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Experimental Study of M20 Grade Concrete Using Packing Density Method

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ABSTRACT

Packing density method of mix design of concrete is new method to design different types of concrete. The mix design obtained from the packing density method has suitable workability, maximum packing density and minimum voids ratio. The geometrical characteristics like shape, size and proportion of fine aggregate and coarse aggregate affect packing density. The objective of this research is to study the mix designof concrete using packing density method and develop the correlation between bulk density, packing density and voids ratio. In this work large number of trail to decide the proportion of aggregate for that optimum bulk density and packing density calculated for different varying proportion of 20 mm: 12.5 mm coarse aggregate (i.e. 90:10, 80:20,70:30, 65:35, 60:40 and 50:50) and for varying proportion coarse aggregate: fine aggregate (i.e. 90:10, 80:20, 70:30, 60:40, 55:45 and 50:50). To finalize the mix design using packing density method also varies the percentage of excess cement paste (i.e. 5%, 7%, 9%, 10%, 11% and 12%). Tests were performed for the properties of fresh concrete like workability test (Slump cone) and hardened concrete like compressive strength, split-tensile strength, pull-out test, rebound hammer and flexural Test etc. tests were determined at 7, 14 and 28 days. The obtained results for above mentioned test using packing density method at 9% of excess cement paste are satisfying the standard results.

Key Words: Bulk Density, Excess of Cement Paste, Packing Density, Void Ratio.

1. INTRODUCTION

Concrete is the most used building material in the construction industry and has several advantages such as durability properties, low cost and high performance concrete. Concrete is made of cement, water, fine and coarse aggregate in proper proportions to satisfy the overall performance of the concrete. Thus, the aggregate mixing ratio provides the required workability, highest bulk density, highest compact density and lowest void ratio in the concrete. The above-mentioned parameter depends on the geographical characteristics of the aggregate, such as the size, shape and mixing percentage of fine and coarse aggregate. For the compact density method, also calculate the cement paste required to fill the voids in this aggregate to minimize voids and maximize compaction. Using the packing density method, fine and coarse aggregates ensure the necessary workability and minimize porosity, permeability and segregation. Excess cement paste has been shown to cause variation in workability, thereby affecting quality concrete. However, it should be noted that if the ratio of fine and coarse aggregate is different, the density and porosity ratio will become large..

2. LITERATURE SURVEY

Henry H. C. Wong & Albert K. H. Kwan et al **,** described that the packing characteristics of the cementitious materials have great influence on the performance of a concrete mix, but there is so far no generally accepted method of measurement. Herein, a new method, called the wet packing method, is developed. It mixes the cementitious materials with water and then measures the apparent density and voids content of the resulting mixture at varying water/cementitious materials ratio to characterize the packing behaviour of the cementitious materials **[1]**.

S.A.A.M. Fennis & J.C.Walraven et al described how centrifugal consolidation can be used to determine the packing density of powders. The method is assessed based on experimental data, calculations and polarization and fluorescence microscopy of the samples. An average maximum packing density can be measured, which depends on the initial water powder ratio, the use of super plasticizer, the mixing procedure of the paste and the applied compaction energy. Viscosity measurements show the influence of the particle packing density on water demand and how concrete mixtures can be designed to lower the cement content in concrete [2].

3. OBJECTIVE OF RESEARCH

The project work is to investigate the optimal materials and cost effectiveness in the design of M20 grade concrete. using the packing density method. The effect of the proportion of fine and coarse aggregate and the proportion of excess cement paste on the properties of fresh and hardened concrete. When choosing a concrete mix model, it is always advisable to pack the aggregates as closely as possible, ie. Maximum compaction. . This minimizes the amount of binder required to fill the voids between aggregates to ensure continued workability of the concrete. Apart from the obvious financial benefits, minimal binder in concrete results in less shrinkage, shrinkage and a denser, therefore probably more durable and stronger type of concrete. The aim of this work is to use optimal materials that improve various parameters of concrete.

