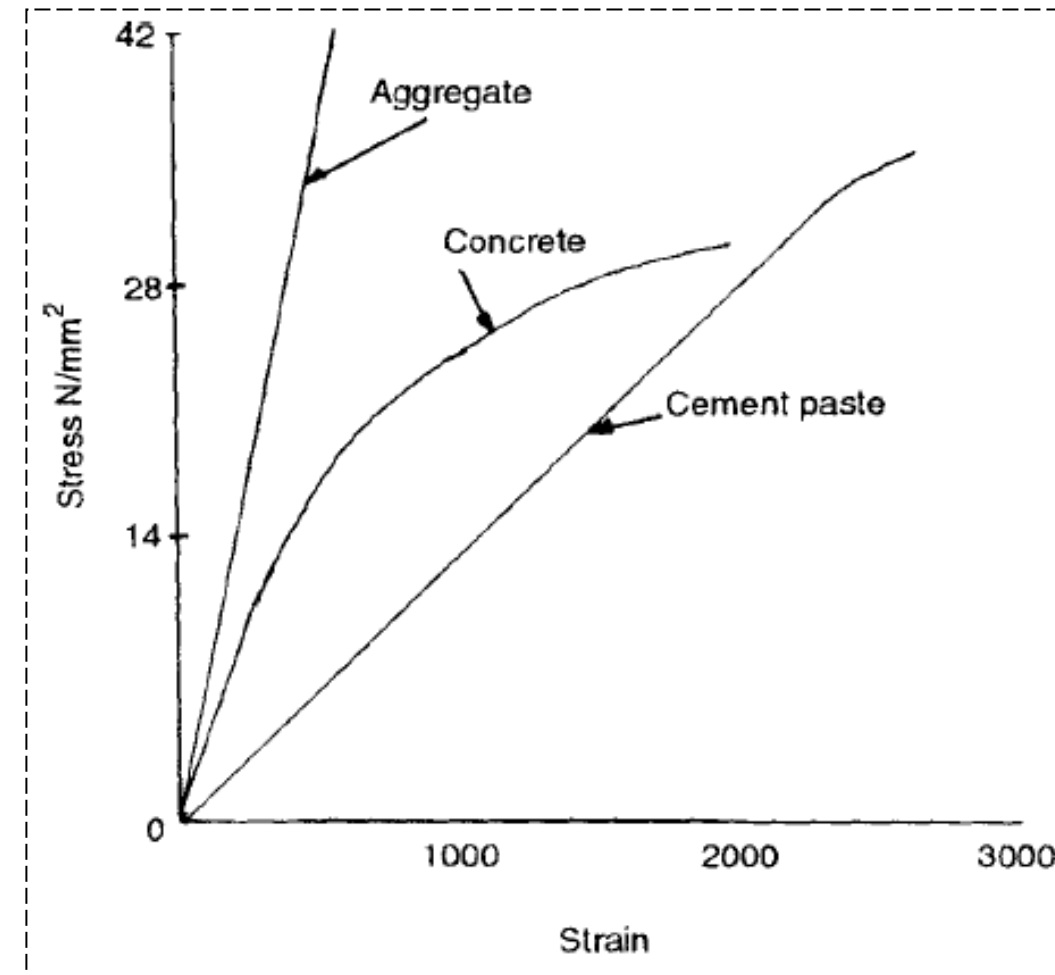
Characteristics of Aggregates



Strength

The test conducted for strength evaluation are;

- Crushing Test (More Reliable Test)
- Impact test
- Ten per cent fines test
- ✓ Generally the specifications prescribe 45 per cent for aggregate used for concrete other than wearing surface and 30 per cent for concrete for wearing surfaces, such as runways, roads etc. limit for the crushing value.
- ✓ The toughness of aggregate is measured by impact test. The impact value should not exceed 30 per cent for wearing surface and 45 per cent for remaining concretes.
- ✓ Hardness of aggregate is tested by abrasion test. The abrasion value is restricted to 30 per cent for wearing surfaces and 50 per cent for concrete for other purposes.



