"Effect of Specific Gravity on Aggregate Varies the Weight of Concrete Cube "

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ABSTRACT: - *The variation in weight of concrete cube with water cement ratio, mix design and cube size (150mmx150mmx150mm), were tested at Quality Control Lab for research work. The cube was casted at different location in India and was tested at different place around different location in India. When the cube was weighted for the 7days and 28 day test compressive strength of differently casted cube. It was found that variation in concrete cube weight found to be varying from place to place and location in India. After Sieve analysis of coarse aggregate, it was also found that variation in Fineness Modulus of coarse aggregate varied for different location. The variation in Fineness modulus increases volume of coarse aggregate and increases in weight of concrete cube. If the fineness Modulus is constant, the volume of coarse aggregate increase with size of the aggregate, or with the decrease in surface area of the coarse aggregate The main cause in variation in weight of cube found to be specific gravity of Coarse Aggregate. It plays an important role in weight of concrete cube and specific gravity of an aggregate is considered to be a measure of strength or quality of material and specific gravity test helps in identification of stone. Hence we can say that Specific gravity of Aggregate varies at different location in India and weight of concrete cube varied at different location. We can say that weight of cube plays an important role in determining the quality of concrete and compressive Strength of cubes*.

Keywords: *Specific gravity, Coarse Aggregate, Relative Density, Fineness Modulus, Unit mass, Cubes,*

I. INTRODUCTION

Aggregate is a collective term for the mineral materials such as sand, gravel and crushedstone that are used with a binding medium (such as water, bitumen, Portland cement, lime etc.) to form compound materials (such as asphalt concrete and Portland cement concrete).By volume, aggregate generally accounts for 92% to 96% of hot mix asphalt and 70%to 80% of Portland cement concrete. Aggregate is used for base and sub base course for both flexible and rigid pavements. Aggregates can either be natural or manufactured. Natural aggregate are generally extracted from natural rock formations through an open excavation (quarry).Extracted rock is typically reduced to usable sizes by mechanical crushing. Manufactured aggregate is often the by product of other manufacturing industries. Concrete Contains 25% to 40% (absolute volume of cement may be 7% to 15%; water may be 14% to 21% and up to air(depending on top size of coarse aggregate).Therefore aggregates make up 60% to 75% of total volume of concrete.

1. Aggregate sources: Aggregate can come from either natural or manufactured sources .Natural aggregate come from rock, of which there broad geological classifications.

a. Igneous Rock: These rocks are primarily crystalline and are formed by the cooling of molten beneath the earth's crust (magma).

b. Sedimentation rocks: These rocks formed from deposited insoluble material. This material is transformed to rock by heat pressure. Sedimentary rocks are layered in appearance and are further classified based on their predominant mineral as calcareous (lime. chalk, etc.), siliceous (sandstone) or argillaceous (shale).

2. Physical Properties of Aggregates

a. Unit weight and voids (Unit mass or Bulk Density): The weight of the aggregate required to fill a container of a specified unit volume. Volume is occupied by both the aggregates and voids between the aggregate particles. Depends on size distribution and shape of particles and how densely the aggregate is packed. Voids contents affect mortar requirements in mix design; water and mortar requirement tend to increase as aggregate void content increases. Voids contents between aggregate particle increases with increasing aggregate angularity. Void contents range from 30% to 45% for coarse aggregate to about 40% to 50% for fine aggregates. Total volume of voids can be reduced by using a collection of aggregate sizes.

b. Specific Gravity of Coarse Aggregate (Relative Density): The ratio of the mass (or weight in air) of a unit volume of a material to the mass of the same volume of water at stated temperature. The value is dimensionless. The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. The specify gravity test helps in identification of stone. The specific gravity of aggregates ranges from 2.5 to 3.0.Specific Gravity is the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. Water; at a temperature of 73.4'C (23'C) has specific gravity .Specify gravity is important for several reasons. Some deleterious particles are lighter than the good aggregate. Tracking specify gravity can sometimes indicates a change of material or possible contamination. Difference in specific gravity may be used during production to separate the deleterious particles from the good using a heavy media liquid. In Portland Cement Concrete the specify gravity of the aggregate is used in calculating the percentage of voids and the solid volume of aggregate in computations of yield.

The absorption is important in determining the net water-cement ratio in the concrete mix. Knowing the specific gravity of aggregate is to the construction of water filtration systems, slope stabilization projects, railway bedding and many other applications.

