



R.C.Patel College Of Engineering & Polytechnic, Shirpur

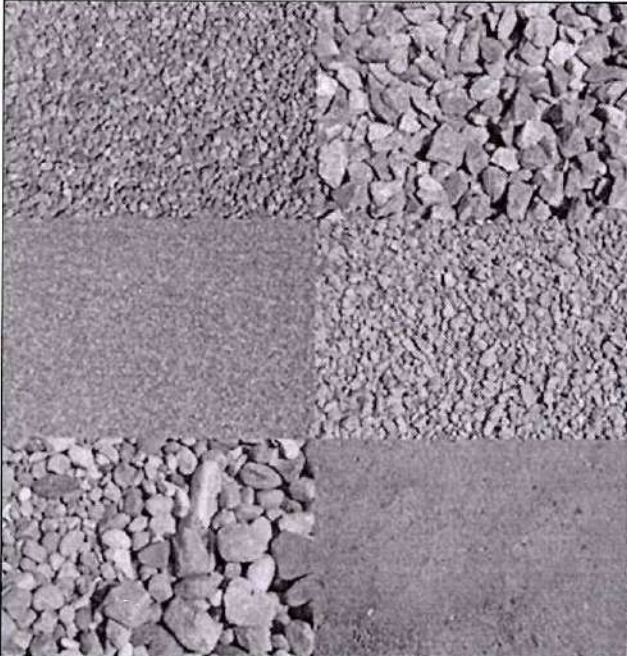
Department of Civil Engineering



Course Title- Concrete Technology
Programme Name -Civil Engineering

Course Code -313322
Semester-Third

Unit	Title	COs	Learning hours	R Level	U Level	A Level	Total Marks
I	Aggregates	CO2	08	2	4	6	12



Aggregate Classification : Size

- Fine Aggregate**
 - Sand and/or crushed stone.
 - < 4.75 mm.
 - F.A. content usually 35% to 45% by mass or volume of total aggregate.
- Coarse Aggregate**
 - Gravel and crushed stone.
 - > 4.75 mm.
 - Typically between 9.5 and 37.5 mm.



* What is an Aggregate? (Basic Definition & Introduction)

1. Basic Definition :- In civil Engineering and construction, aggregates are inert, granular materials - such as sand, gravel, crushed stone, slag and recycled concrete - that are mixed with a binding materials like Portland cement, bitumen, or lime) to form concrete, mortar or asphalt.

2. Introduction & Role in construction :-

Aggregate form the bulk of construction materials typically making 70% to 80% of the volume of concrete and nearly 90% of asphalt pavement. Because they take up such a large portion of the mixture, their properties directly dictate the quality, strength, durability, and cost of the finished structure.

* Key Function of aggregates :-

- provide volume and economy : Since cement is expensive, filling the bulk of the mixture with relatively cheap aggregates significantly the overall cost of construction.
- structural strength :- They give the concrete or pavement its compressive strength and load-bearing capacity, resisting heavy weights and traffic loads.
- Dimensional stability :- They minimize shrinking and cracking. pure cement paste shrinks heavily as it hardens and dries; aggregates act as a rigid anchor that restrains this volume change.

- Durability :- High quality aggregates resist wear, weathering, abrasion, and chemical attacks better than cement paste alone.

3) Broad classification :-

Aggregate are broadly classified into two main categories based on their size (as separated by the 4.75mm IS sieve)

1. Fine aggregate :- particle size smaller than 4.75mm (e.g. natural river sand, manufactured sand/m-sand). They fill the gaps between coarse aggregate pieces

2. Coarse aggregate :- particle larger than 4.75mm (e.g. crushed stone, gravel, pebbles) They form the massive structural backbone of concrete

* Requirement of good aggregates :-

- 1) The good aggregate should be strong having sufficient impact, crushing and abrasion strength.
- 2) A good aggregate should be durable to resist atmospheric variation.
- 3) It should be non-reactive type to avoid alkali-aggregate reaction.
- 4) It should be clean i.e. free from ~~lean~~ organic and inorganic impurities
- 5) It should be well graded with minimum voids
- 6) It should have rough texture for better bonding.
- 7) It should not absorb water more than 5% from added

water to avoid variation in w/c ratio.

