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Influence of Grades of Cement on Strength of Concrete as per IS 10262-2019

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Abstract: ***Concrete is the most used material in the world for construction. As we know Cement is the major constituent of concrete which is produced by natural raw materials like limestone rock, clay and chalk etc. Cement is produced in various grades and types used for construction according to the requirement. According to various grades used the strength of the concrete is influenced. The present investigation deals with the development of mix design of concrete using the IS 10262 - 2019. The study mainly focuses on the discussion of strength characteristics of concrete when various grades of cements used with reduction of 5% & 10% to understand if the concrete reaches the required target strength. It also focuses on understanding as to which grade of cement would be able to reach the required strength with less cement content. Compression test and Split Tensile test were conducted for strength analysis. The research evaluates the variation in Mix Design Guidelines between IS 10262-2009 & IS 10262-2019; strength factors of hardened concrete, by using various grades of cement at different percentages for M30 grade concrete at different ages. From this study it can be concluded that, 53 grade gives the better compressive strength with lesser amount of cement content, hence it is suggested that 53 grade cement can be used wherever bulk or mass concreting is done or concrete is produced***

Keywords: Mix Design, Concrete, Cement, OPC 53, OPC 43, PPC, Compressive Strength, Split-Tensile Strength.

I. INTRODUCTION

Any material or substance used to construct any type of structure is referred to as a building material. The construction business uses a variety of materials for construction. Depending on their structural capacities, we use various materials. Building materials used in construction are governed by regional and national standards. Architects, on the other hand, select building materials based on cost & beauty. By selecting the best material for the project, it may improve and extend its lifespan.

One of the most common building materials utilised globally is concrete. Its main benefit is that, because it is a manmade substance, one may pour it into moulds of any shape before setting, eliminating the need to carve the material as is necessary with stone. Another benefit is that its characteristics can be significantly customised to fit various situations. Cement, Coarse Aggregate (range of 5 - 20 mm), Fine Aggregate, and Water are the essential components of concrete. Only the cement, which makes up around 15% of the total weight of the concrete and is utilised in very tiny amounts compared to the sand and gravel, is an element that is produced industrially.

Compared to steel, concrete is therefore a less expensive building material. The quality of the component materials and the proportions used in the mix, however, determine the quality of the concrete that is created; the characteristic strength of the concrete decreases with increasing sand content in clay and silt.

A. Cement

There are various types of cement are used for various purposes in construction depending on the environmental condition of the region.

Here in our research we are using:

1) Ordinary Portland Cement

- 43 grade OPC
- 53 grade OPC

2) Portland Pozzolana Cement

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B. Cement Consumption

India ranks second in the world in terms of cement production and consumption, the real estate market is booming and the government is investing heavily in urban infrastructure and smart cities. According to CLSA (Credit Lyonnais Securities Asia), demand for cement in India has increased.

1) The company identifies ACC, Dalmia and Ultratech Cement as key partners. Indian cement companies recorded a significant increase in profitability and industrial demand

2) The company identifies ACC, Dalmia and Ultratech Cement as key partners. Indian cement companies recorded a significant increase in profitability and industrial demand in the second quarter of FY21 as a result of the recovery in the rural economy.

3) With rural markets returning to normal, the demand picture remains encouraging.

4) For fiscal 2021, CLSA (Credit Lyonnais Securities Asia) expects 14% growth in EBITDA (earnings before interest, tax, depreciation and amortization) for its cement-merged companies.

5) In the wake of the COVID-19 pandemic, infrastructure and real estate industries are expected to expand, leading to increased demand for cement in 2021. The industry is expected to increase cement production capacity by 8 million metric tons annually.

6) Demand from road construction, urban infrastructure and commercial real estate is expected to drive cement production in India between FY2016-22 at a compound annual growth rate (CAGR) of 5.65%. Cement consumption in India is expected to grow at a compound annual growth rate of 5.68% from FY16 to FY22.

7) Cement production increased to 329 million metric tonnes in FY20 and is expected to increase to 381 million tonnes in FY22.