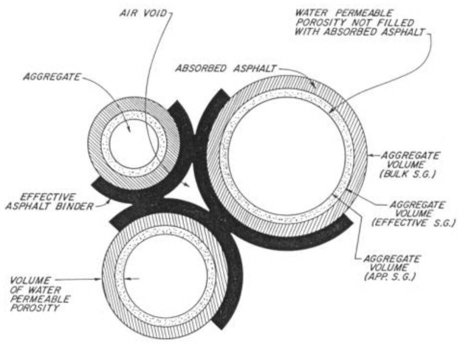

Figure1. Aggregate Specific Gravities

c. Partical Shape and Surface Texture: Rough texture ,angular ,elongated particles require more water to produce workable concrete than do smooth ,rounded , compacted aggregtes. Aggregates should be relatively free of flat and elongated particles (limit to 15%by weight of total aggregate).Important for coarse and crushed fine aggregate –these require an increase in mixing water and may affect the strength of the concrete ,if cement water ratio is not maintained.

d. Shrinkage of aggregate: Whathappens if abnormal aggregate shrinkage occurs? Excessive cracking, large deflection of reinforced beams and slabs, some spalling.If more than 0.08 percentage shrinkage occurs, the aggregate is considered undesirable.

e. Absorption and Surface Moisture: If water content of the concrete mixture is not kept constant, compressive strength, workability, and other properties will vary from batch to batch.

f. Resistance to Freezing and Thawing: If aggregates or concrete absorbs so much water that when the water freezes and expands the concrete cannot accommodate the build-up of internal pressure, pop-outs may occurs.

g. Density and Specify Gravity: Density is the weight per unit of volume of a substance. Specify gravity is the ratio of the density of the substance to the density of water. The density and specify gravity of an aggregate particle is dependent upon the density and specify gravity of the minerals making up the particle and upon the porosity of the particle. These may be defined as follows:

a) All of pore space **(bulk density or specify gravity)**

b) Some of the pore space **(effective density or specify gravity)**

c) None of the pore space **(apparent density or specify gravity)**

Determining the porosity of the aggregate is often necessary; however, measuring the volume of pore space is difficult. Correlations may be made between porosity and the bulk, apparent and effective specific gravities of the aggregate. Porosity is a ratio of the volume of the pores to the total volume of the particle. The internal pore characteristics are very important properties of aggregates. The size, the number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surface texture, specific gravity, bonding capabilities, and resistance to freezing and thawing action.

3. Fineness Modulus of Coarse Aggregate:

Fineness Modulus is defined as an index to the particle size not to the gradation. Fineness Modulus is calculated from the sieve analysis. An empirical factor obtained by adding the total percentage of sample of the aggregate retained on each of a specified series of sieves, and dividing the sum by 100.If the fineness Modulus is constant, the volume of coarse aggregate increase with size of the aggregate, or with the decrease in surface area of the coarse aggregate. The coarse aggregate specific gravity test is used to calculate the specific gravity of coarse aggregate sample by determining the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. Specific Gravity is a measure of a material's density (mass per unit volume) as compared to density of water at 73.4'F (23'C).The FM is an index of the fineness of an aggregate –the higher the FM, the coarser the aggregate. Different aggregate grading may have the same FM.FM of fine aggregate is useful in estimating proportions of fine and coarse aggregates in concrete mixtures.FM of the Coarse aggregate is higher the volume of the aggregate more. Hence the concrete cube weight increases. Volume of Aggregate is consider for determining the specify gravity. Any variation in Volume will affect the Specify gravity. The volume of aggregate varies from place to place. Hence we can say that weight of cube varies with variation in fineness modulus of coarse aggregate. Fineness Modulus (FM) is used in determining the degree of uniformity of the aggregate gradation. It is an empirical number relating to the fineness of the aggregate. The higher the FM is, the coarser the aggregate is. If FM is less then finer the aggregate. In general a small value indicates a fine material while a large value indicates a coarse material. The value of fine aggregate commonly ranges from 2.00 to 4.00 and for coarse aggregate from 6.50 to 8.00.Many agencies use fineness modulus variation as a convenient means of keeping quality data on uniformity of particle –size distribution of aggregate production, delivery, and use. Some agency require that aggregates be processed to remain within upper and lower limits of fineness modulus. Such requirements are more frequently applicable to fine aggregate than coarse aggregate or combined aggregate.