Stress Strain curve for aggregate

Stiffness

The modulus of elasticity of concrete is approximately equal to the weighted average of the moduli of the cement paste and the aggregate, as such the modulus of the coarse aggregate has an important influence on the stiffness of concrete. A high value reduces the dimensional changes due to creep and shrinkage of cement paste, but at the cost of higher internal stresses. In concrete that is to be subjected to wide variations of temperature and humidity, internal cracking is reduced by the use of a more compressible aggregate, but in practice this effect is rarely of sufficient importance to determine the choice of aggregate.

Characteristics of Aggregates



Shape and Texture

The shape influences the properties of fresh concrete more than when it has hardened. Rounded aggregate are highly workable but yield low strength concrete. Same is the case with irregular shaped aggregate. Flaky aggregate require more cement paste, produce maximum voids and are not desirable. Angular shape is the best. Crushed and uncrushed aggregates generally give essentially the same strength for the same cement content. The shape and surface texture of fine aggregate govern its void ratio and significantly affect the water requirement.

Specific Gravity

The specific gravity of most of the natural aggregates lies between 2.6-2.7. The specific gravity and porosity of aggregates greatly influence the strength and absorption of concrete. Specific gravity of aggregates generally is indicative of its quality. A low specific gravity may indicate high porosity and therefore poor durability and low strength. The concrete density will greatly depend on specific gravity.

Characteristics of Aggregates



Bulk Density

The bulk density of aggregate depends upon their packing, the particles shape and size, the grading and the moisture content. For coarse aggregate a higher bulk density is an indication of fewer voids to be filled by sand and cement.

Voids

Void ratio is calculated as

$$\text{Void ratio} = 1 - (\text{Bulk density} / \text{Apparent specific gravity})$$

Characteristics of Aggregates



Porosity

The entrapped air bubbles in the rocks during their formation lead to minute holes or cavities known as *pores*. The porosity of rocks is generally less than 20 per cent; the concrete becomes permeable and ultimately affects the bond between aggregate and cement paste, resistance to freezing and thawing of concrete and resistance to abrasion of aggregate. The porous aggregate absorb more moisture, resulting in loss of workability of concrete at a much faster rate.

