OPSC-AEE 2020

Odisha Public Service Commission

Assistant Executive Engineer

Civil Engineering

Building Materials

Well Illustrated **Theory** *with*
Solved Examples and **Practice Questions**

MADE EASY Publications

Building Materials

Contents

UNIT	TOPIC	PAGE NO.
1.	Cement	3
2.	Concrete	32
3.	Bricks	78
4.	Stones	113
5.	Timber	131
6.	Aggregates	159
7.	Mortar and Lime	170
8.	Structural Steel & Other Construction Materials	181

❍❍❍❍

CHAPTER 6

Aggregates

6.1 Introduction

- Aggregates are the materials basically used as filler with binding material in the production of mortar and concrete.
- They are derived from igneous, sedimentary and metamorphic rocks or manufactured from blast furnace slag etc.
- They occupy 70-80 percent of the volume and have considerable influence on the properties of the concrete.
- They should be clean, hard, strong, durable and graded in size to achieve almost economy from the paste.
- Earlier aggregates were considered to be chemically inert but latest research has revealed that some of them are chemically active and also that certain type exhibits chemical bond at the interface of aggregates and cement paste.
- To increase the bulk density of concrete aggregates are used in two different sizes: (i) the bigger ones known to be coarse aggregate (grit) and (ii) the smaller ones fine aggregate (sand).
- Coarse aggregate forms the main matrix of concrete and fine aggregate form the filler matrix between the coarse aggregate.

6.2 Classification of Aggregates

(i) On the basis of geological origin

(a) **Natural Aggregates:** These are obtained by crushing from quarries of igneous, sedimentary or metamorphic rocks. Gravels and sand reduced to their present size by the natural agencies also fall in this category. The most widely used aggregates are from igneous origin. Aggregates obtained from pits or dredged from river, creek or sea are most often not clean enough or well graded to suit the quality requirement. They therefore require sieving and washing before they can be used in concrete.

(b) **Artificial Aggregates:** Broken bricks, blast furnace slag and synthetic aggregates are artificial aggregates. Broken bricks known as brick bats are suitable for mass concreting, for example, in foundation bases. They are not used for reinforced concrete works. Blast furnace slag aggregates is obtained from slow cooling of the slag followed by crushing. The dense and strong particles as obtained are used for making precast concrete products. The specific gravity of these range between 2-2.8 and bulk density 1120-1300 kg/m^3. The blast furnace slag aggregate has good fire resisting properties but are responsible for corrosion of reinforcement due to sulphur content of slag. Synthetic aggregates are produced by thermally processed materials such as expanded clay and shale used for making light weight concrete.

(ii) On the basis of size

(a) **Coarse Aggregates :** Aggregate retained on 4.75 mm sieve are identified as coarse. They are obtained by natural disintegration or by artificial crushing of rocks. The maximum size of aggregate can be 80 mm. The size is governed by the thickness of section, spacing of reinforcement, clear cover, mixing, handling and placing methods. For economy the maximum size should be as large as possible but not more than one-fourth of the minimum thickness of the member. For reinforced sections the maximum size should he at least 5 mm less than the clear spacing between the reinforcement and also at least 5 mm less than the clear cover. Aggregate more than 20 mm size are seldom used for reinforced cement concrete structural members.

(b) **Fine Aggregates :** Aggregate passing through 4.75 mm sieve are defined as fine. They may be natural sand - deposited by rivers, crushed stone sand - obtained by crushing stones and crushed gravel sand. Sand is essentially quartz. The smallest size of fine aggregate (sand) is 0.06 mm. Depending upon the particle size, fine aggregate are described as fine, medium and coarse sands. On the basis of particle size distribution, the fine aggregate are classed into four zones i.e. zone I to zone IV; the grading zones being progressively finer from grading zone I to grading zone IV (IS: 383).

(iii) On the basis of shape

(a) **Rounded Aggregates :** These are generally obtained from river or sea shore and produce minimum voids (about 32 percent) in the concrete. They have minimum ratio of surface area to the volume, and the cement paste required is minimum. Poor interlocking bond makes it unsuitable for high strength concrete and pavements.

(b) **Irregular Aggregates :** They have voids about 36 percent and require more cement paste as compared to rounded aggregate. Because or irregularity in shape they develop good bond and are suitable for making ordinary concrete.

(c) **Angular Aggregates :** They have sharp, angular and rough particles having maximum voids (about 40 percent). Angular aggregate provide very good bond than the earlier two, are most suitable for high strength concrete and pavements; the requirement of cement paste is relatively more. Angular aggregate most of whose particles have their three dimensions approximately equal are called cubical aggregate.

(d) **Flaky Aggregates :** These are sometimes wrongly called as elongated aggregate. However, both of these influence the concrete properties adversely. The least lateral dimension of flaky aggregate (thickness) should be less than 0.6 times the mean dimension. For example, the mean sieve size for an aggregate piece passing through 50 mm and retained on 40 mm sieve is (50 + 40)/2 = 45.0 mm. If the least lateral dimension is less than 0.6 × 45 = 27.0 mm, the aggregate is classified as flaky. Elongated aggregate are those aggregate whose length is 1.8 times its mean dimension. Flaky aggregate generally orient in one plane with water and air voids underneath. They adversely affect durability and are restricted to maximum of 15 percent.