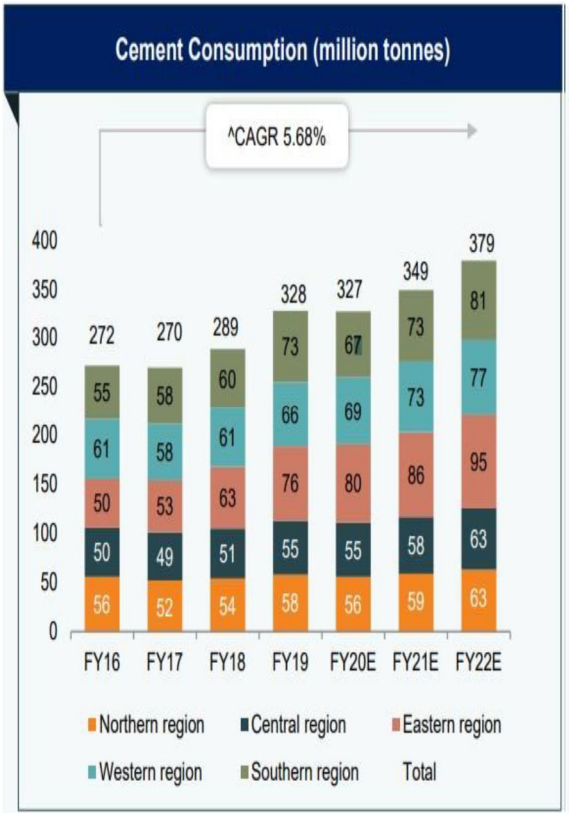


Fig 1 Cement Consumption in India [12]

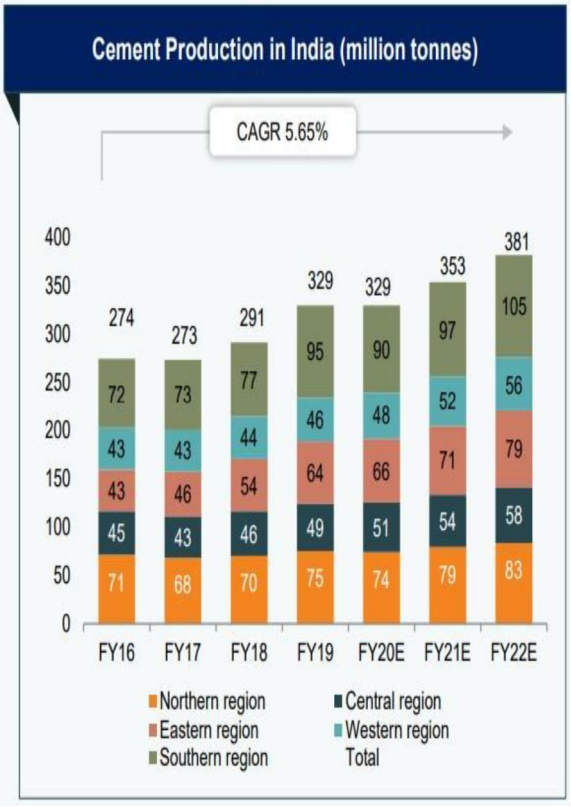


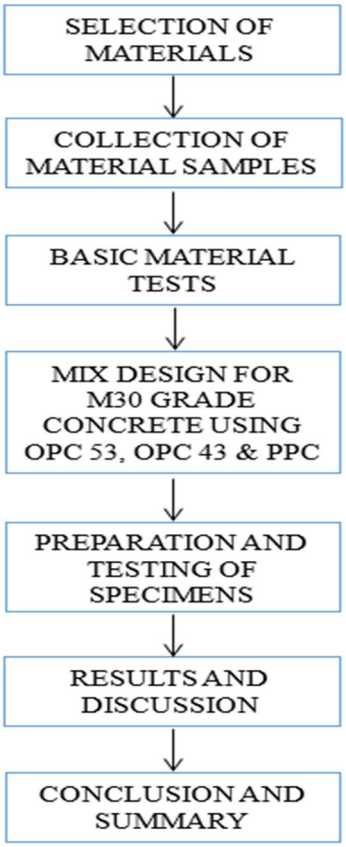
Fig 2 Cement Production in India[12]

II. METHODOLOGY

This chapter deals with the methodology followed to carry out the study. It consists of detailed experimental work carried out in the characterization of materials like cement, water, super plasticizer, fine aggregate, coarse aggregates, are characterized through a series of physical tests.

After the testing of materials, the next step is to go about preparing the specimens. Mix design is done as per IS 10262:2019 to obtain mix proportion such that the targeted compressive strength is achieved. Cubes & cylinders are casted.

