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MAJOR INGREDIENTS AND RAW MATERIALS OF ORDINARY CONCRETE INCLUDING OPTIMUM WATER FOR SUFFICIENT REACTION

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Abstract -*This manuscript aims to describe the different ingredients of Concrete and amount of raw materials required to manufacture the concrete by considering the properties of materials. As per the IS code too much water reduces the strength of the concrete. By taking the care that guideline optimum water is calculated for the sufficient hydration of cement. In RCC salt is the most harmful substance for Reinforcement, so in this paper it is also included which types of water is used and how much percentage of salt is acceptable in a concrete.*

***Key words* -Concrete, Heterogeneous, Active Group, Inactive Group, Bulking, Hydration of Cement, Dampness, Yield of Concrete, Cement factor.**

1. INTRODUCTION

Concrete is a heterogeneous composite material consisting of cement, water, fine aggregates and coarse aggregates. Aggregates occupy about 60 to 80 percent of the volume of concrete. The paste which is formed from cement and water constitutes 20 to 40 percent of the total volume. Concrete is one of the most frequently used building materials. Its usage worldwide, ton for ton. The quality of the concrete is greatly depending upon the quality of paste, which in turn, is dependent upon the ratio of water to cement content used. To get quality concrete due attention should be paid in choosing the constituents, in mixing them in correct proportions, in mixing the concrete in correct manner and finally in using it properly followed by proper curing.

2. MAJOR INGREDIENTS OF CONCRETE

The materials used in the manufacture of concrete are known as Ingredient of Concrete. When the word concrete is used usually it means cement Concrete. The ingredient of concrete can be classified in to two groups Active Group: Cement and water. Inactive Group: Fine and Coarse Aggregate.

2.1 FINE AGGREGATE

The particle that passes through 4.75 mm sieve and retain on 0.075 mm sieve is known as fine aggregate. The surface area of fine aggregates is higher. The voids between the coarse aggregate are filled up by fine aggregate. It reduces the cost of the concrete and increase the Workability of concrete. The main characteristics of fine aggregate which affect in the properties of concrete is **Bulking**.

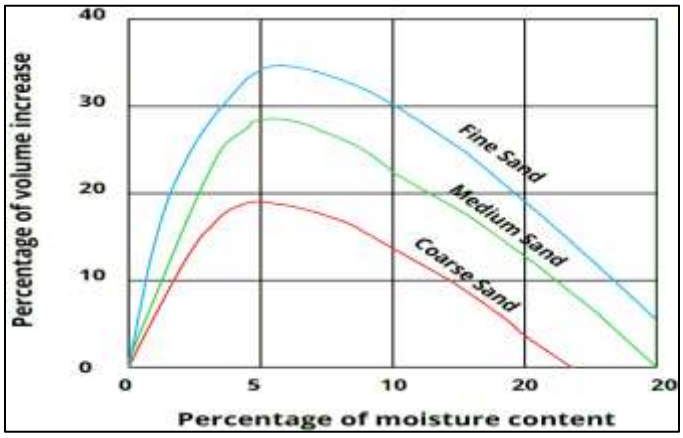

Fig.1 Bulking of Sand

The phenomenon of increase in sand volume due to the increase of moisture content i.e. called Bulking of sand. The main causes of bulking of sand are the moisture content in the sand makes thin films around

sand particles. Hence, each particle exerts pressure. Thus they move away from each other causing increasing in volume. The bulking of the aggregates are dependent on two factors: The fineness of the aggregates and Percentage moisture content.

A fully saturated fine aggregate does not show any bulking. Thus when the sand contains sufficient moisture 12-20%, it occupies the same volume as when it was dry. The percentage of bulking is inversely proportional to the size of the fine aggregates. Hence, finer the sand more is bulking.