Important points:

S. No.	Classification Rounded	Examples
1.	Rounded	Rivers or sea shore gravels, desert and wind blown flints
2.	Irregular or partly rounded	Pit sands or gravels, land or dug flints
3.	Angular	Crushed rocks of types
4.	Flaky	Laminated rocks

- From the point of economy in cement requirements a given w/c ratio, rounded are preferred over angular aggregates.
- Angular aggregates have greater durability, interlocking nature, higher surface area and higher bond characteristics, resulting in higher strength.
- Flaky and elongated aggregates make poor concrete.

Example - 6.1 The aggregate which is obtained from the seashore or rivers and produces minimum voids in the concrete is known as_____.

(a) angular aggregates (b) flaky aggregates
(c) irregular aggregates (d) rounded aggregates

Solution: (d)

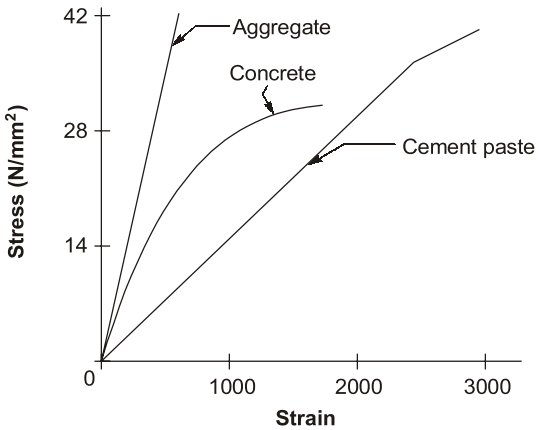
6.3 Characteristics of Aggregate

The properties to be considered while selecting aggregate for concrete are strength, particle shape, specific gravity, bulk density, voids, porosity, moisture content and bulking.

6.3.1 Strength

The strength should be at least equal to that of the concrete. Rocks commonly used as aggregates have a compressive strength much higher than the usual range of concrete strength. A typical stress-strain curve for aggregate is shown in figure below. The test conducted for strength evaluation are crushing test, impact-test and ten per cent fines test. Of these the first one is the most reliable.

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 5t) per cent for concrete for other purposes.



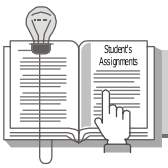
Stress-Strain Curves for Aggregates, Concrete and Cement Paste

6.3.2 Stiffness

The-modulus of elasticity of concrete is approximately equal to the weighted average ot 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. Further, in general, the modulus of elasticity of concrete increases with increasing aggregate

6.9 Soundness of Aggregate

Soundness is denned as the ability of aggregate to resist changes in volume as a result of changes in physical conditions. The conditions affecting this property are freezing and thawing, temperature changes, and alternate wetting and drying. Porous and weak aggregate containing undesirable extraneous matter undergo excessive volume changes under favourable conditions The freeze-thaw resistance of aggregate is related to its porosity, absorption, and pore structure. This may cause local scaling to surface cracking consequently leading impaled appearance and sometimes structural failure. Aggregate may also be chemically unstable. Some of the aggregate with certain chemical constituents react with alkalis in cement which may cause abnormal expansion and map cracking to concrete.



Student's Assignment

Q.1 Maximum size of coarse aggregate used as base course in ground floor is
(a) 12 mm (b) 20 mm
(c) 40 mm (d) 50 mm
[BPSC 2018]

Q.2 Fineness modulus is
(a) the ratio of fine aggregates to coarse aggregates
(b) the ratio of fine aggregates to total aggregates
(c) an index which gives the mean size of the aggregate used in the mix
(d) none of the above
[BPSC 2018]

Q.3 Fine aggregates are those which pass and retain on which of the following sizes of IS sieves respectively?
(a) 6 mm and 75 μ
(b) 4.75 mm and 75 μ
(c) 75 μ and 4.75 mm
(d) 10 mm and 4.75 mm
[KPSC 2017]

Q.4 Which of the following coarse aggregate requires minimum cement paste?
(a) Rounded (b) Irregular
(c) Angular (d) Flaky
[HPSC 2016]

Q.5 An aggregate is said to be flaky if its least dimension is less than
(a) $\frac{2}{3}$ mean dimension
(b) $\frac{3}{4}$ mean dimension
(c) $\frac{3}{5}$ mean dimension
(d) $\frac{5}{8}$ mean dimension

Q.6 If aggregate completely pass through a sieve of size 75 mm and are retained one sieve of size 60 mm, the particular aggregate will be flaky 1 and its minimum dimension is less than
(a) 20.5 mm (b) 30.5 mm
(c) 40.5 mm (d) 50.5 mm

Q.7 The aggregates is called fine aggregate if it is completely retained on
(a) 0.15 mm sieve (b) 0.30 mm sieve
(c) 4.75 mm sieve (d) None of the above