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A. Basic Material Tests

The following tests are conducted on the materials to understand its properties:

1) Cement

- Initial setting time
- Final setting time
- Specific gravity

2) Fine aggregates

- Specific gravity
- Water absorption
- Moisture Content

3) Coarse Aggregates And Recycled Tile Aggregate

- Specific gravity
- Water absorption

a) Basic Properties of Cement

Table 1 Details of Tests Conducted on Cement

Description	Results
Specific Gravity	3.0
Initial Setting Time in min	30
Final Setting Time in min	540

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b) Basic Properties of Fine Aggregate

Table 2 Details of Tests Conducted on Fine Aggregate

Description	Results
Specific gravity	2.76
Moisture Content	1.63%
Water absorption (%)	3.6%

c) Basic Properties of Coarse Aggregate

Table 2 Details of Tests Conducted on Coarse Aggregate

Description	Results
Specific gravity	2.64
Bulk density (kg/m)	1540
Water absorption (%)	1.36

B. Specimen Preparation

1) Mix Proportions

Four different mixes including one control mix were wont to examine the influence of adding WCT as coarse aggregates on the properties of concrete. The combination was designed as per Indian standard code IS 10262: 2019. For details of the combination, design refer Annexure.

The control mix (CM) for OPC 43, OPC 53 & PPC features a proportion of 1 (Cement): 2.26 (Fine aggregate): 3.05 (Coarse aggregate) for a targeted strength of 38 MPa. The main points of the mixes are given in Table 3.

Table 3 Details of Mix Proportions

Sl.No	Grade of Cement	Specimen Designation	Cement (Kg)	Coarse Aggregate (Kg)		Fine Aggregate (Kg)	Water (Kg)
				20 mm	12 mm		
1	OPC 53	CM	351	641	427	791	158
		Red by 5%	333.5	641	427	791	158
		Red by 10%	316	641	427	791	158
2	OPC 43	CM	351	641	427	791	158
		Red by 5%	333.5	641	427	791	158
		Red by 10%	316	641	427	791	158
3	PPC	CM	351	641	427	791	158
		Red by 5%	333.5	641	427	791	158
		Red by 10%	316	641	427	791	158

2) Casting

For each mix, cubes of 150mm in size, cylinders of 150mm diameter and 300mm height conforming to IS: 10086-1982 were casted.

Table 4 Details of Total Moulds Casted

Cubes	81
Cylinders	81

III. RESULTS

Test Results of Compressive Strength & Split-Tensile Strength of various grades of cement are given.

A. Compressive Strength Test

Table 5 Compressive Strength Results for M30 Grade Using OPC 53, 43 & PPC

Grade		7 DAYS	AVERAGE	14 DAYS	AVERAGE	28 DAYS	AVERAGE
OPC 53	CM (Strength In N/mm^2)	27.56	27.36	35.64	35.02	40.00	40.16
		28.13		34.53		37.78	
		26.40		34.89		42.27	
	5% RED (Strength In N/mm^2)	27.02	26.43	34.04	33.20	39.29	39.04
		25.78		32.44		37.16	
		26.49		33.11		40.67	
	10% RED (Strength In N/mm^2)	26.87	26.04	32.56	32.58	38.72	38.83
		25.97		33.25		39.53	
		25.58		31.93		38.26	
OPC 43	CM (Strength In N/mm^2)	26. 03	25.92	34.43	34.67	39.63	38.99
		26. 12		35.57		38.21	
		25.61		34.01		39.15	
	5% RED (Strength In N/mm^2)	25.61	25.44	32.01	31.91	37.31	37.64
		25.21		32.20		37.97	
		25.52		31.53		37.66	
	10% RED (Strength In N/mm^2)	25.19	25.14	32.03	31.49	36.21	36.59
		25.22		31.35		36.64	
		25.02		31.09		36.93	
PPC	CM (Strength In N/mm^2)	26.32	26.62	34.73	34.96	40.09	39.71
		27.03		35.43		38.67	
		26.51		34.71		40.37	
	5% RED (Strength In N/mm^2)	26.02	25.98	32.97	32.81	37.51	38.48
		25.83		32.12		39.26	
		26.09		33.36		38.67	
	10% RED (Strength In N/mm^2)	26.11	25.49	32.02	32.25	36.21	37.26
		25.17		32.69		38.35	
		25.20		32.04		37.24	

The variation of compressive strength at 7 days is shown in Fig. 3.

