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An Experimental Study On Ternary Blended Polypropylene Fiber Reinforced Concrete

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ABSTRACT

Concrete has been extensively used in construction for many years especially. Cement, fine aggregate, coarse aggregate, admixtures, and water are all used to make concrete. Cement manufacture requires very high temperatures and the release of pollutant gases such as CO_2 and NO. The introduction of greenhouse gases, such as CO_2, into the atmosphere cause environmental issues such as global warming and climate change. This form of problem is solved by replacing concrete with various alternative materials. Due to its great tensile strength and density, dolomite powder is utilized in building.. The use Dolomite Powder to partly substitute cement by 5%, 10%, and 15% based on cement weight. Rice husk ash has a high concentration of amorphous silica, which is used as a substitute cementing element in concrete due to its pozzolanic reactivity. It has environmental, economic, and technical benefits when used in concrete. The use RHA to partly substitute cement by 9% by weight of cement. Polypropylene fiber reinforced concrete is stronger than regular concrete and has reduced cracks due to shrinkage. Polypropylene fiber was incorporated into concrete in the following proportions: 0%, 0.15%, 0.30% and 0.45% by the volume of concrete. This investigation was carried out on M_{20} concrete grade. strength parameters, concrete grade for each proportion, cubes, prisms, and cylinders are casted for 3, 7 days and 28 days. The Mechanical properties are determined and contrasted to find the best possible dosage amount.

Keywords: Rice Husk Ash, Dolomite Powder, Polypropylene Fiber, Global Warming and Mechanical Properties.

1. Introduction

Concrete is now one of the most widely utilised materials in building and other infrastructure projects. A total of 2700 million cubic metres of concrete were produced around the world. [1] and by the year 2050, the output of concrete may be further boosted to 18 billion tonnes an annum [2]. Today's environment is enduring transformation of extremely complex and challenging structures, and concrete, as the most essential and commonly utilised structural material, is being called upon to exhibit extremely high strength Ordinary portland cement is the primary constituent of traditional concrete. The level of carbon dioxide in the atmosphere is about equal to the amount of cement produced, causing global warming climate variability, and other challenges. Cement production needs a significant quantity of natural resources. To counteract the aforementioned negative consequences, the introduction of fresh materials and construction techniques and in this effort, admixture of modern items with various ingredients, has become a requirement. A century-old practise in the construction business is the incorporation of pozzolanic materials with OPC. The use of extra cementing ingredients or component substitutions, as well as Dolomite Powder and Rice Husk Ash (RHA) consistency in concrete on its own. Dolomite is a mineral that forms rocks and is known for its exceptional wet ability and dispensability. Dolomite is resistant to weathering. Due to its superior surface hardness and density, dolomite is a desirable construction material. Dolomite could be used as a cementitious ingredient to make dolomite cement. RHA's reactivity is due to its high quantity of amorphous silica and its relatively large surface area, which is controlled by the porous composition of the particles. Increasing the fineness of the pozzolanic component improves reactivity in general. Because it contains silica 88.99 %, alumina 0.58 %, ferric oxide 0.49 %, and calcium oxide 0.22 %, The aim of this do research is to find the appropriate degree of substitution for Dolomite Powder and Rice Husk Ash as a supplemental cement - based substance and polypropylene fiber reinforcement.

1.1 Objective

- To study the effect of dolomite powder in compression, tension and flexural behavior.
- To study the effect of rice husk ash in compression, tension and flexural behavior.
- To observe the influence of polypropylene fibers under compression, tension, and flexure.
- To lower carbon dioxide emissions.
- To assess the best dolomite powder dose for ternary blended concrete.
- To determine the optimum dosage of polypropylene fibers in ternary blended concrete.

2. Materials and methodology

2.1 Materials

2.1.1 Cement

Cement is a binder, or a substance that ties other materials together by setting and hardening separately. Portland cement is the most common form of cement.. The study used ordinary Portland cement of grade 53 from the Deccan Cement Company, which is in compliance with IS 8112:1989. The determined standard consistency is 29.22%, 45 mins for the initial setting and 265 mins for the ultimate setting and specific gravity as 3.15.

