Concrete Mix Design By Packing Density Method

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Abstract- *Concrete mix design is a critical factor in determining the quality and durability of concrete structures. The traditional trial and error approach to mix design can be time-consuming and yield suboptimal results. In recent years, the Packing Density Method has emerged as an alternative approach to optimize concrete mixtures.The Packing Density Method focuses on achieving maximum particle packing within the concrete mixture. By optimizing the arrangement and distribution of aggregates, cement, and water, this method aims to improve the overall performance of concrete. This abstract provides an overview of the key principles and considerations involved in the Packing Density Method, including aggregate selection, grading optimization, and the use of admixtures. The advantages of the Packing Density Method include improved workability, strength, and durability of concrete. However, challenges such as the availability of suitable aggregates and accurate particle size analysis need to be addressed. Rigorous experimentation and testing are essential to validate the mix design for specific applications.*

Keywords- Concrete mix design, Packing Density Method, Particle packing, Aggregate selection, Grading optimization, Admixtures, etc.

I. INTRODUCTION

There are various methods of proportioning for various types of concrete such as Fineness Modulus method, Minimum Void method, Maximum Density Method, Water Cement Ratio method, Arbitary method. The subject of optimizing the concrete composition by selecting the right amounts of various particles has already aroused interest for more than a century. Concrete is a multiphase material consisting of coarse aggregate, fine aggregate, binding material and water. Thus, the properties of concrete depend upon the characteristics of the aggregates, performance of cement paste and interfacial transition zone. Approximately 75% of the concrete volume is occupied by the aggregates in which around 45% are coarse aggregate, it is assumed that the aggregate properties greatly affect the durability and the structural performance of concrete material. In concrete, cement is very expensive item than aggregates and is responsible for huge amount of carbon di oxide generation. In IS code method of mix design we have curves to decide the water cement ratio. Here an attempt has made to develop co-relation curves between compressive strength of concrete versus water cement ratio and paste content versus Compressive strength.

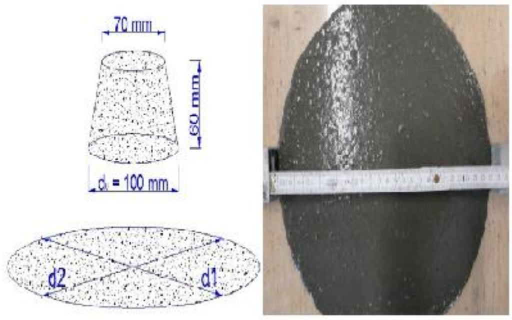


Fig.1.1 Particle Packing Density

1.1 Scope of the Study

The scope of the study is to develop a concrete mix design method based on the packing density of aggregate particles. This method aims to optimize the use of aggregates in concrete mixes, ensuring that the maximum density of the mixture is achieved, and the desired properties of the hardened concrete, such as strength, durability, and workability, are met. The study will involve experimental investigations to determine the packing characteristics of aggregates, as well as numerical simulations to optimize the mix design parameters. The ultimate goal of this study is to provide a reliable and efficient method for concrete mix design that can be used by engineers and contractors in the construction industry.

- To find the minimum cement content in concrete.
- To check the durability of concrete.
- To check the porosity in concrete.

1.2Problem Statement

The different geographical basis which has variation in quality of material and which affect the level of variation in achievement of concrete grading, this method is helpful to select same type of grading of material, minimize voids to increase particle packing and to reduce the binder content & achieve economy.

1.3Aim and Objectives

The aim of concrete mix design by packing density method is to obtain the proportion of ingredients for concrete mix that results in the highest packing density of the particles, which in turn leads to a stronger and more durable concrete.

1. To minimize the content of cement.
2. To find effective cost of concrete.
3. To use same material as per IS specification for packing density method to obtain better results as per IS specification.

II. LITERATURE REVIEW

Badrinarayan Rath et.al (2020). In this research, a mix design method is proposed by using the principle of dense particle packing arrangement to sustainable concrete by partial replacement of cement and sand with fy ash and pond ash, respectively. Various mixes were prepared with combinations of replacement material, and a best combination is selected according to maximum compressive strength of 28-day curing. That optimized combination is further designed by packing density method and compared the mix proportions with Indian Standard Code method.