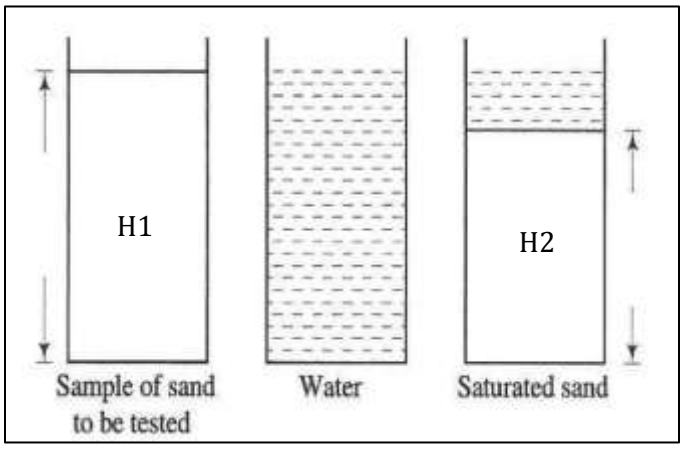

Fig. 2 Depth of Sample

$$\therefore \text{Bulking of sand} = \frac{H1-H2}{H2}$$

2.2 COARSE AGGREGATE

The particles that are retained on the 4.75 mm sieve are called coarse aggregate. Use of the largest maximum size of coarse aggregate permits a reduction in cement and water requirements. Using aggregates larger than the maximum size of coarse aggregates permitted can result in interlock and form arches or obstructions within a concrete form. That allows the area below to become a void, or at best, to become filled with finer particles of sand and cement only and results in a weakened area.

Size of aggregate shall depend upon the type of work and the reinforcement. And size should be less than the distance between two consecutive steel bars in RCC. The main characteristics of fine aggregate which affect in the properties of concrete is **Crushing strength** of Aggregate. The Crushing strength of Aggregate defines as the resistance of aggregate to the compressive load. The Compressive strength of concrete is depending on the strength of aggregate.

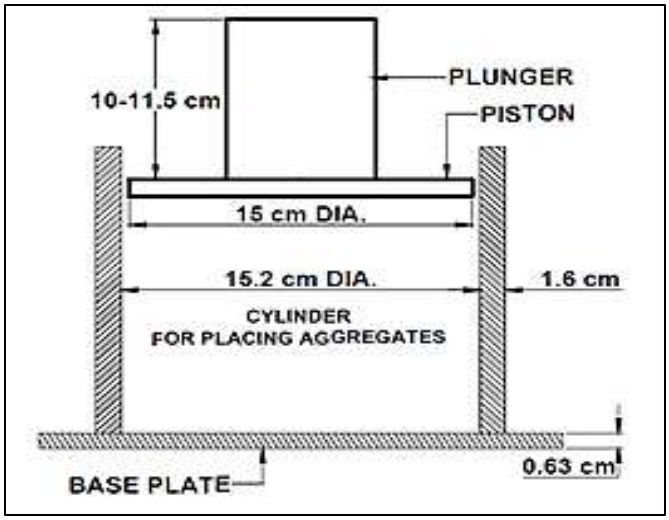

Fig. 3 Crushing Test Setup

Procedure of Crushing Test: Fill aggregate sample passing through 12.5 mm and retained on 10 mm IS sieve in measuring cylinder in 3 equal layers such that each layer is subjected to 25 strokes using the tamping rod. Take the weight of aggregate as **W1.** Operate Compression machine such that 40 tonnes of the load is applied on aggregate in approximately 10 min. Take out the crushed aggregate sample and sieve on with 2.36mm **W2**.

$$\therefore \text{Aggregate crushing value} = \frac{W1}{W2} X100$$

Note: A value less than 10 signifies an exceptionally strong aggregate while above 35 would normally be regarded as weak aggregates.

Table 1: limit value of Crushing

Types of Road, Pavement, Building	Crushing Value Limit
Flexible Pavement	
i. Soling	50
ii. Water bound macadam	40

iii. Bituminous macadam	40
Rigid Pavements	
i. Other than wearing course	45
ii. Surface or Wearing course	30
Building	
i. RCC	30

2.3 CEMENT

Cement is the most important ingredient of concrete act as a binding material having both adhesive and cohesive properties. Cement binds the coarse and fine aggregate by filling the voids and chemically reacting with water. It contains about 10% of the volume of concrete mix.