2.1.2 M- Sand

River sand can be replaced with artificial sand provided by proper machines. It is necessary to grade the sand. properly (Particles ranging in size from 150 microns to 4.75 mm should be evenly distributed.). There would be less voids in the sand if the small particles are properly proportioned. The amount of cement needed will be reduced. This type of sand would be less expensive. The need for produced fine aggregates for concrete production is escalating every day, as river sand cannot keep up with the construction industry's growing demand. Manufactured sand, which is free of silt and organic impurities, may be used in place of river or natural sand. The fine aggregate was found to have a specific gravity as 2.6.

2.1.3 Coarse Aggregate

The coarse aggregate utilised in the experiment was 20mm in size. coarse aggregate had a specific gravity of 2.74, a fineness modulus of 2.72, a water absorption rate of 0.48 percent, and a bulk density of 1545 kg/m^3

2.1.4 Water

The pH of the water used to make concrete is between 6 and 8. This project used locally accessible drinking water.

2.1.5 Dolomite Powder

The dolomite powder were used to determine the properties of concrete. The specific gravity is 2.75 given by JJ Fine Chemicals.

Figure 1: Dolomite Powder

Table 1: Chemical Properties Of Dolomite Powder by JJ Fine Chemicals.

Chemical Component	Chemical Composition
$CaCo_3$	55.12%
$MgCo_3$	46.63%
Al_2O_3	0.022%
SiO_2	0.33%
Total carbonate	97.32%

2.1.6 Rice Husk Ash

The rice husk ash were used to determine the properties of concrete. The specific gravity 2.25 given by Astra Chemicals.

Figure 2: Rice Husk Ash

Table 2: Chemical Properties Of RHA by Astra Chemicals.

Content	Chemical Composition	Amount(%)
Silica	SiO_2	88.99
Alumina	Al_2O_3	0.58
Ferric Oxide	Fe_2O_3	0.49
Calcium Oxide	CaO	0.22
Total Alkalies	(Na_2O+K_20)	0.69

Specific gravity	-	2.25
Bulk Density	-	0.2 – 0.3 gm

2.1.7 Polypropylene Fiber

The properties of concrete are evaluated using polypropylene fibers. Below are the physical characteristics of polypropylene fiber.

Figure 3: Polypropylene Fiber

Table 3: Characteristics Of Polypropylene Fiber by Mangpol.

Properties	Values
Length (mm)	12
Diameter (microns)	30-35
Melting Point (Celsius)	240-260

2.2 Methodology

The tests were carried out on a partially substituted sample by dolomite powder and rice husk ash, and also the insertion of polypropylene fibres, to achieve mechanical attributes of M20 grade concrete, and the mix proportions was designed according to IS 10262-2009. For different admixture dosages, mechanical properties such as compressive strength, split tensile strength, and flexural strength are evaluated.

2.2.1 Casting And Curing

The materials needed were measured and weighed on an electronic scale according to their blend. The same procedure was followed for each mix percentage, and the requisite samples were cast. The moulds was allowed to sit for a day. They were labelled after they were demolded as A1, A2, A3, and so on for each casted specimen based on their blends and stored in a curing tank that was held at a constant temperature during the curing period. All concrete samples were acquired for their 3, 7, and 28 day processing periods.

Figure 4(a): Casting

Figure 4(a): Curing

2.2.2 Compressive Strength Test

IS 516-1969 was used to cast and test the sample, which was a cube with dimensions of 150mm x 150mm x 150mm. Three samples were taken for each test every 3, 7 and 28 days.

Figure 5: Compressive Strength Test Setup.

2.2.3 Split Tensile Strength Test

IS 5816-1970 was used to cast and test the samples, which was a cylinder with a radius 75mm and a height of 300mm. Three samples were obtained for each test every 3, 7 and 28 days.

Figure 6: Split Tensile Strength Test Setup.

2.2.4 Flexural Strength Test

To achieve results, a prism measuring 400mm x 100mm x 100mm was casted,, and experimented on. Every 3, 7, and 28 days. Three samples were obtained for each test.

Figure 7: Flexural Strength Test Setup.

2.2.5 Concrete Mix Proportion

The following variables were considered for the experimental studies.

- The mix proportion as per IS 10262 : 2019 conventional concrete is 1 : 1.98 : 3.2.
- Dolomite powder [DP] as supplementary cementing materials with replacement of 5%, 10% and 15% (weight of cement per cubic meter).
- Rice Husk Ash [RHA] supplementary cementing materials with replacement of 9% (weight of cement per cubic meter).
- Polypropylene Fiber [PPF] with length of 12mm and three fiber volume fractions of 0, 0.15%, 0.30% and 0.45% (volume of concrete per cubic meter).