4. RESEARCH METHODOLOGY

A) Materials

1) Cement - For this research, locally available ordinary Portland cement (53 grade) of Specific gravity of cement 3.15 was used throughout the work.
2) Physical Properties of Fine Aggregate - Locally available fine aggregate used was 4.75 mm size confirming to zone II with specific gravity 2.693. The testing of sand was conducted as per IS: 383-1970.
3) Physical Properties of Coarse Aggregate - Crush stone aggregate of size 20 mm and 12.5 mm was used throughout the experimental work. Coarse aggregate used was 20mm with specific gravity 2.912 and coarse aggregate of 12.5 mm with specific gravity 2.822. Testing of coarse aggregate was conducted as per IS: 383-1970.
4) Water - The water used was potable, colour less and odor less that is free from organic impurities of any type.

B) Concrete Mix Design

Mix design is process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible.

1) Determination of Aggregate Fraction
   It is calculated using the bulk density method, bulk density itis the ratio of solid mas to the bulk volume of water. The aim of obtaining maximum packing density the proportion offine and coarse aggregate was calculated by using bulk density of mix proportion.
2) Determination of Packing Density
   The packing density is the ratio of solid volume of aggregateparticles to the bulk volume occupied by the particle. It has been observed that when the bulk density is maximum the packing density also maximum.
3) Determination of Voids Content

It is the ratio of volume of voids between the aggregate particles to the bulk volume occupied by the aggregate. It has been observed that when the packing density is maximum thevoids content minimum and the required amount of binder will be less. The voids content is calculated as one minus thepacking density.

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Table 1: Mix Design of M20 Grade of Concrete usingPacking Density Method

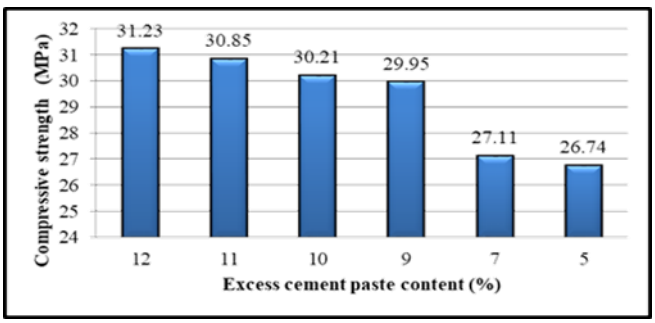
Excesscement paste content (%)	Water(lit.)	Cementkg/m^3	Fine Aggregate kg/m^3	Coarse aggregate 12.5 mmkg/m^3	Coarse aggregate 20 mm kg/m^3
5	188.61	342.94	789.34	355.20	827.63
		1	2.30	1.04	2.41
7	193.37	351.58	779.80	350.91	818.79
		1	2.22	1.00	2.33
9	197.17	358.50	773.07	347.88	811.72
		1	2.16	0.97	2.26
10	198.76	361.38	770.26	346.62	808.78
		1	2.13	0.96	2.24
11	200.34	364.24	767.46	345.35	805.83
		1	2.11	0.95	2.21
12	202.24	367.72	764.09	343.84	802.30
		1	2.08	0.94	2.18

5. RESULT AND DISCUSSION

Compressive Strength Test- A cube compression test is performed on standard cubes of size 150 x 150 x 150 mm after 7, 14 and 28 days of immersionin water for curing.

Table 2: Experimental Test Result for Compressive StrengthUsing Packing Density Method

Sr. No.	Excess cement pastecontent (%)	Compressive Strength (MPa)		
		7 Days	14 Days	28 Days
1	12	21.02	25.78	31.23
2	11	20.82	25.12	30.85
3	10	20.58	24.86	30.21
4	9	20.45	24.57	29.95
5	7	17.55	24	27.11
6	5	17.33	23.62	26.74