Moisture Content

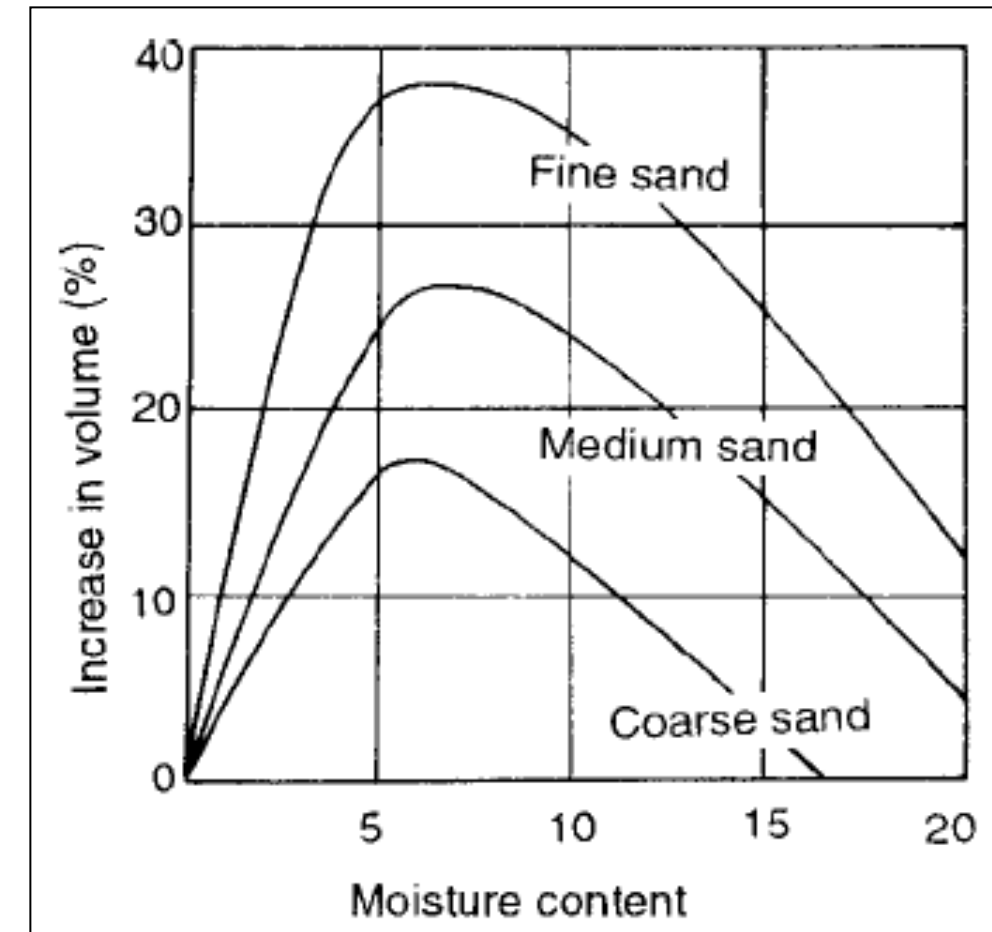
The surface moisture expressed as a percentage of the weight of the saturated surface dry aggregate is known as moisture content. A high moisture content increases the effective water/cement ratio to an appreciable extent and may render the concrete weak.

Characteristics of Aggregates



Bulking

The increase in the volume of a given mass of fine aggregate caused by the presence of water is known as bulking. The water forms a film over the fine aggregate particles, exerts force of surface tension and pushes them apart increasing the volume. The extent of bulking depends upon the percentage of moisture present in the sand and its fineness. With ordinary sand bulking varies from 15-30 percent. It increases with moisture content up to a certain point (4-6%), reaches maximum, the film of water on the sand surface breaks, and then it starts decreasing.



Effect of moisture content on
Bulking of Sand

Characteristics of Aggregates

Fineness Modulus

Fineness Modulus is an index number which gives some idea about fineness or coarseness of an aggregate. In this method, a convenient weight of the sample is taken and passed through a set of sieve one after another. It is defined as the **sum of the cumulative percentage retained on the sieve** of the standard series divided by **100**.