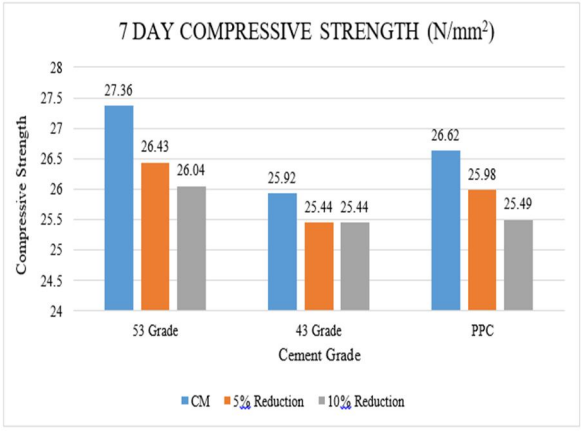


Fig 3 Variation in Compressive Strength at 7 Days

The variation of compressive strength at 14 days is shown in Fig. 4.

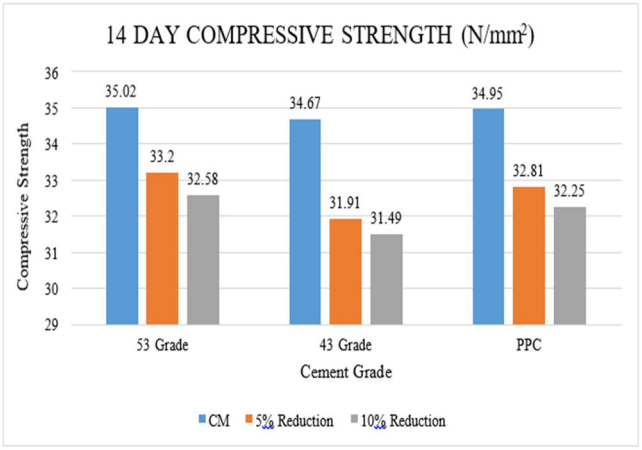


Fig 4 Variation in Compressive Strength at 14 Days

The variation of compressive strength at 28 days is shown in Fig. 5.

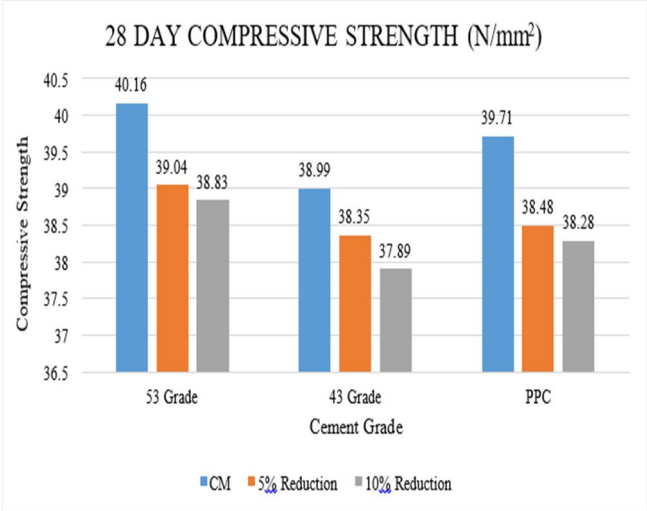


Fig 5 Variation in Compressive Strength at 28 Days

B. Split-Tensile Strength Test

Table 6 Split-Tensile Strength Results for M30 Grade Using OPC 53, 43 & PPC

			7 DAYS	14 DAYS	28 DAYS
OPC 53 GRADE	CM	N/mm^2	2.12	2.56	3.02
	5% REDUCTION		2.07	2.49	2.91
	10% REDUCTION		2.02	2.42	2.89
OPC 43 GRADE	CM	N/mm^2	2.04	2.41	2.91
	5% REDUCTION		1.96	2.29	2.81
	10% REDUCTION		1.92	2.18	2.63
PPC	CM	N/mm^2	2.06	2.46	2.98
	5% REDUCTION		2.01	2.35	2.85
	10% REDUCTION		1.98	2.30	2.72

The variation of split-tensile strength at 7 days is shown in Fig. 6.