Table 4(a) : Mix Proportion

Mix Proportion						
Mix Designation	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**
DP (%)	5	5	5	5	10	10
RHA (%)	9	9	9	9	9	9
PPF (%)	0	0.15	0.3	0.45	0	0.15
W/C	0.55	0.55	0.55	0.55	0.55	0.55
OPC kg/m^3	339	339	339	339	320	320
DP kg/m^3	19.3	19.3	19.3	19.3	39	39
RHA kg/m^3	35.5	35.5	35.5	35.5	35.5	35.5
F.A kg/m^3	694	694	694	694	694	694
C.A kg/m^3	1123	1123	1123	1123	1123	1123
PPF kg/m^3	0	3.61	7.23	10.8	0	3.61
WATER lt/m^3	197	197	197	197	197	197

Table 4(b): Mix Proportion

Mix Proportion						
Mix Designation	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**
DP (%)	10	10	15	15	15	15
RHA (%)	9	9	9	9	9	9

PPF (%)	0.3	0.45	0	0.15	0.3	0.45
W/C	0.55	0.55	0.55	0.55	0.55	0.55
OPC kg/m^3	320	320	300	300	300	300
DP kg/m^3	39	39	59.2	59.2	59.2	59.2
RHA kg/m^3	35.5	35.5	35.5	35.5	35.5	35.5
F.A kg/m^3	694	694	694	694	694	694
C.A kg/m^3	1123	1123	1123	1123	1123	1123
PPF kg/m^3	7.23	10.8	0	3.61	7.23	10.8
WATER lt/m^3	197	197	197	197	197	197

3. Results And Discussions

3.1 Compressive Strength

The main factor that governs the other properties of concrete is compressive strength. Here are the compressive strengths of concrete specimens after 3, 7 and 28 days.

Table 5: Compressive Strength of CC, A1, A2, A3 and A4.

Mix Designation	**Compressive Strength N/mm^2**		
	3 Days	7 Days	28 days
CC	8.3	12.2	20.3
A1	9.7	13.8	22
A2	10.15	14.3	23.92
A3	11.81	16.05	25.8
A4	9.51	13.4	19.8

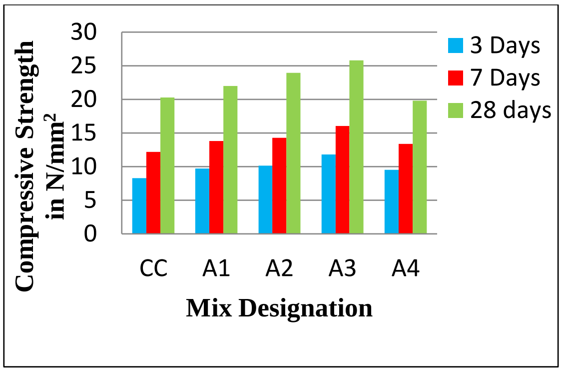

Figure 8: Compressive Strength Comparison

The compressive strength of polypropylene fibres improves as the number of fibres rises as 0%, 0.15% and 0.30%. It's also obvious that after a while, compressive strength drops at 0.30% (A3) from table 5. When dolomite powder and rice husk ash kept constant at 5% and 9%. The increases in the compressive strength at 3, 7 and 28 days observed from fig 6 compared with the conventional concrete.

Table 6: Compressive Strength of CC, A5, A6, A7 and A8.

Mix Designation	Compressive Strength N/mm^2		
	3 Days	7 Days	28 days
CC	8.3	12.2	20.3
A5	10.21	14.3	22.8
A6	10.86	15.03	25
A7	13.22	19.4	28.8
A8	10.22	15.6	21.95

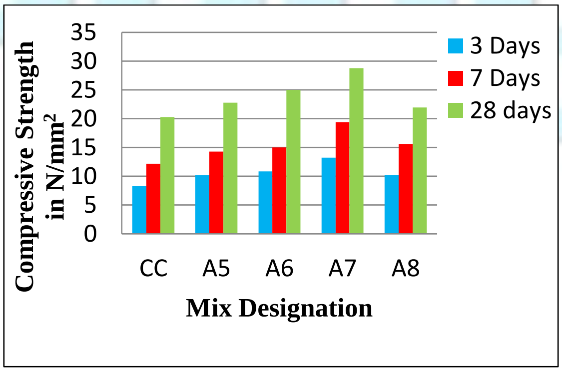

Figure 9: Compressive Strength Comparison

The compressive strength of polypropylene fibres improves as the number of fibres rises as 0%, 0.15% and 0.30%. It's also obvious that after a while, compressive strength drops at 0.30% (A7) from table 6. When dolomite powder and rice husk ash kept constant at 10% and 9%. The increases in the compressive strength at 3,7 and 28 days observed from fig 7 compared with the conventional concrete.