4. Classification of Aggregates

The most common classification of aggregates on the basis of bulk specific gravity is lightweight, normal weigth and heavyweight aggregates. In normal concrete the aggregate weights 1520 -1680 Kg/m3,but occasionally designs require either lightweight or heavyweight concrete. Lightweight concrete contains aggregates that is natural or synthetic which weighs less than 1000 Kg/m3 and heavyweight concrete contains aggregates that are natural or synthetic which weight more than 2080 Kg/m3.Althoughaggregates are most commonly known to be inert filler in concrete ,the different properties of aggregate have a large impact on the strength ,durability ,workability and economy of concrete. These different properties of aggregate allow designers and contractors the most flexibility to meet their design and construction requirements. The variability in density can be used to produce concrete of widely differently unit weights, given in table -1.The most common classification of aggregates on the basis of bulk specific gravity is lightweight, normal-weight and heavyweight aggregates.

Table :-(1)Density Classification of concrete Aggregates

Category	Unit Weight of Dry-rodded Aggregate (Kg/m3)	Unit Weight of Concrete (Kg/m3)	Typical Concrete Strengths (Mpa)	Typical Applications
Ultra	< 500	300-1100	<7	Non structural
Lightweight	500-800	1100-1600	7-14	
Lightweight	650-1100	1450-1900	17-35	Insulating material
Structural	1100-1750	2100-2500	20-40	Masonry Units
Lightweight	>2100	2900-6100	20-40	Structural
Normal weight				Structural
Heavy weight				Radiation shielding

II. Methods:

The project specimen of fine aggregate, aggregate, cement was test at quality control lab. Combined Sieve analysis of aggregate 20mm (55%) and 10 mm (45%) was tested .While concrete pour, Slump test was taken at site to find the workability of concrete during pour. Once workability is found ok, cubes are casted(150mmx150mmx150mm).The sampling of the entire test was carried out from the start of project to end of the project. Concrete Mix design M-25 .The specimen sample was taken in different location in India. Following test was conducted in site. Fineness modulus defines the size of the aggregates on concrete mix design. There are some limits on it though. If you have high modulus of fineness, the tendency of mixture is to have less pores as possible .The less pores you have, the good is your bonding between each elements. However, less pores means less breathing space for the concrete. This inhibits hydration. Once moisture does not escape from concrete, then the strength is very difficult to achieve. On the other hand, low modulus of fineness tend to have lower bonding between concrete elements. However, you can have better curing condition of you have optimum pores on your concrete. The strength can be achieve quickly. The aggregate shall be comply with the requirements of IS 383 .As far as possible preference shall be given in natural aggregates. The Nominal maximum size of coarse aggregate should be as large as possible within the limits specified but in no case greater than one-fourth of the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of the form. For most work, 20mm aggregate is suitable .The coarse aggregate and fine aggregate should be batched separately. The particle size distribution of aggregate is called grading. The grading determining the paste requirement for a workable concrete since the amount of void requires needs to be filled by the same. This test were carried out for 35000m3 of concrete, minimum quantity of material for carrying out the test for stone aggregate that is practical size distribution is 45m3/per test.

Table: - (2) Combined sieve analysis of coarse aggregate (20mm)(Rajasthan)

SeiveNo	Wt.Ret	Ret.Wt %	Cum.WtRet%	Cum.pass%	As per IS
40mm	0.0	0.0	0.90	100.0	100
20mm	109.0	3.63	3.63	96.37	85-100
10mm	1978.0	65.93	69.57	30.43	0-20
4.75mm	800.0	26.67	96.23	3.77	0-5
Pan	113.0	3.77	100.0	0.00	0
Total	3000.0			230.57	

Fineness modulus Coarse aggregate: - 230.57/100 = 2.3057

Cube Weight 150mmx150mmx150mm= 3560.00 grams

Density of Cube =1054.81 Kg/m3

Table: - (3)Combined sieve analysis of coarse aggregate (20mm) (Pondicherry)

SeiveNo	Wt.Ret	Ret.Wt %	Cum.WtRet%	Cum.pass%	As per IS
40mm	0.0	0.0	0.0	100.0	100
20mm	680.0	13.60	13.60	86.0	85-100
10mm	4270.0	85.40	99.0	1.0	0-20
4.75mm	50.0	1.0	100.0	0.0	0-5
Pan	0.0	0.0	0.0	0.0	0
Total	5000.0			187.00	

Fineness modulus Coarse aggregate:- 187/100 = 1.87

Cube Weight 150mmx150mmx150mm= 8250.00 grams

Density of Cube=2444.44 Kg/m3

Table :-(4)Combined sieve analysis of coarse aggregate (20mm) (Chhattisgarh)