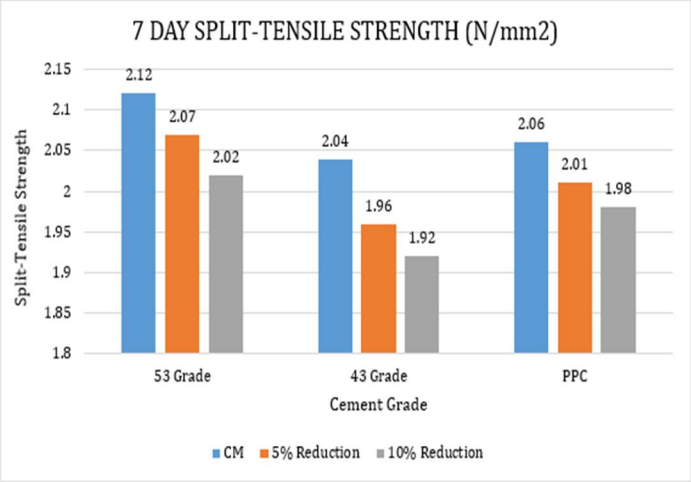


Fig 6 Variation in Split-Tensile Strength at 7 Days

The variation of split-tensile strength at 14 days is shown in Fig. 7.

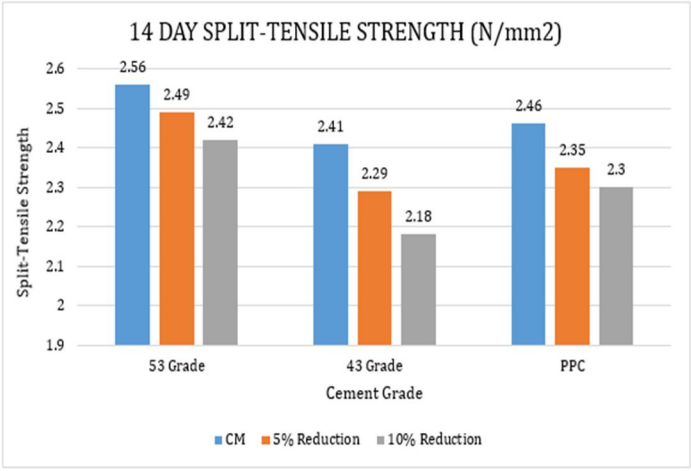


Fig 7 Variation in Split-Tensile Strength at 14 Days

The variation of split-tensile strength at 28 days is shown in Fig. 8.

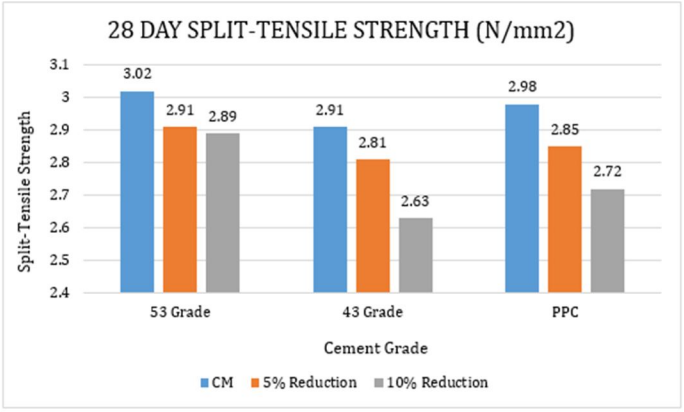


Fig 8 Variation in Split-Tensile Strength at 28 Days

C. Comparative Study on Variation for Normal Concrete and Variation in Cement Content for Various Grades of Cement

1) Comparative Study On Variation in Compressive Strength for Normal Concrete

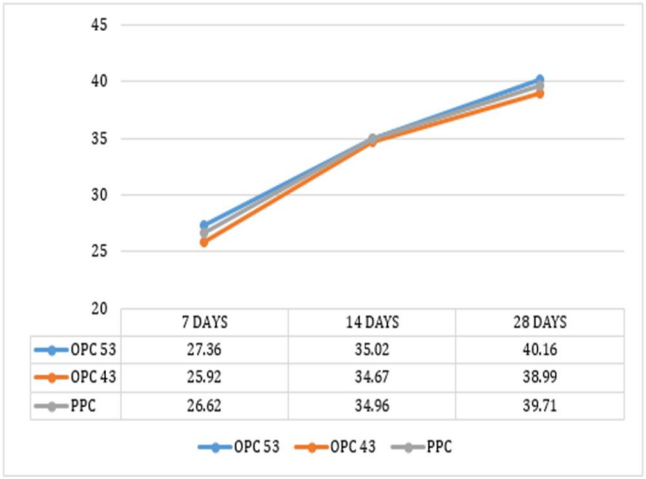


Fig 9 Comparative Study On Variation in Compressive Strength for Normal Concrete

2) Comparative Study On Variation in Compressive Strength for Concrete with 5% Reduction in Cement

