iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** II **Month of publication:** February 2020

DOI: http://doi.org/10.22214/ijraset.2020.2045

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 8 Issue II Feb 2020- Available at www.ijraset.com

Development and Experimental Investigations on the Performance of High Strength Concrete by Adding Admixture as Nano ZrB_2 for Thermal Shielding Applications

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Abstract: ***The concrete shows different properties with aggregates with their respective proportions of mix. Many investigations and improvements were done to get high strength and durability, which implies to upgrade the physical and mechanical properties of concrete. Additionally by experimental, using admixtures as Nano particles (ZrB_2) is added to implement the compressive strength. Experiment was carried out on concrete cubes of standard sizes with addition of various percentages i.e., 0%,1%,1.25%,1.5% and 2% by weight of cement, fine and coarse aggregate and results were obtained. The present study carried out on M60 grade of plain cement concrete and different percentages of Zirconium diboride (ZrB_2) nanoparticles with the diameter of 30-50 nm were used in different contents by weight of cement of 0%,1%,1.25%,1.5% and 2%.Consequently we got results shows that the better changes in mechanical properties of concrete.It is concluded that partial replacement of cement with nanophase ZrB_2 particles improves the compressive strength, split tensile strength and flexure strength of concrete compare with the plain concrete.***

I. INTRODUCTION

Concrete is the most important of all the construction and development activities around the world. The most important ingredient of ordinary concrete is Ordinary Portland Cement. Concrete as a construction material are grouped as usual concrete or high strength concrete based on its compressive strength. For Thermal exposed Structures, where the building materials are subjecting to the high temperature as well as mechanical loads. As per the literature, it is found that the heat effects are can significantly alter the mechanical strengths of the materials. To overcome this, high strength concretes are mixed with thermal insulating materials in nanoscale without compromising the strengths.

Concrete is typically categorized as Normal strength concrete (NSC), high strength concrete (HSC) and ultra high strength concrete (UHSC). The other constituents are water and both fine and coarse aggregate. Binders are made from Portland 'clinker' ground simultaneously with a little calcium sulphate and generally also include fine mineral powders such as limestone, fly ash, pozzolona, and granulated blast furnace slag To change the properties of a concrete for definite applications, the chemical admixtures such as super-plasticizers and air entrancing agents can be added in lesser quantities. The role of Nano ZrB_2 in increasing the mechanical properties of cement has been carried out by few researchers. The optimized level of Nanoparticles to attain the ultimate strength was reported.

The flexural strength of fresh concrete was increased by increasing the amount of ZrB_2 particles. The setting time of fresh concrete was decreased by increasing the amount of ZrB_2 particles. It is terminated that fractional replacement of cement with ZrB_2 particles, enhances the Split tensile and flexural strength of cement but diminishes its setting time. The details and features of materials that were used in this research are discussed on Combined application of Zirconium diboride.

II. MATERIALS AND TEST METHODS

The following materials were used for making concrete mix.

A. JSW cement of 53 grade.
B. Fine aggregate.
C. Coarse aggregate.
D. Nano ZrB_2.
E. Super plasticizers SP430.
F. Water.

1) *Cement:* The crude materials recommended for manufacturing the Portland cement are calcareous materials as like limestone or chalk, and argillaceous material such as shale or clay. There are two cases stated as wet and dry courses subject to either the mixing and pulverizing of raw materials is executed in wet or dry condition. The raw materials used in the production of cement contains usually of lime, Silica, alumina and iron oxide. Such oxides collaborate mutually to design greatly complex composites in the kiln up to the high temperature.
2) *Fine Aggregate:* Fine aggregates are initially sands earned from the land or marine environment. Fine aggregates highly consist of natural sand or crushed stone with most particles passing through a 4.75mm sieve. The fine aggregate used in this study is river sand which is gained from local company.
3) *Coarse Aggregate:* The shape and size of coarse aggregates is very crucial as it many times governs both fresh properties as well as the long term properties of concrete. Size of these aggregates varies from 4.75mm to 80mm. For normal concrete works we use below 40mm size of coarse aggregate.
4) *Nano ZrB_2:* The role of ZrB_2 in increasing the mechanical properties of cement has been carried out by few researchers. The optimized level of particles to attain the ultimate strength was reported.In the present research ,the Compressive strength, Split tensile strength& Flexure strength of concrete with various amounts of Zirconium Diboride Powder (% wt of cement) having standard particle size of 30-50nm were partially added to cement paste (Portland cement together superplasticizer) and the Compressive strength of the specimens has been calculated. The results show that ZrB_2 particles are adequate to increase Compressive strength of concrete upto certain percentage of quantity. ZrB_2 particles as a partial replacement of cement up to 2%wt could accelerate C-S-H gel generation as a result of increased amount of crystalline calcium hydroxide at initial age of hydration. The increased zirconium diboride particles content of more than 2%wt leads to reduced Compressive strength because of unsuitable dispersion of ZrB_2 particles in concrete mix.The increased nano particles zirconium diboride content of more than 4%wt leads to reduced Compressive strength because of unsuitable dispersion of microparticles in concrete mix.