8) It should have angular shape for strong interlocking of particles.

* classification of aggregate according to source :-

- 1) Natural aggregate :- The aggregates are found in the natural sources like river, basin, sea bed, slope deposits e.g. pit run gravel, sand.
- 2) Crushed rock aggregate :- These aggregate is formed by crushing the various rocks obtained from quarries e.g. stone aggregate.
- 3) Artificial aggregate :- The aggregate are made up of various waste materials e.g. burnt clays, artificial cinders, steel rivet, iron ore etc.
- 4) Recycled aggregate :- The aggregate is manufactured by crushing inert construction and demolition waste.

* classification of aggregate according to size :-

- i) Fine aggregate :- The aggregate having size of particle less than 4.75mm are called as fine aggregate.
- ii) Coarse aggregate :- The aggregate having size of particle more than 4.75mm are called as coarse aggregate.
- iii) All in one aggregate :- The aggregate containing both fine and coarse aggregates is called as all in one aggregate.

* classification of aggregate according to shape

- i) Rounded :- This type of aggregate is completely shaped by attrition or water worn.
- ii) irregular or partly rounded :- This type of aggregate is naturally irregular or partly shaped by attrition.
- iii) Angular :- This type of aggregate contains well defined edges formed at intersection of roughly planer faces.
- iv) flaky and elongated :- This type of aggregate having small thickness as compared to width or length.

NOTE → i) In flaky aggregate whose thickness is less than its $(3/5)^{th}$ mean aggregate passing.

ii) In elongated aggregate whose length is more than its $(1.4/5)^{th}$ mean aggregate related on length gauge.

* Grading of Aggregates :-

- 1) well graded aggregate :- The aggregate sample which contains particles of all sizes (i.e. finer to coarser) in it, such sample is said to be well graded aggregate.
- 2) gap graded aggregate :- It is the aggregate in which particles of any specific sizes are available and other sizes are totally absent, such sample may be termed as gap graded aggregate.
- 3) poorly graded aggregate :- It is the aggregate sample which contains excess amount of any specific size

deficiency of other sizes of aggregates, hence called as poorly graded aggregate

* Properties of fine aggregate

The properties of fine aggregate are stated as follows.

1. size 2. source 3. specific gravity 4. shape
5. Bulk density 6. fineness modulus 7. cleanliness
8. silt content 9. Bulking.

* specific gravity :-

Defn: the ratio of the wt. of a fine agg. sample to wt. of an equal volume of water.

procedure to find specific gravity of the fine aggregate

- 1) Take the empty wt. of the pycnometer, let the weight be w_1
- 2) Take the sample of fine aggregate for which the specific gravity has to be found out and transfer that to the empty flask and then it is weighed let the weight be w_2 .
- 3) The pycnometer with the sample is filled with water upto to a mark and its weight is taken. The flask should be completely dry on the outer surface w_3 .
- 4) fill the flask with water to the top cone, Roll the flask in an inclined position to eliminate the air bubble and replace with water by means of wash bottle w_4 .
- 5) calculate the specific gravity of the fine aggregate by using the formula.
- 6) specific gravity = dry weight of aggregate / wt. of equal vol. of water

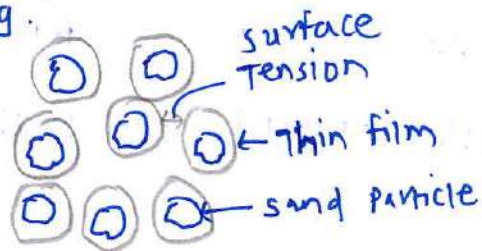
$$\text{i.e. sp. gravity} = \frac{w_2 - w_1}{(w_4 - w_1) - (w_3 - w_2)}$$

* Bulking of sand :-

Defn:- Bulking of sand is defined as increase in volume of given sand due to surface moisture present on surface of particles.