Graph 1 Compressive strength of concrete excess of cementpaste for 28 days

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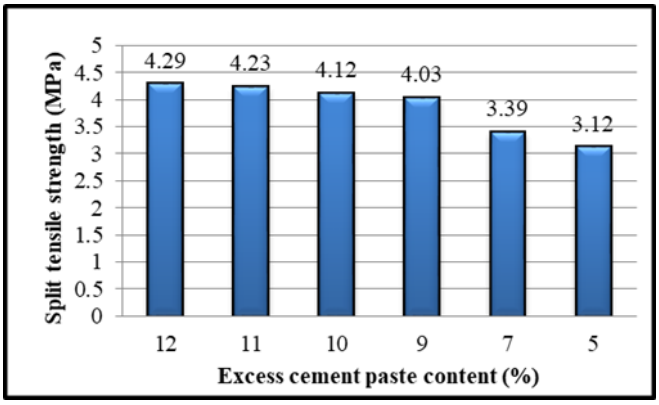
B) Split Tensile Test

The split tensile test is well known indirect test used to determine the tensile strength of concrete. Cylinder is tested after 28 days. Split tensile strength of cylinder specimens is determined by placing between the two plates of compressiontesting machine, iron strips of 3 mm thick, 25 mm wide and 300 mm long, were placed between the plates and surface ofthe concrete specimens.

Table 3: Experimental Test Results for Split TensileStrength (Packing Density Method)

Sr. No.	Excess cement paste content (%)	Split Tensile Strength (MPa)
1	12	4.29
2	11	4.23
3	10	4.12
4	9	4.03
5	7	3.39
6	5	3.12



Graph 2: Split Tensile Strength of Concrete Excess ofCement Paste for 28 Days

C) Pull Out Test - Specimens are prepared by filling the concrete of M20 gradein mould having internal dimensions 150 mm X 150mm X 150 mm and inserted the mild steel or TMT bar at the center of specimen. Specimens are cured for 28 days and tested in UTM. 3 cubes of each variation were casted for the conduction of test and cured for 28 days under water. Pull out test results obtained are given as follows:

Table 4: Test Results for Pull out Test

Sr. No.	Excess cement paste content (%)	Bond Strength (MPa)
1	12	1.88
2	11	1.81
3	10	1.72
4	9	1.67
5	7	1.49
6	5	1.32

It is clear from table 4, maximum bond Strength obtained forconcrete with 9% excess cement paste content is 1.67 MPa for 28 days.

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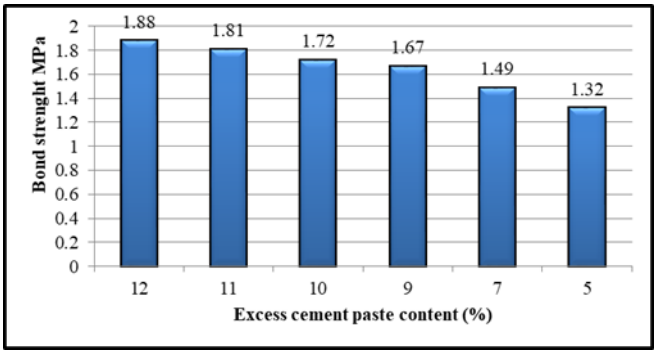

Graph 3: Bond Strength of Concrete Excess of Cement Pastefor 28 Days.

6. CONCLUSION

As the percentage of excess cement paste increases, the workability of the concrete increases. During this time, excess cement paste increases the volume of the cement gel, which can help improve workability, compact density and reduce the void ratio. Compressive strength and split tensile test were carried out using 1000 kN compression testing machine as per IS 516-1959. As the percentage of excess cement paste increases, the strength also increases. When the excess cement paste was 9%, it gives a compressive strength of about 20.45 N/mm2, 24.57 N/mm2, 29.95 N/mm2 at 7, 14 and 28 days respectively, and the cracking tensile strength after 28 days was about 4.03 N/mm2. Thus, it can be concluded that the optimum level of excess cement paste was 9%. The bond strength increases as the percentage of excess cement paste in the concrete increases, but decreases again at 1.32, 1.49, 1.67, 1.72, 1.81 and 1.88 MPa. Strength was observed at 5, 7, 9, 10, 11 and 12 MPa. % respectively. So we conclude that for M20 grade concrete, additional cement paste of 9% is required, keeping in mind economy, 9% additional cement paste gives satisfactory results.

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