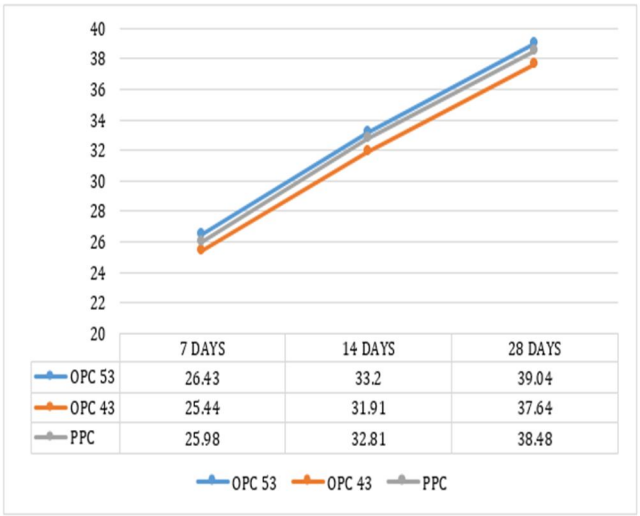


Fig 10 Comparative Study On Variation in Compressive Strength for Concrete with 5% Reduction in Cement

3) Comparative Study On Variation in Compressive Strength for Concrete with 10% Reduction in Cement

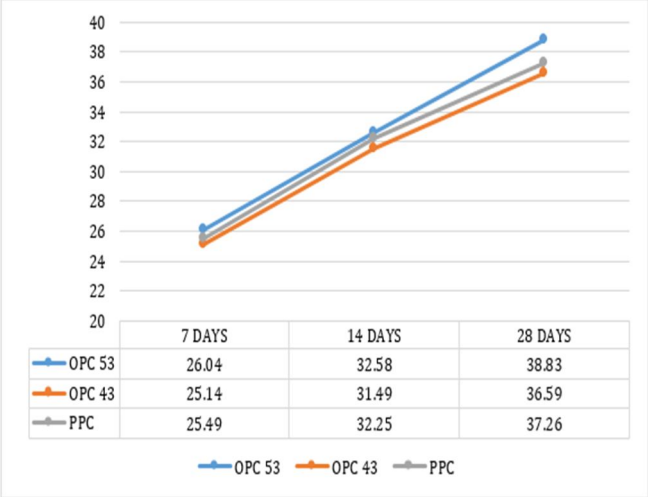


Fig 11 Comparative Study On Variation in Compressive Strength for Concrete with 10% Reduction in Cement

IV. CONCLUSION

In summary this report documents the variation in Mix Design between IS 10262-2009 & IS 10262-2019. It also documents the strength of concrete and its variations when various grades of cement are used in various proportions. The strength parameters whose variations was reported were compressive strength and split-tensile strength. After studying the compressive strength value of specimen consisting of assorted grades of cement having different percentages and curing it for 7, 14, 28 days it is concluded that:

1) By adding a replacement factor supported the grade of the concrete, the formula for the target mean strength for mix proportioning has been improved. it had been done to form sure there was a minimum margin between the required mean strength and therefore the characteristic compressive strength.

2) In place of the basic assumption regarding the water-cement ratio, a graph of W/C vs. 28-day concrete strength was introduced, accounting for various cement types and grades.

3) The concept of air content was once again incorporated into the formulation of the typical concrete mix proportion.

4) The early strength obtained in concrete consisting OPC 53 is up to 70% (7 days) which is approximately 3% and 2% more than that of OPC 43 and PPC respectively.

5) It can be observed that in OPC 53 achieves the required target mean strength i.e. 38 MPa in the control mic and even after 5% and 10% reduction of cement.