Table 7: Compressive Strength of CC, A9, A10, A11 and A12.

Mix Designation	**Compressive Strength N/mm^2**		
	3 Days	7 Days	28 days
CC	8.3	12.2	20.3
A9	8.72	14.1	17.95
A10	9.92	15.3	21.25
A11	12.02	17.4	23.25
A12	10.22	17.1	18.9

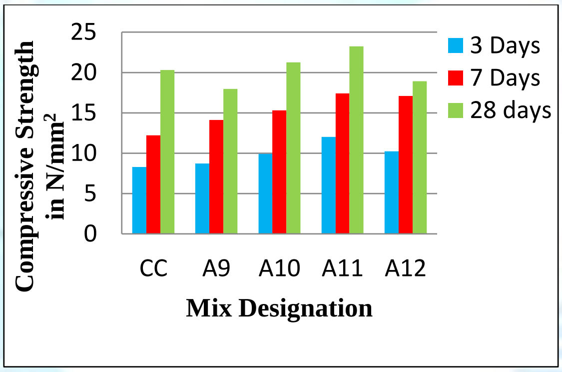

Figure 10: Compressive Strength Comparison

The compressive strength of polypropylene fibres improves as the number of fibres rises as 0%, 0.15% and 0.30% .It's also obvious that after a while, compressive strength drops at 0.30%(A11) from table 7. When dolomite powder and rice husk ash kept constant at 15% and 9%. The increases in the compressive strength at 3,7 and 28 days observed from fig 8 compared with the conventional concrete.

As can be shown, the compression strength as the amount of dolomite powder increases as 5% and 10%. from the table 5 and table 6. It is also clear that it decreases after 10% from table 7. It is evident from the above test results that the cement was replaced with dolomite powder 10%, rice husk ash as 9% and polypropylene fibers as 0.30% increases in the maximum compressive strength by 59.2%, 59% and 41.8% at 3,7 and 28 days correspondingly as compared with the conventional concrete.

3.2 Split Tensile Strength

The key characteristic that determines other concrete qualities is Split tensile strength. Below are the split tensile values of concrete specimens after 3 days, 7 days, and 28 days.

Table 8: Split Tensile Strength of CC, A1, A2, A3 and A4.

Mix Designation	**Split Tensile Strength N/mm^2**		
	3 Days	7 Days	28 days

CC	2	2.45	3.13
A1	2	2.48	3.2
A2	2.1	2.5	3.3
A3	2.2	2.6	3.4
A12	10.22	17.1	18.9

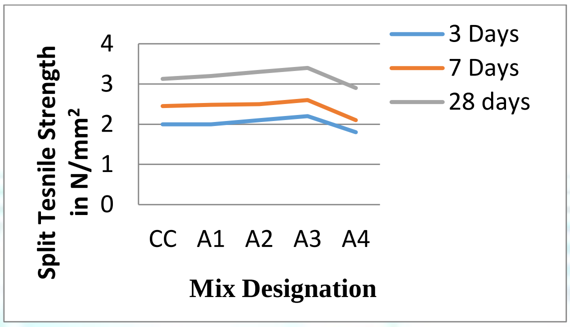

Figure 11: Split Tensile Strength Comparison

The split tensile strength of polypropylene fibres rises as the number of fibres rises as 0%, 0.15% and 0.30%. The reduction in split tensile strength is also obvious after 0.30% (A3) from table 8. When dolomite powder and rice husk ash kept constant at 5% and 9% . The increases in the split tensile strength at 3,7 and 28 days ensured from fig 9 compared with the conventional concrete.

Table 9: Split Tensile Strength of CC, A5, A6, A7 and A8.