Compound of Cement: The raw materials of cement on burning are converted into silicate, aluminates and ferrite of calcium.

Table 2: Compound of Cement

Name of Compound	Chemical Formula	Abbre-viation	Perce-ntage	Liter-ature
Tricalcium silicate	$3caO.SiO_2$	C_3S	40-55	Alite
Dicalcium silicate	$2caO.SiO_2$	C_2S	15-30	Belite
Tricalcium aluminate	$3caO.Al_2O_3$	C_3A	8-10	Celite
Tetra calcium alumino ferrite	$4CaO.Al_2O_3.Fe_2O_3$	C_4AF	13-17	Felite

Properties of the compound: The compound present in cement each has their own properties and action at the time of reaction when we mix the water in cement.

- **Tricalcium silicate-**It hydrates rapidly and generates more heat of hydration
- **Dicalcium silicate-** It hydrates slowly and generates less heat of hydration. It is responsible for the ultimate strength of cement.
- **Tricalcium aluminate-**It reacts fast with water and generates large amount of heat of hydration.it causes initial setting of cement.
- **Tetra calcium alumino ferrite-** It reacts slowly with water and generates little heat of hydration.

Hydration of Cement: The chemical reaction between cement and water is known as hydration of Cement. The reaction takes place between active components of cement and water. New compound of hydrated calcium aluminate, hydrated calcium silicate and calcium hydro-oxide are formed. The calcium silicate break down to form di-calcium silicate C_2S and release the excess lime as $Ca(OH)_2$.

$\therefore C_3S + H_2O \rightarrow Hydrated\ Calcium\ Silicate + Ca(OH)_2$

$\therefore C_2S + H_2O \rightarrow Hydrated\ Calcium\ Silicate + Ca(OH)_2$

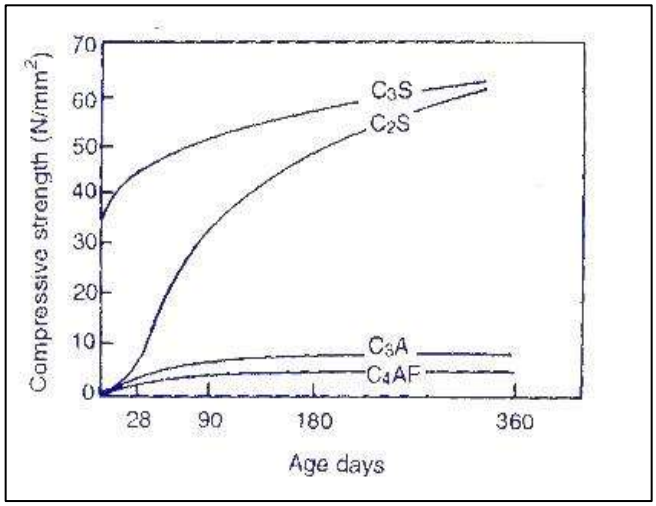

Fig. 4 Development of Strength of cement compounds

Initial and Final Setting Time: The most important physical properties of cement are Setting Time. When the water is mixed with cement to make a cement paste or concrete.it become gradually less plastic and finally becomes hard mass.

The setting time is divided into two types:- initial and final setting time. *Initial setting time* of cement is

the between the addition of water and the instant cement paste starts to lose its plasticity. The time corresponding to paste becoming the hard mass is known as *final setting time*.

[Note: The initial setting time and final setting time of OPC cement is 30 min and 10 Hrs. respectively.]