a) *Details Of Tests:* The following tests are performed on concrete blocks,

i) Workability
ii) Compressive strength

Three cubes (150x150x150mm) for each mix were casted and tested for compressive strength for 3, 7 and 28 days. After casting specimens were tested with the machine.

5) *Superplasticizer:* The function of superplasticizer is proficient for manufacture of flowing, self levelling, self compacting and for the formation of high strength and high performance concrete.

III. TESTING PROCEDURE

A. Mixing

Mixing process was prepared in two stages by pan mixing. Firstly, cement, nano ZrB_2, fine aggregates, coarse aggregates of 12mm and 20mm, and binder were mixed together in concrete mixer for 2.5 minutes. At the end of the dry mixing, a well-shaked super-plasticier SP430 and water added in the concrete mixer and the wet mixing was continued for another 3 minutes. To ensure good homogeneity in the mix fresh concrete was mixed for another 2 minutes. Hence the mix is prepared for casting.

B. Curing

The specimens were demoulded after 24 to 48 hours of casting and were kept submerged in a clean water tank for curing. After 3, 7 and 28 days of curing the specimens were taken out of water and were permitted to dry under shade for few hours.

C. Workability

1) *Slump Cone Test:* Vertical settlement of a standard cone of fresh concrete (actually frustum of a cone) under its own weight is called slump. The cone of concrete in a slump test may sometimes fail in shear, thus casting doubts on the stability of the concrete system. Lack of stability is termed as segregation. Slump cone values for different mix proportions are following.Your paper must use a page size corresponding to A4 which is 210mm (8.27") wide and 297mm (11.69") long. The margins must be set as follows:

Slump cone test results different mix proportions.

Mixed ratio	Mix notation	Slump cone values in cm
M_{60}	*M0*	*10.5*
M_{60}+- ZrB_2 1.0%	*M1*	*7.3*
M_{60}+- ZrB_2 1.25%	*M2*	*6.2*
M_{60}+- ZrB_2 1.5%	*M3*	*5.5*
M_{60}+- ZrB_2 1.75%	*M4*	*4.8*
M_{60}+- ZrB_2 2.0%	*M5*	*3.9*