Mix Designation	**Split Tensile Strength N/mm^2**		
	3 Days	7 Days	28 days
CC	2	2.45	3.13
A5	2.33	2.7	3
A6	2.51	2.8	3.25
A7	2.95	3.28	3.52
A8	1.92	2.22	2.97

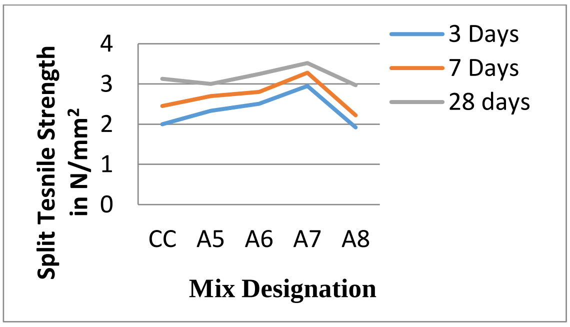

Figure 12: Split Tensile Strength Comparison

The split tensile strength of polypropylene fibres rises as the number of fibres rises as 0%, 0.15% and 0.30%. The reduction in split tensile strength is also obvious after 0.30% (A7) from table 9. When the dolomite powder and rice husk ash kept constant at 10% and 9%. The increases in the split tensile strength at 3,7 and 28 days ensured from fig 10 compared with the conventional concrete.

Table 10: Split Tensile Strength of CC, A9, A10, A11 and A12.

Mix Designation	Split Tensile Strength N/mm^2		
	3 Days	7 Days	28 days
CC	2	2.45	3.13
A9	1.94	2.26	2.54
A10	2.03	2.4	2.72
A11	2.48	2.75	3
A12	2.01	2.3	2.6

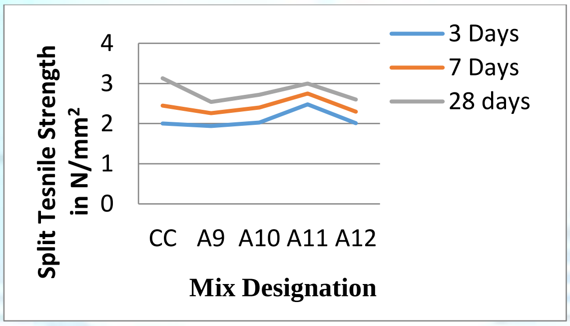

Figure 13: Split Tensile Strength Comparison

The split tensile strength of polypropylene fibres rises as the number of fibres rises as 0%, 0.15% and 0.30%. The reduction in split tensile strength is also obvious after 0.30% (A11) from table 10. When the dolomite powder and rice husk ash kept constant at 15% and 9% The increases in the split tensile strength at 3,7 and 28 days ensured from fig 11 compared with the conventional concrete.

As we see the split tensile strength increases with increase in dolomite powder as 5% and 10% from the table 8 and table 9. It is also clear that it decreases after 10% from table 10. It is evident from the above test results that the cement was replaced with dolomite powder 10%, rice husk ash as 9% and polypropylene fibers as 0.30% increases in the maximum split tensile strength by 42%, 33.8% and 12.46% at 3,7 and 28 days respectively as compared with the conventional concrete.

3.3 Flexural Strength

The primary factor that determines the other attributes of concrete is its flexural strength. Below are the flexural strengths of concrete sample after 3 days, 7 days, and 28 days.

Table 11: Flexural Tensile Strength of CC, A1, A2, A3 and A4.

Mix Designation	Flexural Strength N/mm^2

	3 Days	7 Days	28 days
CC	1.5	2	3
A1	2	2	3
A2	2.5	2.5	3.5
A3	2	2	3.5
A4	2	2.5	3

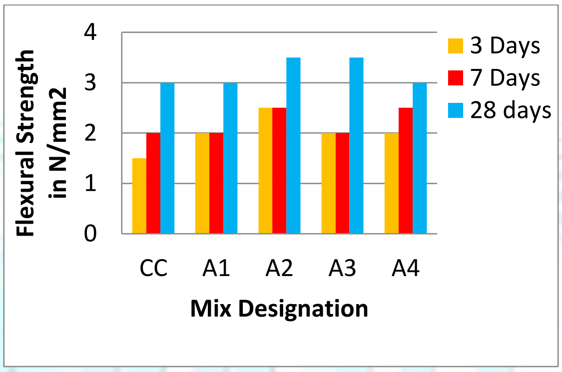

Figure 14: Flexural Strength Comparison

The flexural strength of polypropylene fibres rises as the number of fibres rises as 0%, 0.15% and 0.30%. It is also clear that flexural strength decreases after 0.30% (A3) from table 11. When dolomite powder and rice husk ash kept constant at 5% and 9%. The increases in the flexural strength at 3,7 and 28 days observed from fig 12 compared with the conventional concrete.