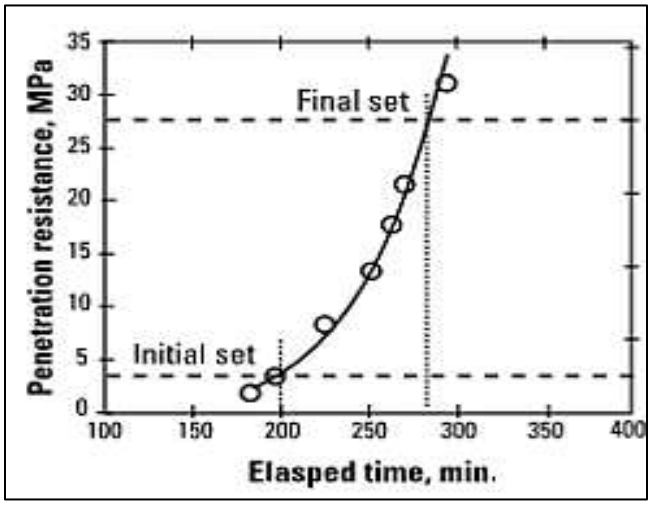

Fig. 5 Setting Time

2.4 WATER

Water is an important ingredient of concrete without which concrete cannot be manufactured. Water in concrete making is used for mixing, washing aggregate and curing.

In General water which is acceptable for drinking purpose is suitable for making the concrete. The main harmful substance in water for concrete is salt which is present in sea water. The salts present in sea water reduce the strength of concrete, but sometimes it has to be used when there is no alternative. Sea water contains up to 3.5% salt and has tendency to decrease the strength 10% - 20% of the concrete. There is more chance of causes of dampness and surface efflorescence in building.

3. OPTIMUM WATER FOR SUFFICIENT REACTION

Water is the only one ingredient in the concrete without it chemical reaction will not start. To a common man it appear that greater the quantity of cement used, grater will be the strength of concrete is based on the mixed proportion but amount of water to be added plays an important role in respect of strength of concrete. The quantity of water in concrete is generally specified as a ratio of cement which is known as **Water Cement ratio**.

$$\therefore \text{Water Cement Ratio} = \frac{\text{Weight of water}}{\text{Weight of cement}}$$

According to Duff Abrahm law W/C ratio is generally taken as 0.45 to 6, if we take w/c ratio is 0.5, it means that 50 kg of cement bag requires 25 liter of water. This w/c ratio is only depending on the quantity of water and aggregate is fully saturated.

But we have also consider the quantity of Aggregate , According to the experimental based value on the lab test the amount of water is used equal to **5%** by the weight of Aggregate Plus **30%** by the weight of cement.

Note: It is important to know that *too much water reduces the strength of concrete and too little water reduces the workability of concrete*. Fig. 6 shows the relationship b/w strength of concrete and W/C ratio.

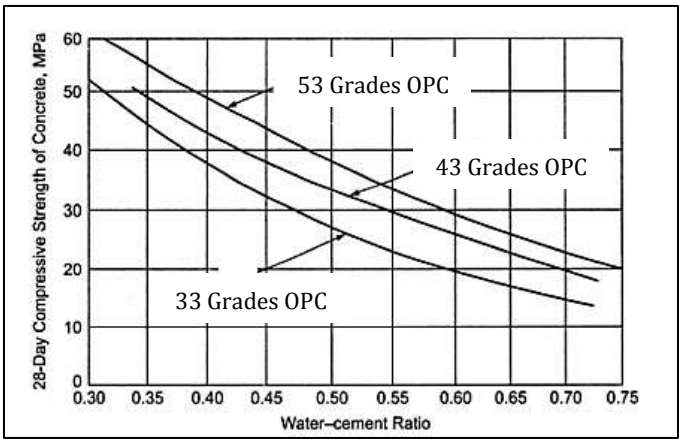

Fig. 6 Strength of concrete Vs. W/C ratio.

Fig. 7 Show the relationship between W/C ratio and workability .**Workability** of concrete indicates the ability of concrete to work easily. W/C ratio is also an important consideration for the workability of concrete. High W/C ratio leads to higher workability because inter particle lubrication is increased.

Similarly, lower W/C ratio leads to lower workability because there is lack of interparticle lubrication.