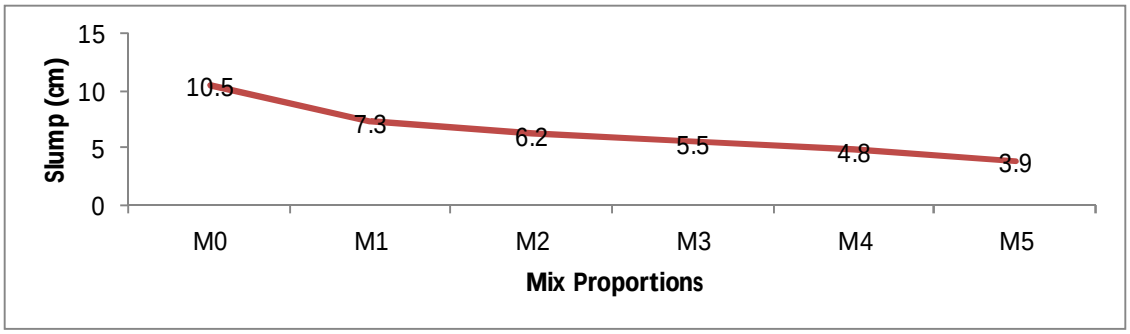
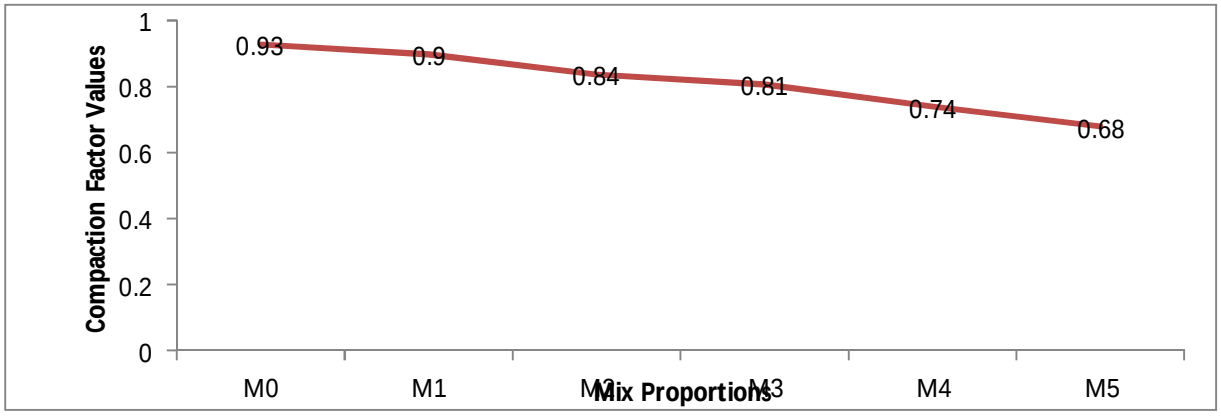


Fig 5.3: Graph for Percentage of ZrB_2 particles replacement with cement Vs slump

2) *Compaction Factor Test:* Compaction factor is a measure of the density of concrete to which a fresh blended concrete can be compacted for a standard input of energy respective to the theoretical maximum density it can have relating to zero air content. This theoretical maximum density can be calculated in the laboratory as that concluded by full of compatibility of freshconcrete.

Compacting factor values for different mix proportions

Mixed ratio	Mix notations	Compacting factor values
M_{60}	M0	0.93
M_{60}+ - ZrB_2 1%	M1	0.90
M_{60}+ - ZrB_2 1.25%	M2	0.84
M_{60}+- ZrB_2 1.5%	M3	0.81
M_{60}+ - ZrB_2 1.75%	M4	0.74
M_{60}+ - ZrB_2 2%	M5	0.68

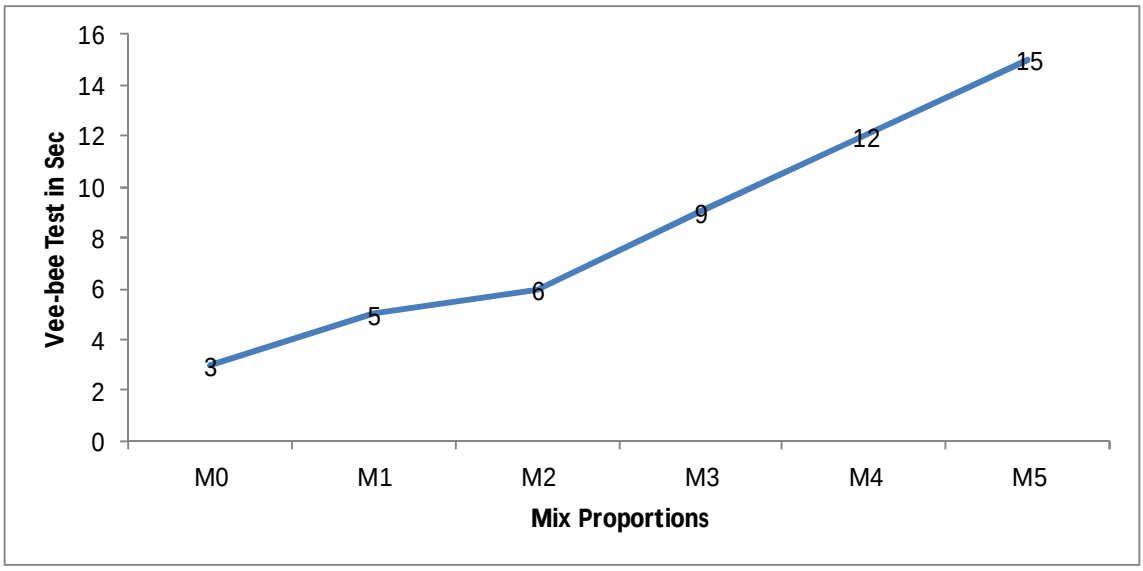


Graph for Percentage of ZrB_2 particles replacement with cement Vs compaction factor