Table 12: Flexural Tensile Strength of CC, A5, A6, A7 and A8.

Mix Designation	**Flexural Strength N/mm^2**		
	3 Days	7 Days	28 days
CC	1.5	2	3
A5	2.5	3	3.5
A6	3	3.5	4
A7	3.5	4	4.5
A8	2.5	2.5	3.5

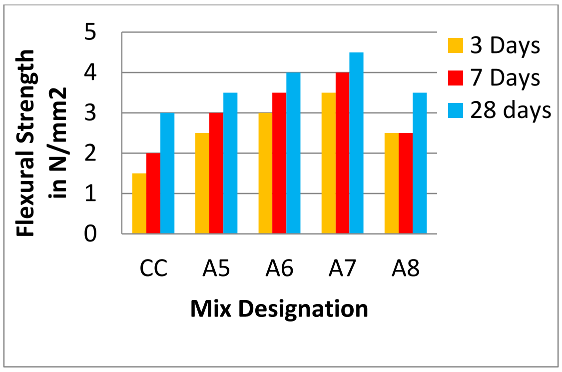

Figure 15: Flexural Strength Comparison

The flexural strength of polypropylene fibres rises as the number of fibres rises as 0%, 0.15% and 0.30%. It is also clear that flexural strength decreases after 0.30% (A7) from table 12. When dolomite powder and rice husk ash kept constant at 10% and 9%. The increases in the flexural strength at 3,7 and 28 days observed from fig 13 compared with the conventional concrete.

Table 13: Flexural Tensile Strength of CC, A9, A10, A11 and A12.

Mix Designation	Flexural Strength N/mm^2		
	3 Days	7 Days	28 days
CC	1.5	2	3
A9	2	3	3
A10	2.5	3	3.5
A11	3	3	3.5
A12	2.5	2.5	3

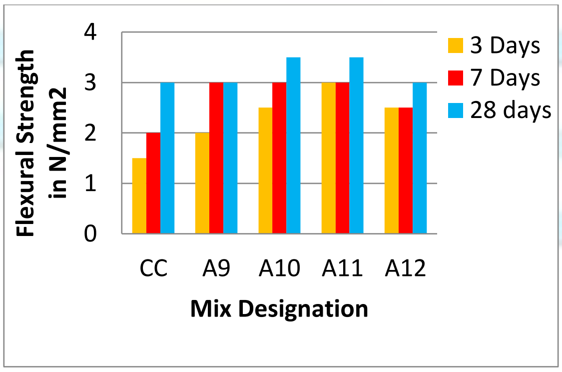

Figure 16: Flexural Strength Comparison

The flexural strength of polypropylene fibres rises as the number of fibres rises as 0%, 0.15% and 0.30%. It is also clear that flexural strength decreases after 0.30% (A11) from table 13. When dolomite powder and rice husk ash kept constant at 15% and 9%. The increases in the flexural strength at 3, 7 and 28 days observed from fig 14 compared with the conventional concrete

As we see the flexural strength increases with increase in dolomite powder as 5% and 10%. from the table 11 and table 12. It is also clear that it decreases after 10% from table 13. It is evident from the above test results that the cement was replaced with dolomite powder 10%, rice husk ash as 9% and polypropylene fibers as 0.30% increases in the maximum flexural strength by 133%, 100% and 50% at 3, 7 and 28 days respectively as compared with the conventional concrete.

4. Conclusion

- The desired substitution proportion of cement with dolomite powder 10%, rice husk ash 9% and polypropylene fibers as 0.30%, increases in the maximum compressive strength by **59.2%, 59%** and **41.8%** at 3,7 and 28 days correspondingly as compared with the conventional concrete.
- The desired substitution proportion of cement with dolomite powder 10%, rice husk ash 9% and polypropylene fibers as 0.30%, increases in the maximum split tensile strength by **42%, 33.8**%, **12.46%** at 3 ,7 and 28 days likewise as compared with the conventional concrete.
- The desired substitution proportion of cement with dolomite powder 10%, rice husk ash 9% and polypropylene fibers as 0.30%, increases in the maximum flexural strength by **133%, 100% 50%** at 3,7 and 28 days respectively as compared with the conventional concrete.

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