Fine Aggregate
(FM Range)
2.0 and 3.5

Coarse Aggregate
(FM Range)
5.5 and 8.0

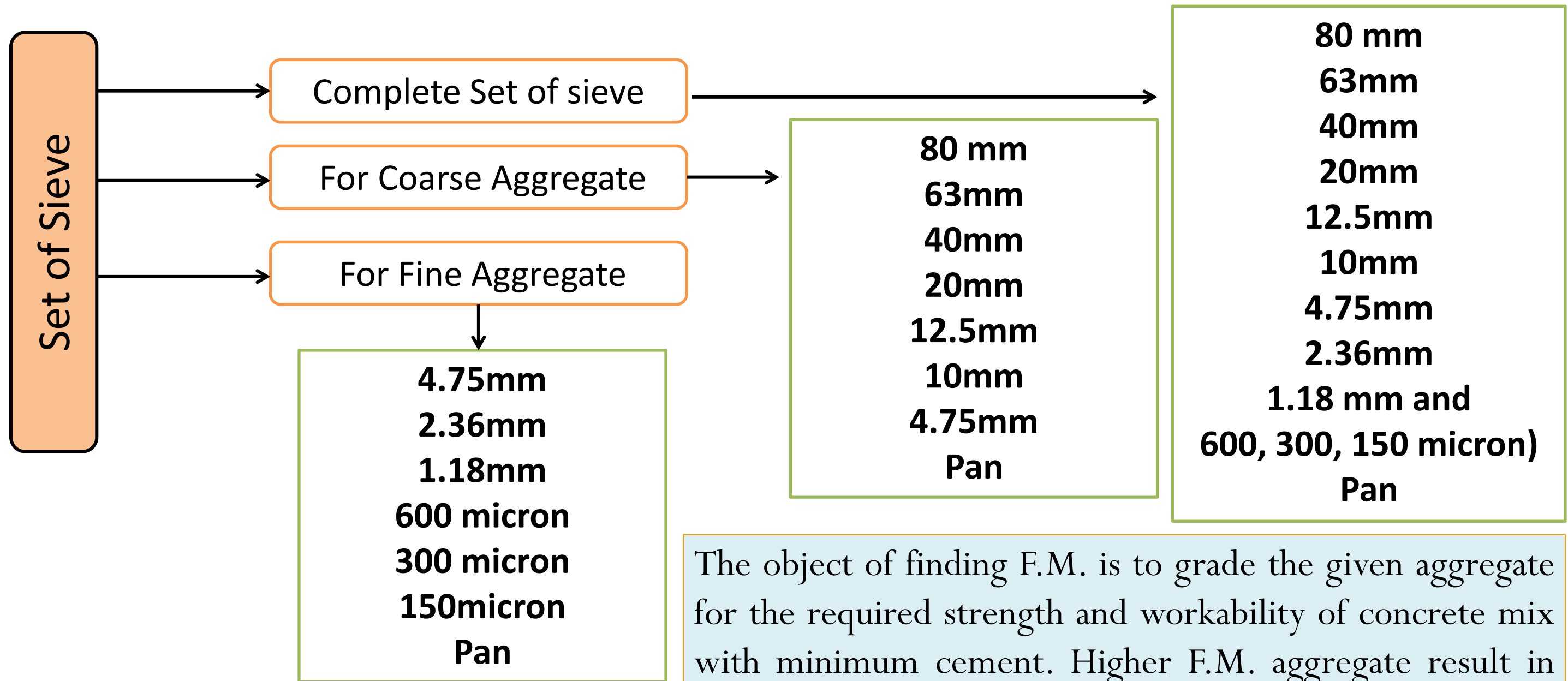
All in Aggregate
(FM Range)
3.5 and 6.5



Set of Sieves.



Characteristics of Aggregates

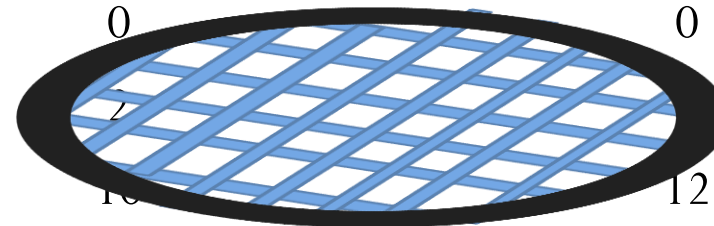


The object of finding F.M. is to grade the given aggregate for the required strength and workability of concrete mix with minimum cement. Higher F.M. aggregate result in harsh concrete mixes and lower F.M. result in uneconomical concrete mixes.

Fineness Modulus of Aggregates

Find the fineness modulus of a sample of fine aggregate for which sieve analysis is given below. The weight of sample is 1000g.

IS Sieve Size	Weight Retained (gm)	Percentage Weight Retained	Cumulative Percentage weight retained
10 mm	0	0	0
4.75 mm	20	2	2
2.36 mm	100	10	12
1.18 mm	170	17	29
600 micron	190	19	48
300 micron	350	35	83
150micron	170	17	100
Total	1000	-	274



Retained Particles are greater than this sieve opening

Passing Particles are smaller than this sieve opening



Fineness Modulus = $274 / 100 = 2.74$

Fineness Modulus of Aggregates



Find the fineness modulus of a sample of fine and coarse aggregate for which the sieve analysis is given below. The weight of sample of coarse aggregate is 15 kg and that of fine aggregate is 500g.