Narasimha Raj et.al (2014) In this work the co-relation curves are developed for packing density method between compression strength and water cement ratio, paste content to reduce the time involved in trial to decide water cement ratio and paste content for a particular grade of concrete. Results obtained by packing density method are compared with IS code method. The optimum bulk density was obtained at proportion of 42% coarse aggregates (20mm downsize), 18% coarse aggregates (12.5mm downsize) and 40% fine aggregates. Large number of trial casting were carried out for each grade of concrete (i.e., M20, M25, M30, M35 and M40) with different water cement ratio and three paste contents in excess of void content.

Yibo Yang et.al (2020) this paper introduced the modified packing density method for the CRFA concrete mix design. The modified packing density method took account of the powder with a particle size of smaller than 75 µm in the CRFA and balanced both the void ratio and the specific surface area of the aggregate system. Concrete (grade C55) was prepared using the CRFA to validate the feasibility of the proposed method. The unit price of the prepared CRFA concrete was around 12.7% lower than that of the natural aggregate concrete. Additionally, the proposed procedure for the concrete mixture design could recycle all concrete waste into the new concrete and replace all the natural fine aggregate in the concrete mixture.

Henry H.C. Wong et.al (2020) The conventional mix design methods are no longer capable of meeting the stringent multiple requirements of HPC. This paper introduces the concept of packing density as a fundamental principle for designing HPC mixes. The concept is based on the belief that the performance of a concrete mix can be optimized by maximizing the packing densities of the aggregate particles and the cementitious materials. A preliminary HPC design method, called three-tier system design, is also presented in this paper.

Chandra SekharKaradumpa et.al (2021) In this study, Composite cement (CC), a ternary blended cement with replacement of fly ash (FA) and granulated blast furnace slag (GBFS) is used in design of concrete mixes. The amounts of OPC, FA and GBFS in CC were optimized based on packing density and compressive strength results. Four mixes of CC concrete were prepared with different values of packing densities of aggregates (0.80, 0.75, 0.70 and 0.65) with two combinations each having coarse and fine aggregate dominant and with three water to binder ratios (0.45, 0.50 and 0.55). It was identified that at the same level of packing density, with variation in proportions of different sizes of aggregates within the domain of extreme size range, the difference in compressive strength was found to be insignificant. Hence, a tri-relationship between compressive strength, water to binder ratio and packing density of aggregate system is established for proposing a new concrete mix design approach. Compressible Packing Model (CPM) is used in proportioning the coarse and fine aggregates to achieve the required packing density.

Qingdao Huang et.al (2017) This paper considers mix of two different aggregate sizes of 10 and 20mm, 0, 30, 50, 70 and 100% recycled aggregate replacement ratios, and water-cement ratio of 0.35, 0.45 and 0.55. In total of fifteen concrete mix designs are considered. The paper presents the material properties of aggregates which were obtained from the material testing. The mix design method and results of mechanical testing will be discussed. The results show that the packing densities of natural and recycled aggregates are different, and should not be treated in the same way. By using packing density mix design method, recycled aggregated concrete strengths fluctuation can be resolved, and the concretes can have similar strengths consistency, regardless the recycled concrete aggregate replacement ratios. This method minimize the influence of recycled concrete aggregates obtain from various sources with variable quality.

Wang Zonglin et.al (2018) In this study, a new mixture design methodology based on the 4-parameters compressible packing model (CPM) of Packing Density Theory was proposed to satisfy the specific performance criteria of high performance concrete for prestressed concrete bridge construction. Iterative algorithms were developed to determine the parameter of critical cavity size ratio x0 which reflect the crushed aggregate particles shape property and optimize the proportions of aggregates with different size range. After the optimization of aggregates, all the components in concrete were calculated. Thirty-one concrete mixtures with coarse aggregate from 5 different sources have been formulated according to this method to validate it both in fresh and hardened state.