Q.8 Which one of the following tests, is used to test aggregate for its abrasion resistance?
(a) Devel attrition test
(b) Darry abrasion test
(c) Los Angeles test
(d) All option are correct

Q.9 If x, y, z are fineness modulii of coarse, fine and combined aggregates, the percentage (P) of fine aggregates to combined aggregate is

(a) $P = \frac{z-x}{z-y} \times 100$ (b) $P = \frac{x-z}{z-y} \times 100$

(c) $P = \frac{x-z}{z+y} \times 100$ (d) $P = \frac{x+z}{z-y} \times 100$

Q.10 Calculate the proportion (in percentage) of fine aggregate in combined aggregate so that the fineness modulus of the combined aggregate becomes 6.4. The fineness modulus of coarse aggregate and fine aggregate in the concrete mix is 7.6 and 2.8 respectively.

(a) 20 (b) 33.33
(c) 35 (d) 66.6

Q.11 The bulk density of aggregates depend upon its:

(a) Shape (b) Grading
(c) Compaction (d) None of the above

Q.12 The most useless aggregates is one whose surface texture is

(a) smooth
(b) granular
(c) glassy
(d) honey combined and porous

Q.13 The aggregate which is obtained from the seashore or rivers and produces minimum voids in the concrete is known as

(a) angular aggregates
(b) flaky aggregates
(c) irregular aggregates
(d) rounded aggregates

Q.14 The aggregate containing moisture in pores and having its surface dry is known as

(a) moist aggregates
(b) very dry aggregates
(c) dry aggregates
(d) saturated surface dry aggregates

Q.15 According to IS : 382 - 1963, a good aggregate should be

(a) Chemically inert
(b) Sufficiently strong
(c) Hard and durable
(d) All options are correct

Q.16 The aggregate is said to be elongated when

(a) its least dimension is $\frac{3}{5}^{th}$ of its mean dimension.
(b) its least dimension is equal to its mean dimension.
(c) its length is equal to its mean dimension.
(d) its length is equal to 1.8 times its mean dimension.

Q.17 Sand requiring a high water cement ratio, belongs to

(a) Zone I (b) Zone II
(c) Zone III (d) Zone IV

Q.18 Which one of the following aggregates gives maximum strength in concrete?

(a) Rounded aggregate
(b) Elongated aggregate
(c) Flaky aggregate
(d) Cubical aggregate

Q.19 Match **List-I** and **List-II** and select the correct answer using the codes given below:

List-I

A. Absorption and surface moisture in aggregates.
B. Deleterious material
C. Grading of aggregate
D. Chemical stability

List-II

1. Interferes with hydration of cement
2. Improves workability of mix
3. Ensure durability of all types of structures
4. Affects the mix proportions

Codes:

	A	B	C	D
(a)	3	1	2	4
(b)	4	2	1	3
(c)	3	2	1	4
(d)	4	1	2	3

Q.20 Which of the following coarse aggregate requires minimum cement paste?

(a) Rounded (b) Irregular
(c) Angular (d) Flaky

Q.21 The fineness modulus of coarse aggregate lies in the range of
(a) 1.2 to 1.9 (b) 2 to 3.5
(c) 3.5 to 6.5 (d) 5.5 to 8

Q.22 For aggregate to be clessed as elongated, its length should be atleast x times its mean dimension, where x is given be
(a) 1.2 (b) 1.5
(c) 1.8 (d) 2.0

Q.23 An aggregate passing through 63 mm sieve and retained on 50 mm sieve is clessed as flaky, if its least lateral dimension is less than about
(a) 63 (b) 50
(c) 34 (d) 25

Q.24 Which of the following aggregate gives maximum bond strength in concrete?
(a) Rounded aggregate
(b) Enlongated aggregate
(c) Flaky aggregate
(d) Angular aggregate

Q.25 The best reflection of strength of coarse aggregate is given by
(a) crushing (b) impact
(c) 10% fines (d) hardness

ANSWER KEY // STUDENT'S ASSIGNMENT

1. (c)	**2.** (c)	**3.** (b)	**4.** (a)	**5.** (c)
6. (c)	**7.** (d)	**8.** (d)	**9.** (b)	**10.** (b)
11. (d)	**12.** (c)	**13.** (d)	**14.** (d)	**15.** (d)
16. (d)	**17.** (a)	**18.** (d)	**19.** (d)	**20.** (a)
21. (d)	**22.** (c)	**23.** (c)	**24.** (d)	**25.** (a)

HINTS & SOLUTIONS // STUDENT'S ASSIGNMENTS

1. (c)

Normal size of aggregate used for ground floor base coarse is 40 mm.

2. (c)

Fineness modulus is a ratio or a number which tells about the grain size of aggregate.

6. (c)

The aggregate is said to be flaky if their dimension is 0.6 times the mean dimension

$$\text{i.e. } 0.6\times\left(\frac{75+60}{2}\right) = 40.5 \text{ mm}$$

■■■■