6) In PPC it is observed that the target mean strength is achieved in control mix and only in 5% reduction of cement but when it is reduced by 10% it is observed that the strength achieved is less than the target strength.

7) In OPC 43 it is observed that the target strength is only achieved in the control mix.

8) The split-tensile strength shows a substantial decrease in the different grades used for all the days (7,14 & 28 days).

9) As per current work done it can be said that 53 grade gives the better compressive strength with lesser amount of cement content, hence it is suggested that 53 grade cement can be used wherever bulk or mass concreting is done or concrete is produced

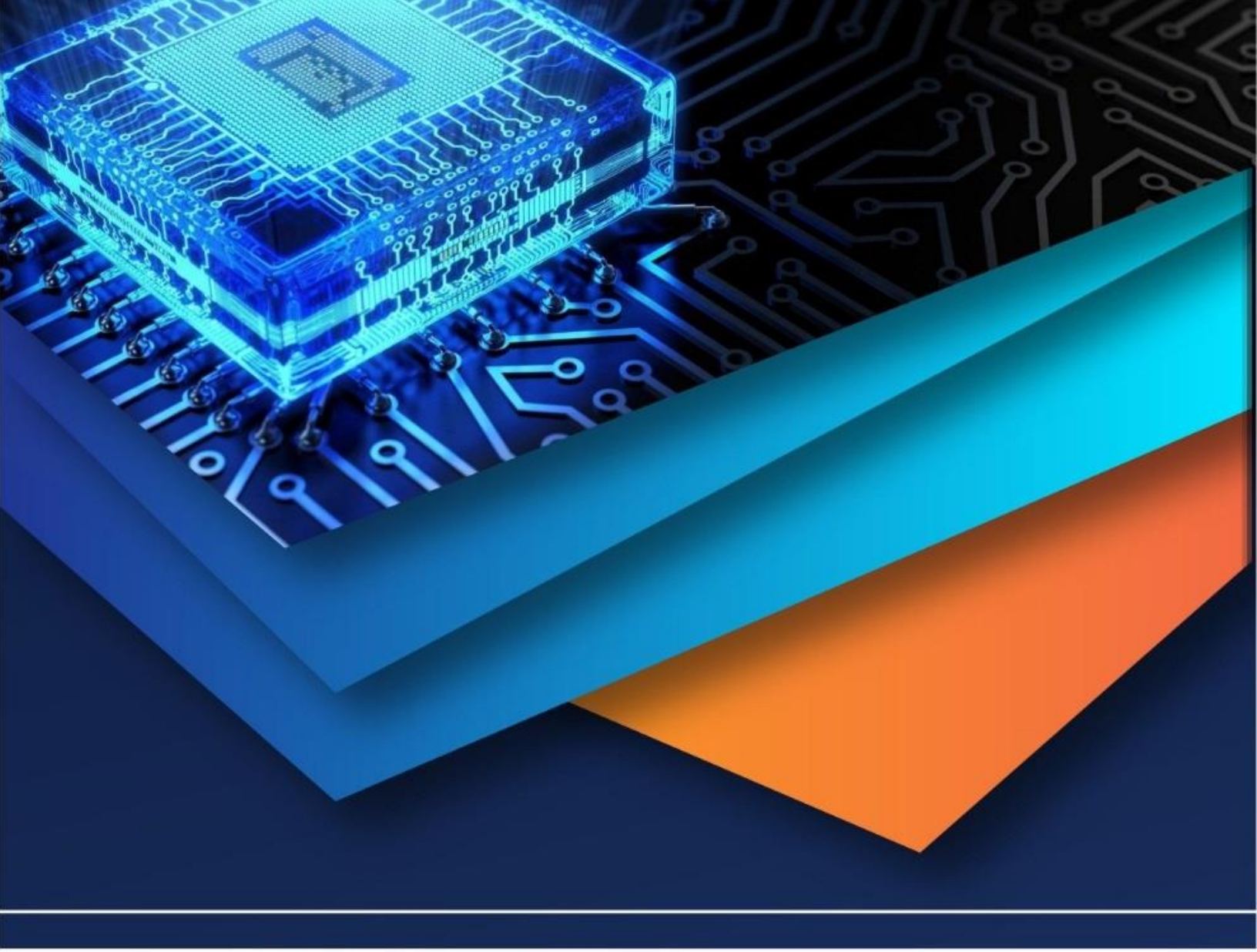
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