III. MATERIALS AND METHOD

3.1 Material

Concrete is a multiphase material consisting of coarse aggregate, fine aggregate, binding material and water. Following are the materials used in concrete are as follows

3.1.1Coarse Aggregate

The portion of the aggregate used in concrete that is larger than 4.75 mm is known as coarse aggregate. The size of coarse aggregate used in this type of concrete is 20 mm and 10 mm aggregate. It is also known as metal.

Fig– 3.1CoarseAggregate (20mm)

Fig – 3.2 Coarse Aggregate (10 mm)

3.1.2 Fine Aggregate

The portion of the aggregate used in concrete that is less than 4.75 mm is known as coarse aggregate. The size of coarse aggregate used in this type of concrete is artificial washed aggregate. It is also known as Sand.

Fig – 3.3 Fine Aggregate (Artificial Washed Sand)

3.2 Test Conducted

Following are the test scheduled to fulfil the requirement of the expected outcome –

3.2.1 Specific Gravity

Specific gravity id the ratio of dry weight of aggregate to the weight of equal volume of water. Instrument used for conducting this test is given in the figure below –

Fig–3.4Coarse aggregatedensitytest set

Fig –3.5 Pycnometer

Table3.1-Determinationofspecificgravityfor20mmcoarse aggregate.

Sr. No.	**Determination**	**Formula**	**Sample 1**	**Sample 2**
1	Wt. of wire basket + Aggregate in water	A1	1454.5	1518.5
2	Wt. of wire basket in water	A2	756	756
3	Wt. of saturated aggregate in water (A)	A1-A2	698.5	762.5
4	Wt. of saturated surface dry aggregate in air (B)	B	1100.5	1200.5
5	Wt. of oven-dried	C	1059	1154

	aggregate in air			
6	Specific gravity	C/(B-A)	2.63	2.63
7	**Average Specific gravity**	**2.63**		

Table 3.2 -Determination of specific gravity for 10 mm coarse aggregate.

Sr. No.	Determination	Formula	Sample 1	Sample 2
1	Wt. of wire basket + Aggregate in water	A1	1455.5	1425.5
2	Wt. of wire basket in water	A2	756	756
3	Wt. of saturated aggregate in water (A)	A1-A2	699.5	669.5
4	Wt. of saturated surface dry aggregate in air (B)	B	1101	1050
5	Wt. of oven-dried aggregate in air	C	1056.5	1009.5
6	Specific gravity	C/(B-A)	2.63	2.65
7	**Average Specific gravity**	**2.64**		

3.2.2 Fineness Modulus

The sum of cumulative percentage retained is divided by an arbitrary number 100 and the resulting value is known as the fineness modulus.

Instrument used for conducting this test is given in the figure below–

Fig–3.6Sieveanalysisofcoarse aggregate

Fig–3.7Sieveanalysisoffine aggregate

Table 3.3 -Determination of fineness modulus for 20 mm aggregate.

Sieve size (mm)	Wt. retained on Sieve (gm)	Wt. retained on sieve (%)	Cumulative percentage of Wt. retained (%)	Percentage passing
40	0	0	0	100.00
25	20.5	0.50	0.50	99.50
20	977.5	23.84	24.34	75.66
16	1753.5	42.77	67.12	32.88
12.5	1047.5	25.55	92.67	7.33
10	263.5	6.43	99.10	0.90
4.75	17	0.41	99.51	0.49
2.36	0	0	99.51	0.49
1.18	0	0	99.51	0.49
0.6	0	0	99.51	0.49
0.3	0	0	99.51	0.49
0.15	0	0	99.51	0.49
0.075	0	0	99.51	0.49
Pan	20	0.49	100.00	0
Total	4099.5			

Table 3.4 -Determination of fineness modulus for 10 mm aggregate.