• The phenomenon "Bulking of sand"

i) Bulking is due to adsorption of moisture of individual sand grains in the form of a thin film. the film or moisture produces surface tension which keeps the sand grains away from each others as shown in fig.



ii) This makes the sand swell and its volume appears more than the actual volume. If the moisture content is increased, the bulking increases up to a certain limit.

iii) After this limit, more moisture causes the film to break and at saturation point, all the sand particles lose the film and sink in to the water, so that no bulking is observed.

• maximum increase in volume may be upto 20 to 40% when moisture content is 5 to 10% by weight.

* silt content :-

step by step procedure to determine of silt content of sand and their standards for silt content as per IS 383.

As per IS 383, procedure for determination of silt content:

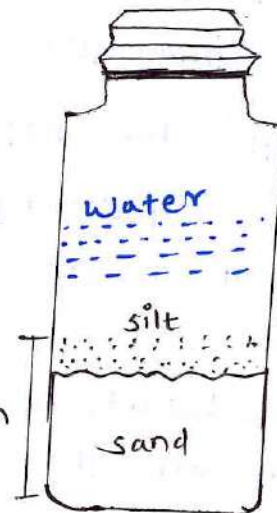


Fig. measuring jar for silt determination

1. Take measuring cylinder of 250ml capacity.
2. prepare 1% common salt solution and fill in the cylinder upto 50ml mark on it.
3. sand is added in the solution till it reaches 100 ml.
4. Now add more salt solution till water level reaches to the level of 150ml mark
5. shake the mixture vigorously in both palms and allow to stand for 3 hours.
6. A distinct layer of silt is appear as a top layer on the sand
7. measure the vol. of sand as V_1 and vol. of silt as V_2 .
8. silt content of given sample is calculated in % as given below

$$\% \text{ silt content} = \frac{V_2}{V_1} \times 100$$

9. As per IS 383, The % of silt should be less than 6%.

* Bulking of fine aggregate :- fine aggregate means sand

Defn:- The increase in volume of a given sand sample due to free (surface) moisture content in the sand is known as bulking of sand or fine aggregate.

* crushed sand :- The sand which is obtained by crushing stone to the required size by machine crusher is called as crushed or manufactured sand.

- India is now focused on infra-structure development project such as expressway, metro rails, sea-link bridges, flyover etc. so availability of huge amount of natural sand is a very difficult task.
- Due to scarcity of natural sand, it becomes cost; with the invention this sand.

Water absorption of Aggregate:

- The water absorption of coarse aggregate is measured by the percent increase in weight of an oven dry sample after immersion in water for 24 Hours.
- But this does not give the true picture, and many times the absorption for a period equal to final setting time of cement is measured. This gives more realistic result.
- Water absorption will decrease the water content in concrete and the concrete will require higher water/cement ratio.
- The water absorption will depend upon the porosity of aggregate, and more water absorption will affect both workability and durability of the concrete.

* Fineness modulus (F.M.)

Define fineness modulus :- It is defined as the sum of the cumulative percentage retained on the sieves of the standard series ranging from 80mm to 150 microns and dividing this sum by 100.

$$\text{Fineness modulus} = \frac{\sum \text{cumulative retained } \%}{100}$$

- F.M. is the numerical index of fineness.
- It give idea of the mean size of particles present.

* Range of F.M.