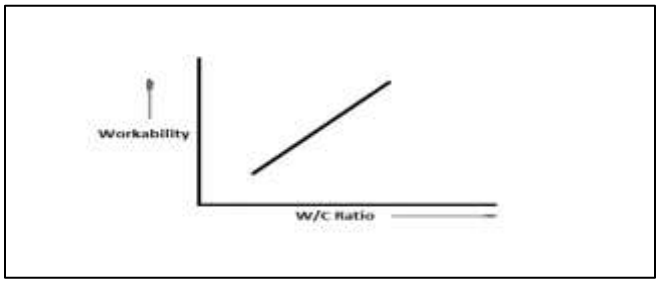

Fig. 7 W/C ratio Vs. Workability

4. RAW MATERIALS OF CONCRETE

Concrete is a composite final product of the main four ingredients which is cement, Fine aggregate, Coarse aggregate and water. There are different method of different quantity surveyor based on their working experience and the adjustment at the site. We discussed two types of method:

i. Based on Experimental Value

In this method ingredients of concrete are calculated based on the Dry-wet ratio of concrete which is observed on field experience and unit weight of ingredient which is tested in the lab .Now take 1m^3 of M_{15}

Table 3: Calculation of Raw Materials

Cement Sand-Aggregate ratio:				**Materials unit weight**	
Cement	1	**Grade of Conc.**(M)	15	Cement :	1440 kg/m^3
Sand	2			Sand :	1450 kg/m^3
Aggregate	4			Aggregate:	1500 kg/m^3
Total	7	Multiplying Conversion factor of m^3 to cft = 35.28			
Volume of Concreting:		1.00 m^3		**Dry-wet ratio:**	1.52
Dry Volume		1.52 m^3			

S.N	**Particular**	**Total Quantity**		
		Volume	Weight	Cft/ Bag
1	Cement	$\frac{1}{7}$ x 1.52 0.217 m^3	0.217 x 1440 312.69 Kg	$\frac{312.69}{50 \text{ per Bag Weight}}$ 6.25 Bags
		$\frac{2}{7}$ x 1.52	0.434 x 1450	0.434 x 35.28

2	Sand	0.434 m^3	629.71 Kg	15.322 cft
3	Aggregate	$\frac{4}{7}$x 1.52 0.869 m^3	0.869 x 1500 1302.86 Kg	0.869 x35.28 30.643 cft
4	Water	-	-	30% x 312.69 +5% x (629.71 + 1302.86) 190.43 liter

ii. Thumb Rule Method

It is applicable when volume batching is adopted. This method is based on two factor Yield of Concrete and Cement factor:

Yield of Concrete: Yield of concrete simply means the actual volume of concrete produced when a given proportion of concrete ingredients are mixed in a certain manner.

$\therefore$ Yield per bag of cement (y) = $\frac{2}{3}$ (Volume of one bag of cement + Volume of Aggregates used for one bag of cement)

$$\therefore \text{Cement factor} = \frac{1}{y} \quad \text{(Bags)}$$

Ex: Estimate the ingredient of concrete mix of proportion M_{15} (1:2:4).Let **a**, **b** and **c** be volume of cement, fine aggregate and coarse aggregate respectively. If we consider final volume of concrete produced will be 1 then it means,

$$\therefore a + b + c = 1$$

A bag of cement containing 50 kg of cement is considered to have a volume of 0.035 m^3. Therefore,

Volume of sand becomes **a** = 0.035 m^3
Volume of sand becomes **b** = 2*0.035 m^3
Volume of coarse aggregate becomes, **c** = 4*0.035 m^3
$\therefore$ Yield of concrete of proportion (1:2:4) = $\frac{2}{3}$*(0.035 + 2*0.035 + 4*0.035)
= 0.163 m^3

Cement factor: Cement factor is defined as the quantity by weight of cement required per m^3 of compacted concrete.

The region where there is scarcity of water cannot use water only on the base of W/C ratio because too much water reduces the strength of the concrete and too little reduces the workability of concrete so we have considered the both properties.

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- Cement factor = $\frac{1}{y} = \frac{1}{0.163}$
  = 6.13 bags of cement
- Fine aggregate = 2*6.13
  = 12.26 bags of sand
- Coarse Aggregate = 4*6.13
  = 24.53 bags of Gravel

5. CONCLUSION

To sum up, this paper not only contributes towards the ingredient and the raw material of the Concrete. It is about how much water is to be added in the concrete as per the amount of Aggregate by taking care of the environmental Condition.

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7. BIOGRAPHIES

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