Sieve size (mm)	Wt. retained on Sieve (gm)	Wt. retained on sieve (%)	Cumulative percentage of Wt. retained (%)	Percentage passing
40	0	0	0	100
25	0	0	0	100
20	0	0	0	100
16	6	0.20	0.20	99.80
12.5	147.5	4.82	5.02	94.98
10	1339	43.79	48.81	51.91
4.75	1545.5	50.54	99.35	0.65
2.36	5.5	0.18	99.53	0.47
1.18	0	0	99.53	0.47
0.6	0	0	99.53	0.47
0.3	0	0	99.53	0.47
0.15	0	0	99.53	0.47
0.075	0	0	99.53	0.47
Pan	14.5	0.47	100.00	0.00
Total	3058			

3.2.3 Flakiness and Elongation Index

1. Flakiness Index:

The term flakiness index is used to indicate the percentage by weight of particles whose lease dimension is less than 60% of their mean dimension.

2. Elongation Index

The term elongation index is used to indicate the percentage by weight of particles whose greatest dimension is more than 80% of their mean dimension. Instrument used for conducting this test is given in the figure below –

Fig - 3.8 Elongation index test Instrument

Fig – 3.9 Flakiness index test Instrument

Table 3.5 -Determination of flakiness and elongation index for 20 mm Aggregate

Passing through IS Sieve (mm)	**Ret. on IS Sieve (mm)**	**Wt. of Agg. taken [A] (gm) [A]**	**Wt. of Agg. ret. on thickness guage. (gm) [B]**	**Wt. of Agg. passing through thickness guage. (gm) [C]**	**Wt. of Agg. Ret. through length guage after ret. on thickness guage. (gm) [D]**
63	50	0	0	0	0
50	40	0	0	0	0
40	31.5	0	0	0	0
31.5	25	0	0	0	0
25	20	3197	2953	244	333.5
20	16	1848.5	1684	164.5	307
16	12.5	1143.5	1086	57.5	168
12.5	10	0	0	0	0
10	6.3	0	0	0	0
Total		6189	5723	466	808.5
Flaniness Index (F.I)		C/A X100		7.53	
Elongation Index (E.I)		D/B X100		14.13	
FI & EI Combined		21.66			

3.3 Design of Concrete Mix Using Packing Density Method

3.3.1 Determination of aggregate fractions

The packing density of aggregate mixture is defined as the solid volume in a unit total volume. The aim of obtaining packing density is to combine aggregate particles in order to minimize the porosity, which allows the use of least possible amount of binder. Two size fractions of coarse aggregates were selected for the study i.e., 20 mm and 10 mm down size. The values of bulk density of the coarse aggregates (20 mm and 10 mm size) were first determined separately. The coarse aggregate 20 mm and 10 mm were mixed in different proportions by mass, such as 90:10, 80:20, 70:30 and 60:40 etc., and the bulk density of each mixture is determined. Addition of smaller size aggregate (10 mm down size) increases the bulk density. However, a stage is reached when the bulk density of coarse aggregate mixture, which instead of increasing, decreases again The results of Bulk density of coarse aggregate fractions (20 mm and 10 mm) are plotted in Fig. 3.1.

3.3.2 Determination of Packing Density

The packing density of individual aggregate in a volume fraction of total aggregate or over all aggregate is determined from its maximum bulk density of mixture and specific gravity from the following relation**.**

$$\text{Packing Density} = \frac{\text{Bulk Density} \times \text{Weight Fraction}}{\text{Specific Gravity}}$$

3.3.3 Determination of Voids Contents and Voids ratio

The voids content in percentage volume of aggregate or mixture of three aggregate is determined from its bulk density from the following relations.

$$\text{Voids content in percent volume} = \frac{\text{Sepcific Gravity} \times \text{Bulk Density}}{\text{Sepcific Gravity}} \times 100$$

From the Figures 3.1, 3.2 and 3.3 it is observed that the bulk density, packing density are maximum and voids ratio is minimum for 65 % of coarse aggregate (20 mm) and 35 % of coarse aggregate (10 mm) respectively