Type of sand	Fineness modulus
Fine sand	2.2 - 2.6
medium sand	2.6 - 2.9
coarse sand	2.9 - 3.2

* Coarse aggregate

Various properties of coarse aggregates:

1. size 2. shape 3. texture 4. water absorption
5. specific gravity 6. bulk density 7. fineness modulus
8. impact strength 9. crushing strength 10. Abrasion test

* Bulk density :- Defⁿ:- The ratio of net weight of aggregate to the volume of aggregate gives bulk density. It is expressed as kg/litre

$$\text{Bulk density} = \frac{\text{Net weight of aggregate (kg)}}{\text{capacity of container (litre)}}$$

Percentage of voids is also calculated from this test as

$$\% \text{ Voids} = \frac{G - Y}{G} \times 100 \quad \text{where, } G = \text{sp. gravity} \text{ \& } Y = \text{bulk density}$$

* Factor affecting Bulk density

- 1) Degree of compaction 2) Grading 3) shape

* Aggregate crushing value Test (IS 2386 Part IV-1963)

* procedure:- This Test gives a relative measure of the resistance of aggregate to compressive stress.

- Aggregate passing through 12.5mm sieve and retained on 10mm sieve is taken. About 6.5kg of surface dry aggregate is filled in the standard cylinder in 3 layers, tamping each layer 25 times by a standard tamping rod. It is leveled off. Its weight is found out (A).
- The plunger is placed on the aggregate taking care that it does not jam the cylinder by becoming tilted.
- The assembly is taken kept under compression testing machine and total load of 40 tones is applied uniformly within 10 minutes.
- The load is released; the aggregate is taken out and sieved on 2.36mm sieve. The fraction passing through is weighted B.

- Aggregate crushing value (ACV) is given by

$$ACV = \frac{\text{wt. of agg. passing through 2.35mm sieve}}{\text{wt. of oven dried aggregate}} \times 100$$

$$ACV = \frac{B}{A} \times 100$$

- The aggregate crushing value should not be more than 45% for ordinary concrete

- It should not be more than 30% for concrete used for wearing surface such as runways, roads and pavements.

* Aggregate Impact Test:-

Need and Importance :- Toughness is its resistance to failure by impact.

- Aggregate Impact value test is performed for finding toughness of aggregate i.e. this test gives relative measure of resistance of aggregate to suddenly applied load or impact load.
- The test sample consist of aggregate passing through 125mm IS sieve and retained on 10mm IS sieve. The aggregate is oven dried at 110°C for 4 hours.
- The aggregate is filled in the cup, (Weight A) By lifting the handle, hammer is allowed to fall freely as it is released by the tripping mechanism, on to the aggregate in the cup.
- 15 such blows are given and then the aggregate is taken out and sieved on 2.36mm sieve.
- The fraction passing through is weighed (weight B)
- The fraction retained is also weighed (weight C) if (B+C) is less than A by more than 1 gram, the result is discarded and a fresh test is made.
- The aggregate impact value is given by $= \frac{B}{A} \times 100$
- As per IS 283:1970, aggregate impact values for concrete should not exceed 30% for wearing surface for roads and pavements and 45% for other types of roads concrete.

* Abrasion value of coarse aggregate -

Determination of Abrasion value (IS 2386. Part IV - 1963)

- Test gives relative resistance of aggregate wearing.
- Los Angeles value method gives more realistic results, it is most commonly used.
- In this method, specific weight 5kg or 10kg depending on the size of the aggregate is taken and it is placed in the cylinder of the LA machine along with the abrasive charge.
- The abrasive value charge consist of a specific number of steel balls.
- The cylinder is rotated at 20 to 33 r.p.m. for 500 or 1000 revolutions depending on the grading of the aggregate.
- The aggregate is removed from the cylinder and sieved on 1.7mm sieve.
- The fraction passing through 1.7mm sieve is expressed as % of original weight gives the aggregate abrasion value.
- Hardness is the resistance of an aggregate, it is normally determine by an abrasion.