SeiveNo	Wt.Ret	Ret.Wt %	Cum.WtRet %	Cum.pass%	As per IS
40mm	0.00	0.0	0.0	100.0	100
20mm	40.0	2.0	2.0	98.0	85-100
10mm	1410.0	70.5	72.5	27.5	0-20
4.75mm	541.0	27.5	99.25	0.45	0-5
Pan	9.0	0.45	100.0	0.0	0
Total	2000.0			225.95	

Fineness modulus Coarse aggregate: - 225.95/100 = 2.2595
Cube Weight (150mmx150mmx150mm) =3500 grams

Density of Cube=1037.036 Kg/m3

Figure :-(2)Showing Cube Weight at Different Location in India

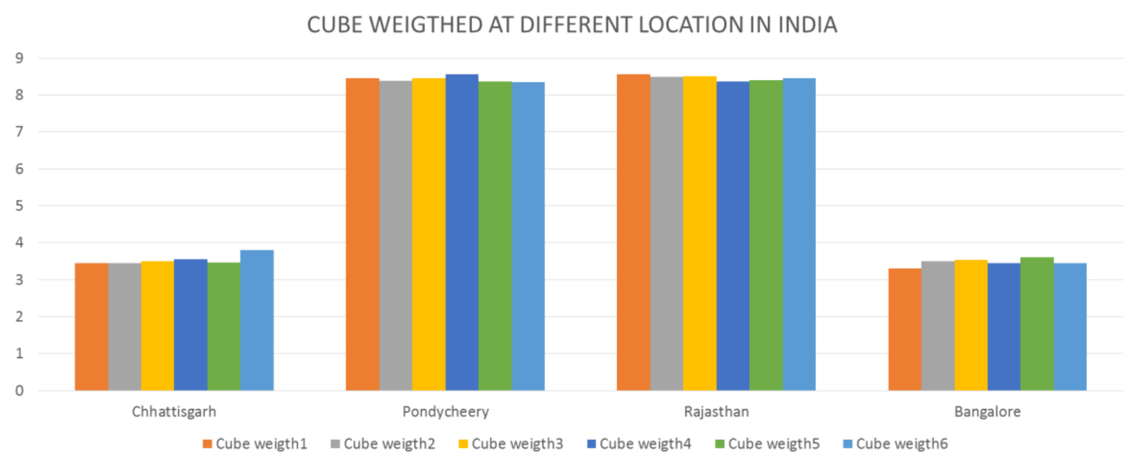

Figure :-(3)Showing Density and Fineness Modulus at Different Location.

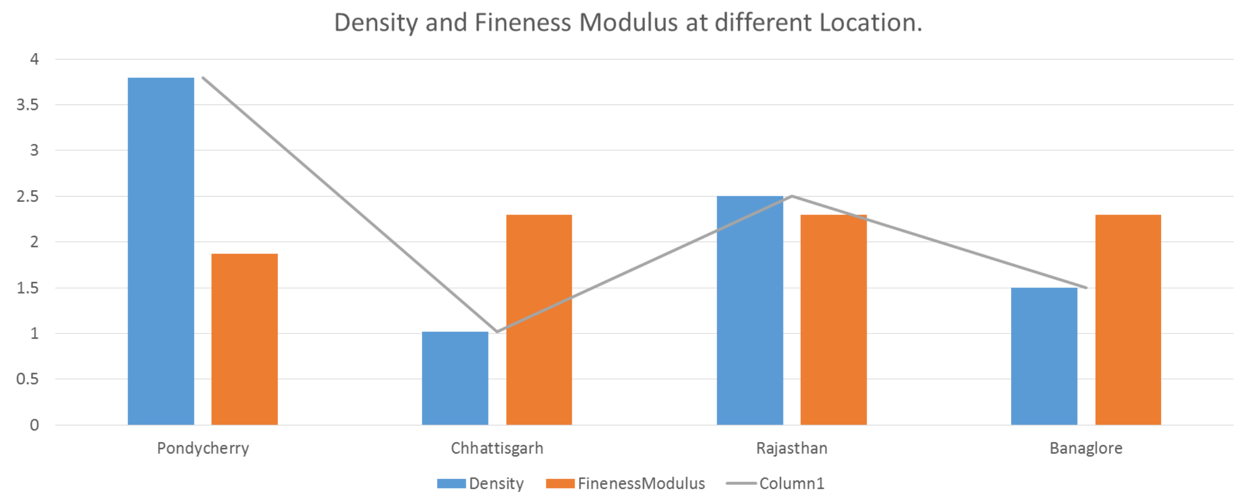

Table: - (5) 7 and 28 Days Cubes tested at Pondicherry result

Identification Mark	Age of Cubes (Days)	Weight of Cube(KG)	Density of Cube (Kg/m3)	Area of Cube (mm2)	Failure of Cube (KN)	Compressive Strength (N/mm2)
P1	7	8.450	2503.7012	22500	380	16.88
P2	7	8.380	2482.9604	22500	385	17.11
P3	7	8.455	2502.1826	22500	390	17.33
P4	28	8.550	2533.3308	22500	575	25.55
P5	28	8.355	2475.5530	22500	600	26.66
P6	28	8.345	2472.5901	22500	605	26.88