Table 3.6 - Proportioning of Coarse Aggregates

Sr. No.	Wt. of Empty Cylinder (Kg)	Wt. of Cylinder with Agg. (Kg)	Net Wt. (Kg)	Wt. of Cylinder with water	Bulk Density	Avg. Bulk Density, (gm/cc)	Proportion of CA1:CA2, (20mm:10 mm)
1	8.82	33.65	24.83	23.58	1.682	1.61179	90:10
	8.82	32.29	23.47	23.58	1.590		
	8.82	31.89	23.07	23.58	1.563		
2	8.82	33.48	24.66	23.58	1.670	1.62534	85:15
	8.82	32.77	23.95	23.58	1.622		
	8.82	32.18	23.36	23.58	1.588		
3	8.82	34.32	25.50	23.58	1.727	1.63889	80:20
	8.82	33.56	24.74	23.58	1.676		
	8.82	31.15	22.33	23.58	1.512		
4	8.82	33.89	25.07	23.58	1.698	1.64092	75:25
	8.82	32.81	23.99	23.58	1.625		
	8.82	32.42	23.60	23.58	1.598		
5	8.82	33.95	25.13	23.58	1.702	1.64702	70:30
	8.82	33.07	24.25	23.58	1.642		
	8.82	32.37	23.55	23.58	1.595		
6	8.82	34.06	25.24	23.58	1.710	1.65515	65:35
	8.82	33.12	24.30	23.58	1.646		
	8.82	32.57	23.75	23.58	1.609		
7	8.82	33.82	25.00	23.58	1.693	1.65108	60:40
	8.82	32.76	23.94	23.58	1.621		
	8.82	32.99	24.17	23.58	1.637		
8	8.82	33.60	24.78	23.58	1.678	1.64837	55:45
	8.82	33.11	24.29	23.58	1.645		
	8.82	32.74	23.92	23.58	1.620		
9	8.82	33.38	24.56	23.58	1.663	1.64363	50:50
	8.82	32.79	23.97	23.58	1.623		
	8.82	33.07	24.25	23.58	1.642		

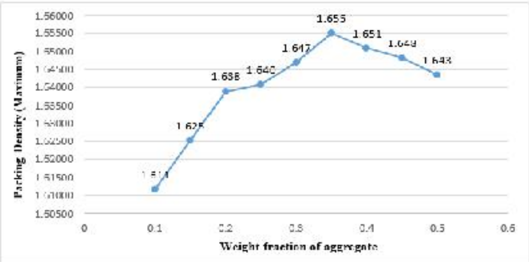


Fig 3.10 – Maximum packing density for 20 mm and 10 mm aggregates

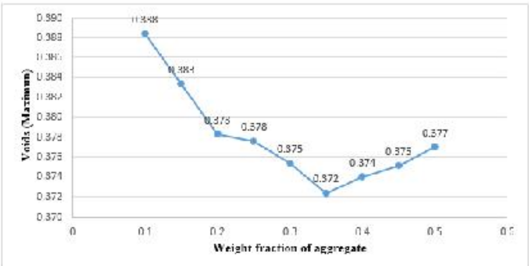


Fig 3.11 – Maximum voids ratio for 20 mm and 10 mm aggregates

Fig 3.12 – Mixing of 20 mm and 10 mm aggregate.

Fig 3.13 – Proportioning of 20 mm and 10 mm aggregate.

Table 3.7 - Proportioning of Coarse & Fine Aggregates

Sr. No.	**Wt. of Empty Cylinder (Kg)**	**Wt. of Cylinder with Agg. (Kg)**	**Net Wt. (Kg)**	**Wt. of Cylinder with water**	**Bulk Density**	**Avg. Bulk Density, (gm/cc)**	**Proportion of CA:FA**
1	8.82	35.65	26.83	23.58	1.817	1.77913	75:25
	8.82	34.78	25.96	23.58	1.758		
	8.82	34.81	25.99	23.58	1.760		
2	8.82	35.98	27.16	23.58	1.840	1.79472	70:30
	8.82	34.87	26.05	23.58	1.764		
	8.82	35.08	26.26	23.58	1.779		
3	8.82	36.19	27.37	23.58	1.854	1.81369	65:35
	8.82	35.28	26.46	23.58	1.792		
	8.82	35.30	26.48	23.58	1.794		
4	8.82	35.98	27.16	23.58	1.840	1.80623	60:40
	8.82	35.52	26.70	23.58	1.808		
	8.82	34.94	26.12	23.58	1.769		
5	8.82	35.74	26.92	23.58	1.823	1.80420	55:45
	8.82	34.83	26.01	23.58	1.762		
	8.82	35.78	26.96	23.58	1.826		