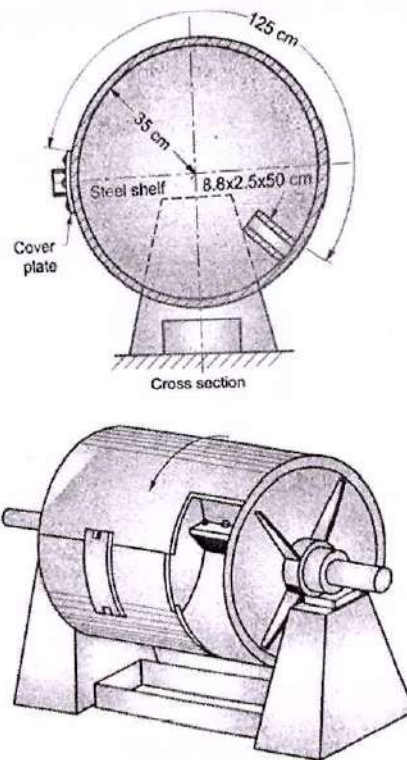


fig. Los angele abrasion testing machine

→ Flakiness Index of coarse Aggregate

- The flakiness Index is the percentage by weight of particles whose least dimension (thickness) is less than $\frac{3}{5}$ th of their mean dimension.
- The test is applicable to aggregate larger than 6.3 mm size.
- The test is conducted by using a metal thickness gauge as shown in fig.

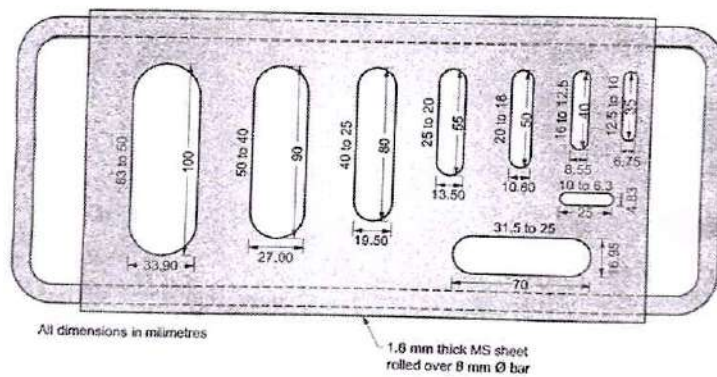


Fig. 2.3.4: Thickness gauge

fig. Thickness gauge

* procedure for flakiness index :-

- 1) take w_1 quantity of coarse aggregate which should possess at least 200 pieces of any fraction.
- 2) sieve the sample through IS sieves as specified in the chart.
- 3) Now the aggregate retained on different sieve should be separated.
- 4) Then each dry aggregate to pass through the corresponding slot of the thickness e.g. The aggregate passing through 20mm size and retained on 16mm sieve size should be pass only through $\left(\frac{20+16}{2} \times \frac{3}{5} \right) = \frac{54}{5} = 10.8$ i.e. through 10 to 12.5 mm slot and if it passes through it, it is called as flaky.

- Now weight all the pieces which passes through respective slot i.e. Flaky (W_2).

∴ Now calculate flakiness index from following ~~data~~ relation,

$$\text{flakiness index} = \frac{W_2}{W_1} \times 100$$

- Excess of flaky particles in concrete aggregates increases quantity of water and sand which decreases workability and affects the durability. flaky particles in concrete more than 15% are not desirable.

* Elongation Index of coarse aggregate :-

- The elongation index is the percentage by weight of particles whose greatest dimension (length) is greater than 1.8 times their mean dimension
- The elongation index is the total weight of material not passing through the various slots expressed as a percentage of the total weight of the sample. The length gauge is shown in fig.