3) Vee-bee Test: Vee bee test is executed to know the consistency of concrete. In this test Vee bee consistometer utilized to find out the time desirable to force the fresh concrete to flow to a standardized extent is called the Vee bee time. It is measure of the mobility of the fresh concrete.

Vee bee time in sec

Mixed ratio	Mix notations	Vee-bee time in (sec)
M_{60}	*M0*	*3*
M_{60}+ - ZrB_2 1.0%	*M1*	*5*
M_{60}+ - ZrB_2 1.25%	*M2*	*6*
M_{60}+- ZrB_2 1.5%	*M3*	*8*
M_{60}+ - ZrB_2 1.75%	M4	12
M_{60}+ - ZrB_2 2%	M5	15



Graph for Percentage of ZrB_2 particles replacement with cement Vs Vee bee in sec

IV. RESULTS AND DISCUSSION

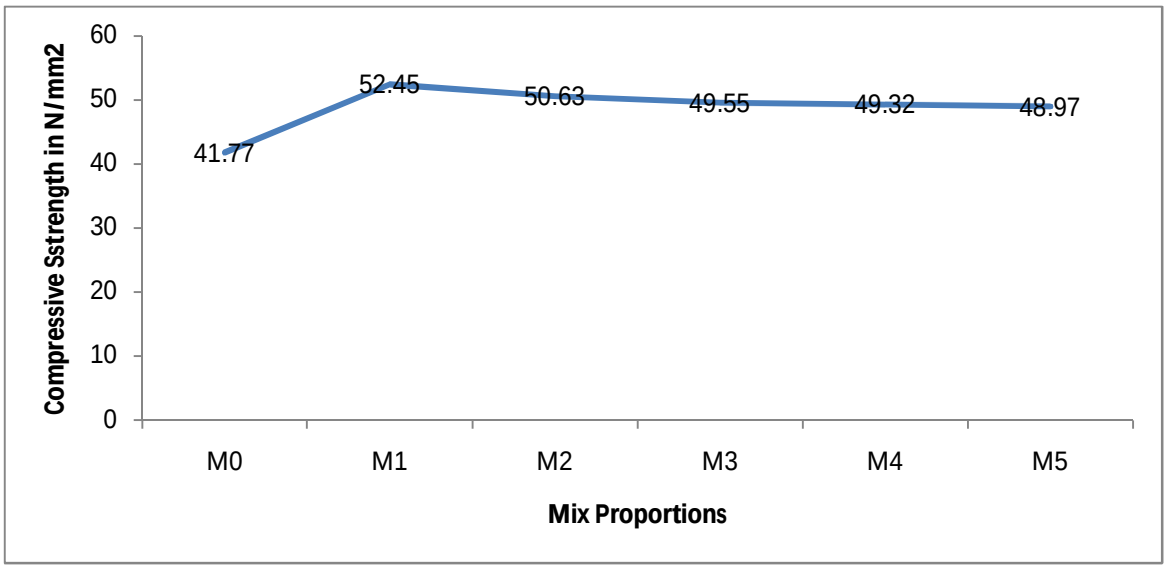
A. Compressive Strength

For designers, Compressive strength is one of the most important engineering properties of concrete. It is a standard industrial practice that the concrete is classified based on grades. This grade is nothing but the Compressive Strength of the concrete cube.