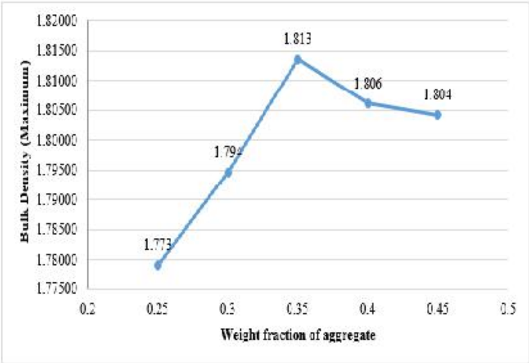


Fig 3.14 – Maximum packing density for 20 mm and 10 mm and fine aggregate

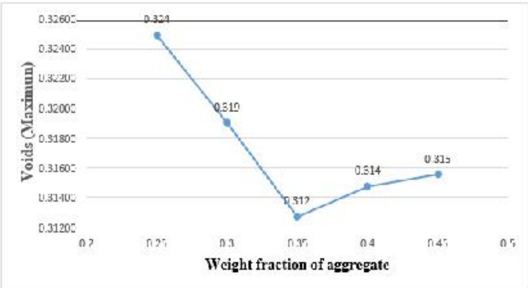


Fig 3.15 – Maximum voids for 20 mm and 10 mm and fine aggregate

Fig 3.16 – Mixing of 20 mm, 10 mm and fine aggregate

Fig 3.17 – Proportioning of 20 mm, 10 mm and fine aggregate.

3.2.1 Aggregate proportions for packing density method

Table 3.15 – Final aggregate proportion for packing density method.

Materials	**Proportions at Maximum Packing Density**		
	20 MM	10 MM	FA
Coarse Aggregates	65 %	35 %	--
All-In-Aggregates	65 %		35 %
Final Proportions	42.25 %	22.75 %	35 %

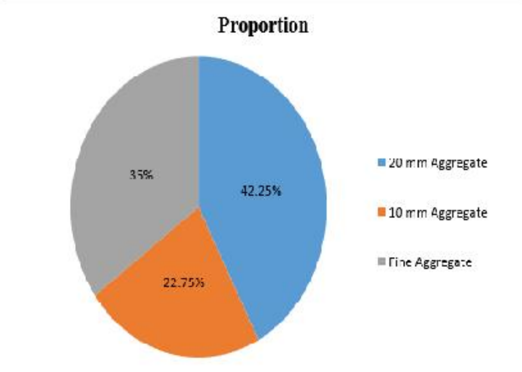


Fig 3.18 – Proportion of packing density method

IV. RESULT & DISUSSION

4.1 Mix Design for M25 Grade Concrete (Packing Density Method)

1. Packing Density of 20 mm aggregate

$$= \frac{Maxbulkdensityofallinaggregates \times weig\square tfraction}{Specificgravity}$$

$$= \frac{1.81369 \times 42.25}{2.635}$$

= 0.02909

2. Packing Density of 10 mm aggregates

$$= \frac{maxbulkdensityofallinaggregates \times weig\square tfraction}{specificgravity}$$

$$= \frac{1.81369 \times 22.75}{2.642}$$

= 0.1562

3. Packing Density of Fine aggregates

$$= \frac{Maxbulkdensityofallinaggregates \times weig\square tfraction}{Specificgravity}$$

$$= \frac{1.81369 \times 35}{2.63}$$

= 0.2403
Total Packing Density
= 0.2909 + 0.1562 + 0.2403
= 0.6873
Percentage of voids
= 1 − Total Packing density
= 1 − 0.6873
=0.3127

