* Fineness modulus - F.M.

	Type of Aggregates	IS sieve used
a.	Coarse	80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm
b.	Fine	4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron, 150 micron
c.	All-in aggregate	80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron, 150 micron

For Ex- If the fineness modulus is 6. it means that average size of aggregate is 6th sieve from the finest sieve = 4.75 mm.

• Object of finding fineness modulus -

a. To gain required strength and workability.

b. Aggregates with higher F.M. leads to harsh mix.

c. Aggregates with lower FM leads to uneconomical mix.

* Methods of proportioning of aggregates -

a. Trial Method - It is a simple trial and error method of combining fine and coarse aggregates. For this, sieve analysis is performed to determine the % of different aggregates passing through the set of sieves. Proportions are decided from the % of given aggregate and % required for specified grading.

b. Fineness Modulus Method -

$$X = (F_2 - F) / (F - F_1)$$

* X = % of fine aggregates mixed with coarse one
* F_2 = Finess modulus of coarse aggregates
* F_1 = Fineness modulus of fine aggregates.
* F = Fineness modulus of combined aggregates.

* Water- Water is an important ingredient of concrete. because it actively participates in the chemical reaction with cement.
The importance of water in concrete are :-
a. It helps in hydration of cement.
b. It acts as a lubricant and increases workability.
c. It makes the concrete homogenous.

*Quality of water to be mixed- The water used in concrete should be as pure as drikable water. It should not contain any impurities.

- Common impurities of water -
a. Dissolved salts - reduce strength by 10-30 %.
b. Chlorides - dampness + efflorescence.

PH of water should range ⇒ 6.0 - 8.0 or 6.5 to 8.5

- Limit of impurities -
  * For PCC - 2000 mg / lts
  * For RCC - 1000 mg / ltr

- Effects of impurities on the properties of concrete -
a. Strength and durability gets reduced.
b. Chlorides cause dampness and efflorescence.
c. Setting time and workability gets reduced.
d. Sea water increases reinforcement corrosion.
e. Presence of silt and clay may affect the bonding.

* Standard sand- A particular variety of sand at Ennore. Chennai is used as standard sand. It resembles the properties

of Leighton Buzzard sand of British standards.

• Standard sand is used for research and testing. It has following properties –

a. It contains grey or whitish broken quartz.

b. It grains may be angular.

c. It should be free from impurities.

d. 100% pass through 2 mm I.S. sieve.

e. 100% retained on 90 micron IS sieve.

Chapter - 3 Water Cement Ratio

- Water to cement ratio is one of the most factor which governs strength, quality and workability of concrete.
- Functions - hydration and workability.

- Water in deficit causes harsh mix.
- In excess, it causes bleeding and segregation.

* Water Cement Ratio - $\frac{\text{Weight of water}}{\text{weight of cement}}$

- It is generally expressed in litres of water required per bag (50 kg) of cement. Ex- If W/C ratio is 0.4 then, 20 litres of water is to be mixed with a bag of cement.

- Water Cement Ration and Compressive Strength -
There is a relation between between water cement ratio and strength of concrete. It has been clear from studies that increase in water leads to decrease in compressive strength.

- Important points -
a. Fully compacted / mechanically vibrated concrete requires less water cement ratio.
b. Hand compaction requires high W/C ration.
c. Concrete with W/C ratio less than .45, becomes less workable and results in decrease in strength.
d. Mechically compacted concrete has its highest strength at W/C ratio of about 0.35.

Note - OPC of different grades obtain their desired strength at W/C ratio of about 0.35 and mechanically compacted.

* Hydration of Cement - The reaction between cement and water is known as hydration. In addition to hydration (25%) a certain amount of water is required to fill gel pores, which is about 42%. But in case of high strength structure, W/C ratio of less than 0.4 is used, as for hydration, it is not necessary that all gel pores should be filled / saturated.

* Chemical Reaction Between Cement & Water -

* $C_3S + H_2O \longrightarrow$ Hydrated $C_3S + Ca(OH)_2$
* $C_2S + H_2O \longrightarrow$ Hydrated $C_2S + Ca(OH)_2$
* $C_3A + H_2O \longrightarrow$ Hydrated $C_3A + Ca(OH)_2$

- In hydration, excess lime is released as $Ca(OH)_2$ and hydrated calcium silicate is gel like structure.
- C_3S and C_2S compose about 70-80% of cement & control most of its strength giving properties.
- C_3A is most active and reacts first with water.
- C_3S is responsible for strength in first 28 days.
- C_4AF has no significant function in cement hydration.

* Concrete strength with Age - Concrete gains its ultimate strength after 360 days. It gains 75% of its strength after completion of 28 days.
Therefore, the 28 days of strength of concrete is considered as standard strength.

Setting & Hardening of Cement -

a. Initial Setting time - The time at which cement starts to lose its plasticity is termed as its initial setting time.

b. Final Setting Time - The time taken by mortar / concrete to attain a hard mass is its final setting time.

* Hardening - Phenomenon by which weak paste develop strength

- Importance of Setting Time - For proper concreting, it is important that initial setting time should be sufficiently long for finishing the operations.
It also helps to calculate the time to remove the frame work.

- Effect of temperature on setting time - The setting time of concrete decreases with rise in temperature upto 30°C and then vice-versa.

* Effects of various W/C Ratios on concrete strength -

a. At insufficient W/C Ratio - The hydration of each particle does not take fully. It produces weak structure and hence its strength is reduced.

b. At just sufficient W/C ratio - Here, every particle gets hydrated and the cement gel occupies all the space previously occupied by water. Hence gives maximum strength.

c. At excessive W/C Ratio - In it, even when full hydration takes place the water occupies a certain space in concrete. The water then gets evaporated and leaves pores.

- It also leads to defects like bleeding and segregation.

* Water Cement Ratio Law (Duff Abrahm's Rule) -

It states that - with given ingredients of concrete & testing conditions, the quantity of water used for mixing alone determines the strength of concrete, as long as the mixture is of workable plasticity.

Duff Abrahm gave following relation in terms of W/C ratio -

$$S = 948 / 7^{x}$$

* S = compressive strength in kg / cm^2 after 28 days
* x = Water cement ratio by volume.

* Limitations of W/C ratio -

a. Concrete specimens are cured under standard specimens.
b. Concrete specimens should be of same size.
c. Concrete specimens should be of same age.
d. Internal moisture conditions of the concrete specimen should be kept uniform.

• Effects of W/C Ratio -

i. On hydration - For this, water is required just sufficient to hydrate each and every cement particle. Increase in concrete strength takes as long as drying of concrete is prevented. After drying, chemical reaction ceases / stops. Thus moisture can be retained in concrete by keeping the capillary pores saturated with water by curing.