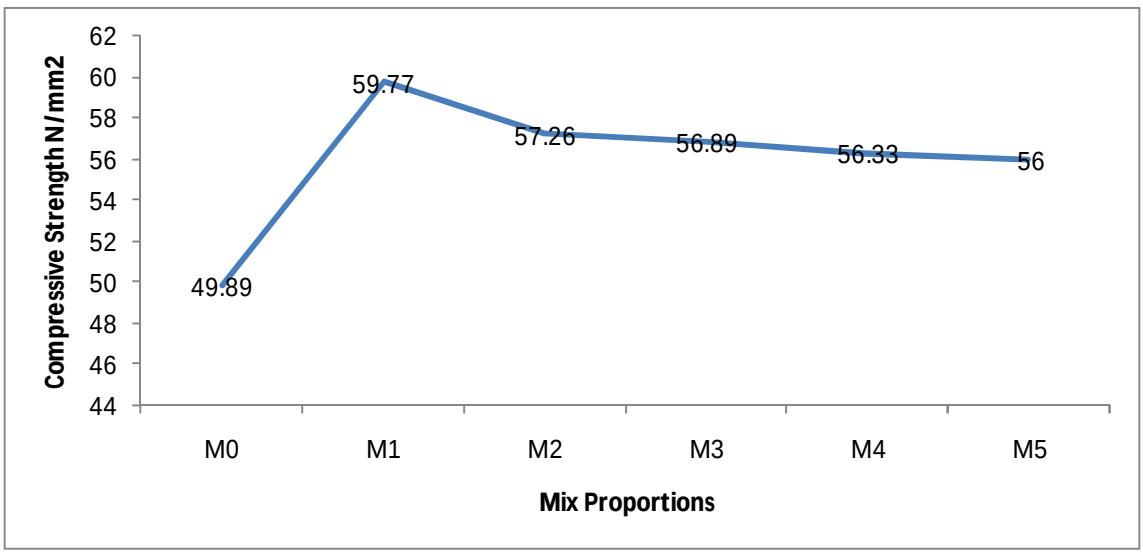
Cube samples are basically tested under a Compression testing machine to acqiure the Compressive strength of concrete. The test requirements differ country to country based on the design code. According to Indian codes, Compressive strength of concrete is defined as the Compressive strength of concrete is given in terms of the characteristic Compressive strength of 150 mm x 150 mm size cubes tested at 28 days (fck). The characteristic strength is defined as the strength of the concrete below which not more than 5% of the test results are expected to fall. All the concrete specimens were tested in a 3000KN capacity automatic Compression testing machine with 0.5KN/sec rate of loading until the specimens are crushed. Concrete cubes of size 150mm x150mm x150mm and cylinders of size 150mm diameter x300mm height are tested for crushing strength. The displacements were automatically recorded through 3000KN digital Compression testing machine. The maximum load applied to the specimens has been noted and dividing the failure load by the area of the specimen, the Compressive strength has been determined.

Compressive strength =load/Area in N/mm2

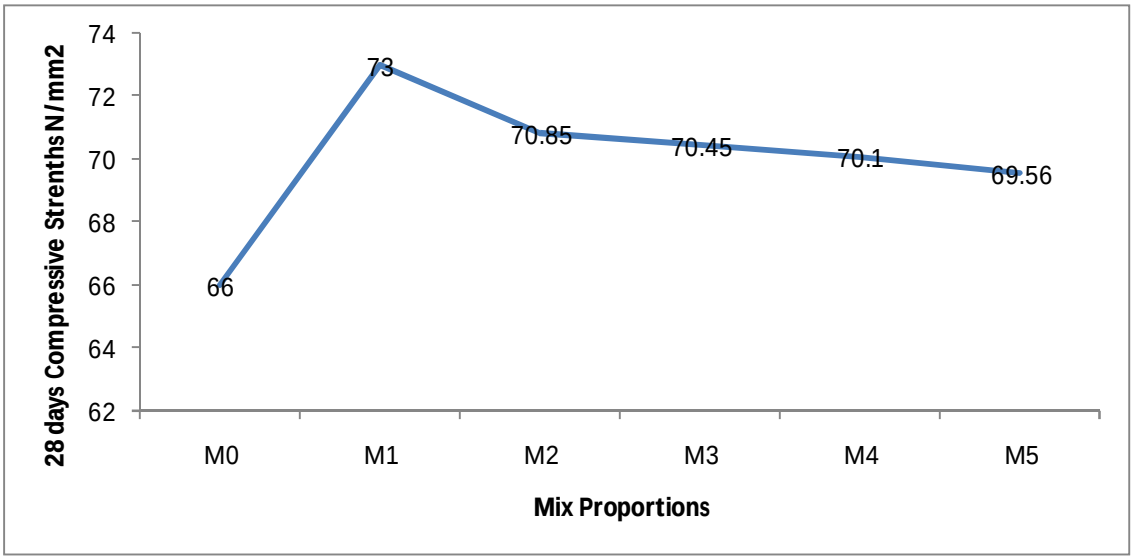
S.No	Mixed design M60 with Zirconium Diboride particles	Mix notations	Percentage of Zirconium Diboride particles.	Compressive strength for cubes in N/mm^2		
				3 days	7days	28days
1	M_{60}	M0	0	41.77	49.89	66
2	M_{60}+- ZrB_2 1.0%	M1	1	52.45	59.77	73
3	M_{60}+ - ZrB_2 1.25%	M2	1.25	50.63	57.26	70.85
4	M_{60}+ - ZrB_2 1.5%	M3	1.5	49.55	56.89	70.45
5	M_{60}+ - ZrB_2 1.75%	M4	1.75	49.32	56.33	70.10
6	M_{60}+ - ZrB_2 2.0%	M5	2.0	48.97	56	69.56