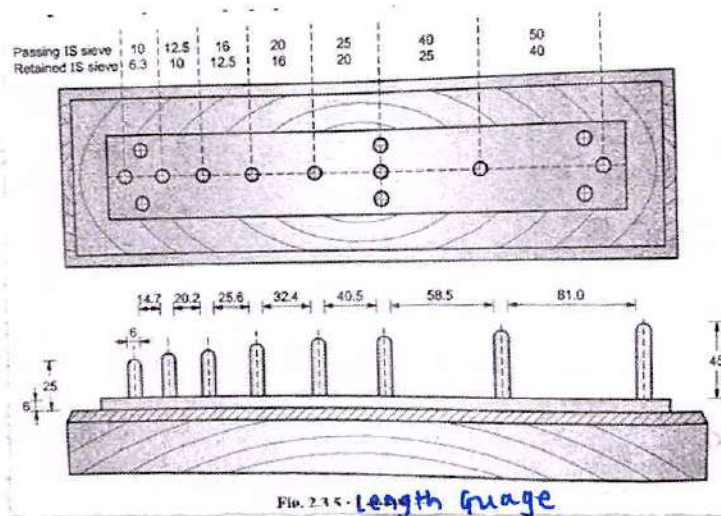


Fig. 2.3.5 - Length Gauge

* Determination the elongation index of coarse aggregate :-

procedure :- 1) sieve the aggregate passing through IS sieve as specified in chart

2) pass each aggregate piece through the corresponding slot of length gauge.

3) weight all material retained by length gauge say W_3

4) NOW calculate elongation index as

$$\text{Elongation Index} = \left(\frac{W_3}{W_1} \times 100 \right)$$

These tests are performed to decide the suitability of coarse aggregate w.r.t. their shape and size.

* Impurities in Aggregates :- Aggregate which contain excessive amount of unwanted materials such as vegetable matter, oil, sulphate, silt, salt, mica and shale etc are considered as impurities.

1) silt and clay :- Excess of silt and clay contain in the aggregate may result in increase shrinkage or permeability.

2) Decayed vegetable matter :- presence of decayed vegetable matter reduce the strength of concrete.

3) salt :- The hygroscopic nature of salt causes efflorescence and unsightly appearance. It also affects setting time and ultimate strength of concrete.

4) mass or algee :- The presence of mass or algee will produce entrained air which reduces its strength.

5) mica and shale :- mica reduces the strength and durability considerably while wetted shale gets swelled results in printing of concrete.

* quality of water :- • water is most imp. ingredient in concrete.

- It react with cement (hydration) to develop strength.
- It helps in mixing, placing and compaction of concrete.
- potable (drinking) water is suitable for concrete.
- Recommended pH of water 6 to 8.

• sea water should not be used in RCC as it causes :

i) corrosion of steel ii) Efflorescence iii) staining

iv) surface dampness * Impure water reduce the strength and durability of concrete

* Impuritiesⁱⁿ mixing water

Impurities in mixing water

- 1. Dissolved salts
- 2. suspended impurities
- 3. Inorganic salts
- 4. sea water
- 5. Acid water
- 6. Alkaline water
- 7. Algae
- 8. sugar
- 9. oil content

fig. Impurities in mixing water

* Permissible limit of solids (impurities) in water as per IS 456.

The amount of impurities is restricted as per the table given under:

Sr. NO	Type of impurities	permissible limit by weight of water
1	organic	0.02
2	Inorganic	0.30
3	sulphate (SO_3)	0.04
4	Alkali chloride	
	a) plain concrete	0.20
	b) reinforced concrete	0.05

Example based on Fineness modulus Test on aggregate:

Ex:-1) sieve analysis test was conducted on sand, tabulated observation are as below, determine the fineness modulus

sieve size	4.75mm	2.36mm	1.18mm	0.6mm	0.3mm	0.15mm	Below 0.15
mass retained	22gm	115gm	225gm	240gm	280gm	105gm	13gm