7. Total solid volume of aggregates

$$= \left(\frac{\text{Weight fraction of 20mm}}{\text{Specific gravity}}\right) + \left(\frac{\text{Weight fraction of 10mm}}{\text{Specific gravity}}\right) + \left(\frac{\text{Weight fraction of fine aggregates}}{\text{Specific gravity}}\right)$$

$$= \left(\frac{0.4225}{2.635}\right) + \left(\frac{0.2275}{2.643}\right) + \left(\frac{0.35}{2.630}\right)$$

=0.3790

Table4.1 –Finalized mix proportions designed by packing density method

Sr. No.	Material	Unit	Quantity
1	Cementcontent	Kg/cum	419.33
2	Watercontent	litre	226.44
3	Wt.ofFine aggregate	Kg/cum	591.48
4	Wt.of10 mmaggregate	Kg/cum	384.46
5	Wt.of20 mmaggregate	Kg/cum	714.00
6	W/Cratio	-	0.54
7	**Total**	**Kg/cum**	**2335.70**

4.2 Mix Design for M25 Grade Concrete (IS Code Method)

1. Target mean strength for mix proportioning
fck\` = fck + 1.65S
= 25 + 1.65 x 4
fck\` = 31.6 N/mm2

2. Selection of W/C ratio
From table No.5 of IS 456, maximum water cement ratio for mild condition = 0.55
Based on experience, we adopt
W/C ratio = 0.54

3. Estimation of air content
From table No.3 of IS 10262, the approximate entrapped air in normal concrete is as follows
Maximum Size of Aggregate - 20
Entrapped Air (%) - 1.00

Table4.2–Allincombined grading

Sieve Size (mm)	**Individual Passing Percentage**			**Proportioning**			100	**Specifications As Per IS 383:2016 Table No. 10**		
				29.95	**24.35**	**45.69**				
	20 mm	**10 mm**	**FA**	**20 mm**	**10 mm**	**FA**	**CG**	**Mid**	**Min**	**Max**
40	100.00	100.00	100.00	29.95	24.35	45.69	100.00	100.0	**100**	**100**
25	99.50	100.00	100.00	29.80	24.35	45.69	99.85			
20	75.65	100.00	100.00	22.66	24.35	45.69	92.71	97.50	**95**	**100**
16	32.88	100.00	100.00	9.85	24.35	45.69	79.89			
12.5	7.32	95.17	100.00	2.19	23.18	45.69	71.06			
10	0.90	51.29	100.00	0.27	12.49	45.69	58.46			
4.75	0.49	0.66	100.00	0.15	0.16	45.69	46.00	40.00	**30**	**50**
2.36	0.49	0.48	80.75	0.15	0.12	36.90	37.16			
1.18	0.49	0.48	22.00	0.15	0.12	10.05	10.31			
0.6	0.49	0.48	6.86	0.15	0.12	3.14	3.40	22.50	**10**	**35**
0.3	0.49	0.48	1.77	0.15	0.12	0.81	1.07	7.00		
0.15	0.49	0.48	0.95	0.15	0.12	0.43	0.70	3.00	**0**	**6**
0.075	0.49	0.48	0.52	0.15	0.12	0.24	0.50			

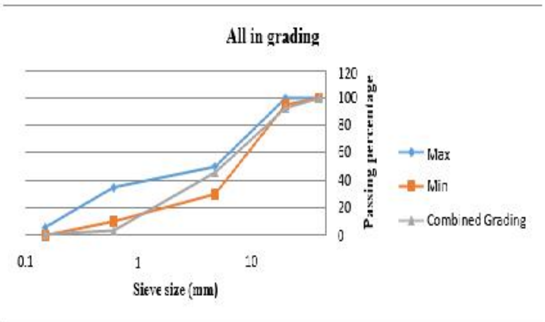


Fig 4.1 – All in grading

7. Mix Calculations

I) Total Volume of Concrete: - 1 Cum
II) Volume of Entrapped Air in wet Concrete: - 0.01