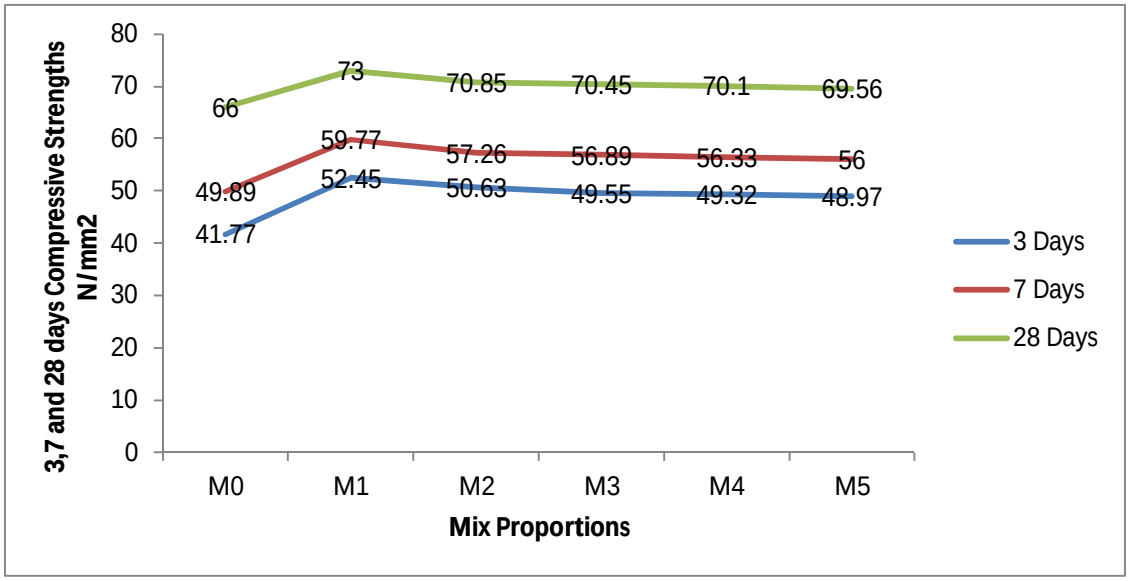
Graph for Percentage of ZrB_2 particles replacement with cement Vs 3days Compressive strength



Graph for Percentage of ZrB_2 particles replacement with cement Vs 7days Compressive strength



Graph for Percentage of ZrB_2 particles replacement with cement Vs 28days Compressive strength



Superimposed line graph for periods of 3,7 and 28 days of percentage of ZrB_2 particles replacement with cement Vs Compressive strength

V. CONCLUSION

A. I concluded that the workability of concrete is lowered by increasing the ZrB_2 particles of 0%, 1.0%,1.25%,1.5%, 1.75%and 2.0% of weight of cement.

B. Nano ZrB_2 is also increases the strength properties to the concrete.

C. Hence the test performed it is examined that great increase in the properties of concrete.

D. The results shows that the different proportions of -ZrB_2 0%,1.0%,1.25%,1.5%, 1.75% and 2.0% gives the higher Compressive strength compare to the plain concrete.