Note:- mass of total sand is 1000gm

⇒

Sr.No.	IS sieve size in mm	Wt. retained gm.	Cumulative weight retained	Cumulative % Useful retained
1.	4.75	22	22	$\frac{22}{1000} \times 100 = 2.2$
2.	2.36	115	$22 + 115 = 137$	$\frac{137}{1000} \times 100 = 13.7$
3.	1.18	225	$22 + 115 + 225 = 362$	$\frac{362}{1000} \times 100 = 36.2$
4.	0.6	240	$362 + 240 = 602$	$\frac{602}{1000} \times 100 = 60.2$
05.	0.3	280	$602 + 280 = 882$	$\frac{882}{1000} \times 100 = 88.2$
06	0.15	105	$882 + 105 = 987$	$\frac{987}{1000} \times 100 = 98.7$
07	Below 0.15	13	$987 + 13 = 1000$	$\frac{1000}{1000} \times 100 = 100$
% Cumulative weight retained = 399.2				

Fineness modulus = $\frac{\sum \text{cumulative retained percentage}}{100}$

$$\therefore \text{F.M.} = \frac{399.2}{100} = 3.99$$

$\therefore$ Fineness modulus for given sample is 3.99

Numerical on Aggregate crushing value

Ex:- calculate the average crushing value of coarse aggregate and write its suitability.

Sr. NO.	sample Number	I	II	III
1	wt. of oven dried sample (w_1) in gms.	3119	3246	3184
2.	wt. of fraction passing through 2.36 mm IS sieve (w_2) in gms.	575	581	598

⇒ Aggregate crushing value (ACV) :-

★ For sample I :-

$$ACV = \frac{\text{wt. of agg. passing through 2.36 mm sieve}}{\text{wt. of oven dried agg}} \times 100$$

$$\therefore ACV = \frac{575}{3119} \times 100 = \underline{18.43\%}$$

★ For sample II :-

$$ACV = \frac{581}{3246} \times 100 = \underline{17.89\%}$$

★ For sample III :-

$$ACV = \frac{598}{3184} \times 100 = \underline{18.78\%}$$

Avg. crushing value of given agg.

$$= \text{Avg. \% ACV} = \frac{18.43 + 17.89 + 18.78}{3}$$

$$= \underline{18.36\%}$$

★ suitability of aggregate → since the avg. % of ACV = 18.36% which is less than 30%, the given agg. is used for concrete used for wearing surfaces such as runway, roads and pavements.

* Reference used :-

- 1) Gambhir M.L. - concrete Technology - Tata Mc Graw Hill Publishing Co. Ltd
- 2) Shetty, M.S - concrete Technology - S. Chand & Co. Pvt. Ltd

3) MSBTE model Ans.

Unit-2 Aggregates (Question Bank)

Que.No.	2 Marks Questions								
1	Define fine aggregate and coarse aggregate.								
2	Enlist test on fine aggregate.								
3	Enlist four shapes of aggregates.								
4	Define the term specific gravity								
5	Define bulking of sand.								
6	Define: i) Flakiness Index ii) Elongation Index.								
	4 Marks Questions								
7	What is aggregate impact value?								
8	State the requirements of good aggregates.								
9	What is meant by grading of aggregates? Explain:								
10	Define fineness modulus and write procedure to determine FM of fine aggregate in Lab.								
11	Explain in detail classification of aggregate according to size and shape.								
12	State four properties of the fine aggregate								
13	Explain procedure to find specific gravity of fine aggregate is determined?								
14	Explain the procedure of determination of Impact value.								
15	Explain with neat sketch the phenomenon "Bulking of Sand".								
16	Define Bulk density of aggregates. State three factors that affect the bulk density.								
17	Calculate fineness modulus of a sample using following data total weight of sample is 1kg.								
	Sieve size in mm	4.75mm	2.36mm	1.18mm	600 μ	300 μ	150 μ	pan	
	Weight retained in gm	100	150	300	200	120	90	40	
18	Calculate the average crushing value of coarse aggregate and write its suitability.								
	Sr.no.	Sample Number					I	II	III
	1	Weight of oven dried sample (w) in grams.					3119	3246	3148
	2	Weight of fraction passing through 2.36 mm IS sieve (w1) in grams.					575	581	598
19	Explain flakiness index and elongation index in detail.								