IS Sieve Size	Coarse Aggregate (15 kg)			Fine Aggregate (500g)		
	Retained (kg)	%age Wt. retained	Cumulative% age wt. retained	Wt. retained (g)	% age Wt. retained	% wt retained
80mm	-	-	-	Fineness modulus of coarse aggregate $733.4/100 = 7.33$ Fineness modulus of fine aggregate $214/100 = 2.14$		
40mm	-	-	-			
20mm	7	46.7	46.7			
10mm	6	40.0	86.7			
4.75mm	2	13.3	100	10	2.0	2.0
2.36mm	-	-	100	50	10.0	12.0
1.18mm	-	-	100	60	12.0	24.0
600 micron	-	-	100	80	16.0	40.0
300micron	-	-	100	90	18.0	58.0
150 micron	-	-	100	100	20.0	78.0
Total	15 kg	-	733.4	390 g	-	214

Fineness Modulus of Aggregates

Coarser the aggregate higher is the value of the fineness modulus. Fineness Modulus of 4 means the average size of aggregate is that of the fourth sieve starting from finest sieve i.e. 1.18mm.



Various Indian Standard Codes for Aggregates



IS : 383 - 1970
(Reaffirmed 1997)

Indian Standard

**SPECIFICATION FOR
COARSE AND FINE AGGREGATES FROM
NATURAL SOURCES FOR CONCRETE**

(Second Revision)

Ninth Reprint SEPTEMBER 1993

UDC 691.322

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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April 1971

IS : 2386 (Part I) - 1963
(Reaffirmed 2002)

Indian Standard

**METHODS OF TEST FOR
AGGREGATES FOR CONCRETE**

PART I PARTICLE SIZE AND SHAPE

(Eleventh Reprint AUGUST 1997)

UDC 691.322:620.1

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October 1963

IS : 2386 (Part II) - 1963
(Reaffirmed 2011)

Indian Standard

**METHODS OF TEST FOR
AGGREGATES FOR CONCRETE**

**PART II ESTIMATION OF DELETERIOUS MATERIALS
AND ORGANIC IMPURITIES**

Eleventh Reprint SEPTEMBER 2006
(Including Amendment No. I)

UDC 691.322 : 543.86

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IS : 2386 (Part III) - 1963
(Reaffirmed 2002)

Indian Standard
METHODS OF TEST FOR
AGGREGATES FOR CONCRETE
PART III SPECIFIC GRAVITY, DENSITY, VOIDS,
ABSORPTION AND BULKING
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UDC 691.322 : 531.75

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IS : 2386 (Part IV) - 1963
(Reaffirmed 2002)

Indian Standard
METHODS OF TEST FOR
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PART IV MECHANICAL PROPERTIES
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(Incorporating Amendment No. 1)

UDC 691.322 : 620.17

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March 1964

IS : 2386 (Part V) - 1963
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Indian Standard
METHODS OF TEST
FOR AGGREGATES FOR CONCRETE
PART V SOUNDNESS

UDC 691.322 : 666.97 : 620.193



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Indian Standard

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PART VI MEASURING MORTAR MAKING PROPERTIES
OF FINE AGGREGATE

Tenth Reprint APRIL 2006
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(Reaffirmed 2002)

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(First Reprint JUNE 1973)

UDC 691.322 : 620.193



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IS : 2386 (Part VIII) - 1963
(Reaffirmed 2002)

Indian Standard

METHODS OF TEST FOR AGGREGATES FOR CONCRETE PART VIII PETROGRAPHIC EXAMINATION

(Ninth Reprint DECEMBER 1996)

UDC 691.322:552.12

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Summary



- ✓ Characteristics of Aggregates
- ✓ Various Indian Standard code available to assess the properties of aggregates

THANK YOU