Table: - (6) 7 Day and 28 days Cubes at Chhattisgarh result

Identification Mark	Age of Cubes (Days)	Weight of Cube(KG)	Density of Cube (Kg/m3)	Area of Cube (mm2)	Failure of Cube (KN)	Compressive Strength (N/mm2)
C1	7	3.450	1022.2212	22500	380	16.88
C2	7	3.455	1023.7026	22500	385	17.11
C3	7	3.500	1037.0360	22500	390	17.33
C4	28	3.550	1051.8508	22500	585	26.00
C5	28	3.470	1028.1471	22500	610	27.11
C6	28	3.580	1060.7396	22500	615	27.33

Identification Mark	Age of Cubes (Days)	Weight of Cube(KG)	Density of Cube (Kg/m3)	Area of Cube (mm2)	Failure of Cube (KN)	Compressive Strength (N/mm2)
B1	7	3.350	1488.8874	22500	385	17.11
B2	7	3.400	1511.1096	22500	390	17.33
B3	7	3.350	1488.8874	22500	395	17.55
B4	28	3.500	1555.5540	22500	590	26.22
B5	28	3.450	1533.3318	22500	615	27.33
B6	28	3.550	1577.7762	22500	620	27.55

Table :-(7) 7and 28 Days Cubes at Rajasthan result

Identification Mark	Age of Cubes (Days)	Weight of Cube(KG)	Density of Cube (Kg/m3)	Area of Cube (mm2)	Failure of Cube (KN)	Compressive Strength (N/mm2)
R1	7	8.566	3807.11	22500	335	14.88
R2	7	8.489	3772.88	22500	355	15.77
R3	7	8.500	3777.77	22500	330	14.66
R4	28	8.355	3713.33	22500	575	25.55
R5	28	8.400	3733.33	22500	600	26.66
R6	28	8.4500	3755.55	22500	605	26.88

Table: - (8) 7and 28 Days Cubes at Bangalore result

III. CONCLUSION: - The variation in weight of concrete cube with w/c ratio, mix design and cube size (150mmx150mmx150mm), when the cube was weighted for the 7days and 28 day test compressive strength of differently casted cube. It was found that variation in concrete cube weight found to be varying from place to place and location in India weighted. It has been observed that strength of mix is dependent wholly on the water cement ratio while the grading of the particles is important from workability and economic point of view. The main cause in variation in weight of cube found to be specific gravity of Coarse Aggregate. It plays an important role in weight of concrete cube and specific gravity of an aggregate is considered to be a measure of strength or quality of material and specific gravity test helps in identification of stone. The grading of practicles, to get maximum density, is difficult and sometimes uneconomical to achieve in practicle. The method is not so popular since grading cannot be accurately achieved in field, and is no control over the strength. Hence fineness modulus method essentially is a substitute for maximum density method, aimed at standardisation of the grading of aggregates. The term fineness modulus, suggested, is a numerical index of fineness of both fine as well as coarse aggregate. Certain values of fineness modulus for mixed aggregates are found to give the best result. If you have high modulus of fineness, the tendency of mixture is to have less pores as possible .The less pores you have, the good is your bonding between each elements. However, less pores means less breathing space for the concrete. Hence we can say that Specific gravity of Aggregate varies at different location in India and weight of concrete cube varied at different location.

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REFERENCE:

[1] B.C Punmia, Ashok Kr.Jain, Arunkr.Jain, Limit State Design of Reinforced Concrete.

[2] Indian Standard code practice for Methods of Test for Aggregates for Concrete, IS: 2386(Part)-1963.

[3] Indian Standard code practice for Specification for coarse and fine aggregates from natural sources for Concrete, IS: 383:1970**.**

[4] Mehta and Monteiro, (1993) Concrete Structure, Properties and Materials, (Englewood Cliffs, NJ: Prentice-Hall, Inc).

[5] Mindess and young (1981) Concrete, (Englewood Cliffs, NJ: Prentice-Hall, Inc).