E. It is well examined that maximum strength gained at 2.0% of Nano ZrB_2 .

F. Zirconium diboride (ZrB_2) is a highly covalent refractory ceramic material with a hexagonal crystal structure with melting point of 3246 °C and good high temperature strength makes it a candidate for high temperature aerospace applications such as Nuclear plant walls, shielding for higher energy explosions and rocket launch pads systems.

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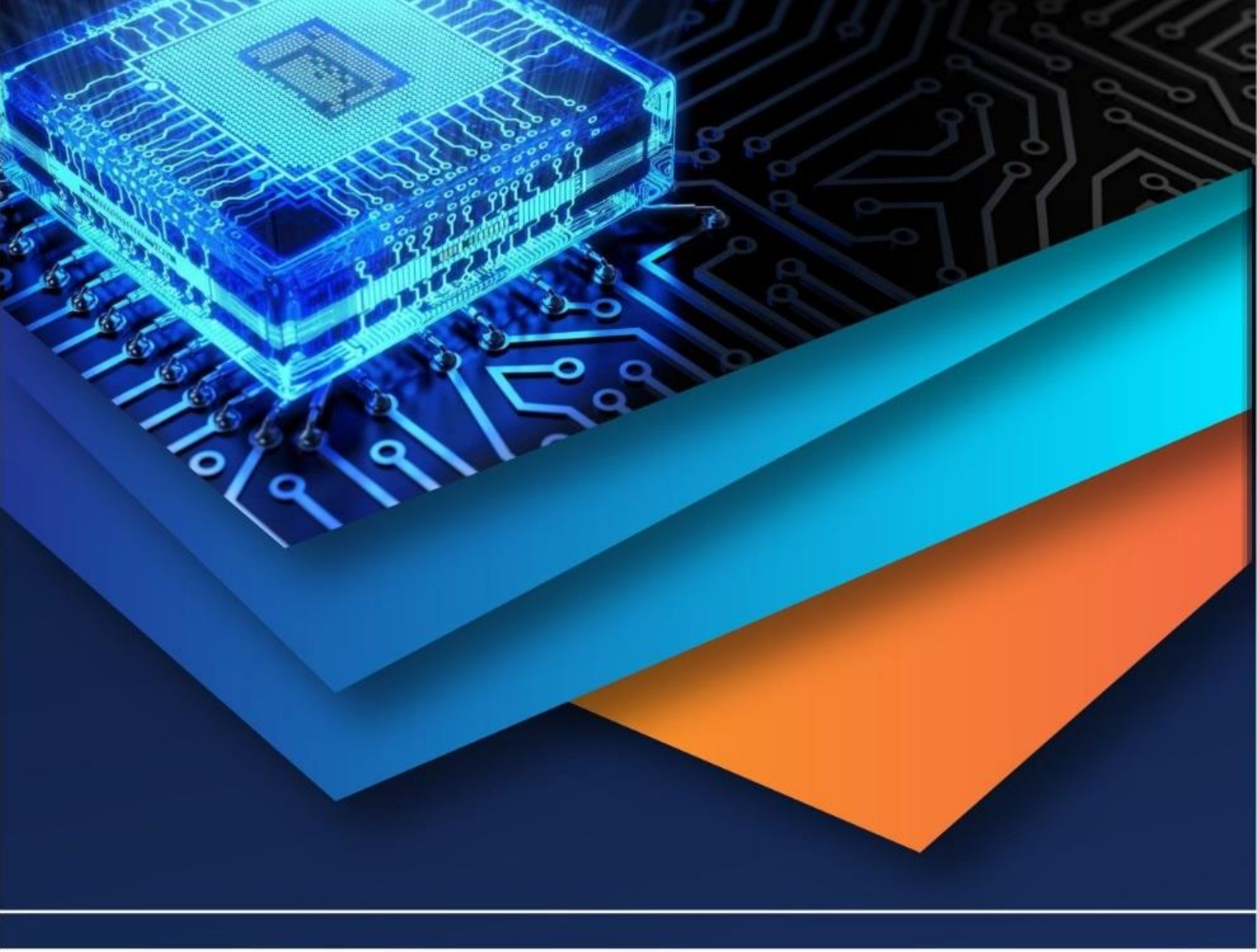

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