a) Volume of concrete
= Total volume of concrete – Volume of entrapped air
= 1 – 0.01 = 0.99 Cum

b) Volume of cement

$$= \frac{Mass\ of\ cement}{Specific\ gravity\ of\ cement} \times \frac{1}{1000}$$

$$= \frac{440}{3.15} \times \frac{1}{1000}$$

= 0.140 Cum

c) Volume of water

$$= \frac{Mass\ of\ water}{Specific\ gravity\ of\ water} \times \frac{1}{1000}$$

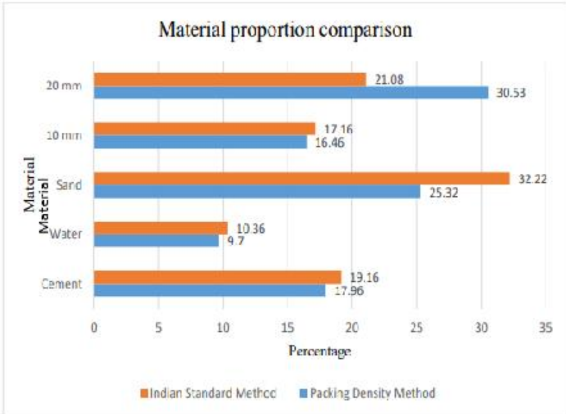
$$= \frac{238}{1} \times \frac{1}{1000}$$

= 0.238 Cum

d) Volume of all in aggregates
$Volume of concrete - (Volume of cement + Volume of water)$
$= 0.99 - (0.140 + 0.233)$
= 0.612 Cum

Table4.3 –Finalized mixproportions designedby IScodemethod.

Sr. No.	**Material**	**Unit**	**Quantity**
1	Cement content	Kg/cum	440
2	Water content	litre	238
3	Wt. of Fine aggregate	Kg/cum	739.13
4	Wt. of 10 mm aggregate	Kg/cum	393.96
5	Wt. of 20 mm aggregate	Kg/cum	483.20
6	W/C ratio	-	0.54
7	**Total**	**Kg/cum**	**2294.29**



Fig–4.2Comparisonof material proportion

Experimental part

Table4.4–Compressive strengthofcube castusingpackingdensity method.

Sr. No.	Days	Unit	Packing Density Strength	IS Code Strength
1	3	Mpa	17.24	16.09
2	7	Mpa	22.61	21.65
3	28	Mpa	32.26	31.46

4.4 Discussions

From the above values it is clear that fine aggregate particles are required more in case of packing density method compared to IS code method. Therefore, water and cement required in case of packing density method is more. In case of IS method coarse aggregate 20 mm and 10 mm down sizes are graded based on sieve analysis results but in case of packing density method aggregates quantity are decided based on actual packing of particles. Coarse aggregate particle 20 mm downsize required will be more in case of packing density method compared to IS method. But both the methods have resulted in nearly same compressive strength at 28 days curing. Coarse aggregate particle may also contribute towards the strength along with bond. In case of packing density, finer aggregate particles required are more and paste required is also more. In this case contribution to the strength due to bond area may be more.

V. CONCLUSION

1. The packing density value will remain same irrespective of grade of concrete.
2. In packing density method, paste content in excess of void content will increase with the increase in grade of concrete.
3. In case of packing density method water cement ratio decreases with increase in grade of concrete.
4. The water and cement content for packing density and IS code method is nearly same for any particular grade of concrete.
5. The workability of concrete achieved is more in packing density method compared to IS code method for the same grade of concrete, as the water cement ratio is slightly higher in packing density method than IS code method.
6. The fine aggregate particles required are more in case of packing density method compared to IS code method. Therefore, water and cement required in case of packing density is more.
7. The fine aggregate and coarse aggregate 20 mm down size required is more in packing density method and coarse aggregate 10 mm down size required is more in IS method. But the cube compressive strength results at 7 days and 28 days curing age obtained by both the methods are nearly same.
8. Though the material quantities are different in both the methods, compressive strength achieved at 28 days by packing density and IS code methods are nearly same.

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