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Experimental investigation on the enhancement of concrete strength

Experimental investigation on the enhancement of concrete strength by incorporation of polypropylene fibres along with partial replacement of cement by a combination of micro-silica and dolomite powder in equal proportion.

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Abstract: Cement is one of the important constituents of concrete, cement manufacturing produces a large amount of heat into the atmosphere and is one of the important causes of global warming to some extent. As we know cement consumption in India ranks 2nd in the world after China with consumption of 370 million tonnes in the year 2022-23 [6]. Reducing the amount of cement even to a small extent in the concrete mix will have a significant impact on the environment in a good manner reducing atmospheric heat. So, in this experiment, we partially replaced cement about 10 and 15% with a blend of dolomite powder and micro-silica in different ratios to get maximum strength. To reduce shrinkage, thermal stresses and increase strength and imperviousness of concrete we are using polypropylene fibre along with dolomite and micro-silica in concrete and finding out the optimum quantity of polypropylene giving maximum strength. So First of all consider partial replacement of cement to 10% and 15% taking the ratio of dolomite powder and micro silica as 1:1 and the quantity of polypropylene fibre in 0.5%, 1% and 1.5% of wet concrete. Six mix combinations were formed for M20 concrete. From their test results, the optimum polypropylene content is fixed which is found to be 1% in our case. A mix containing 1% polypropylene fibre with 10% cement replacement by a combination of dolomite powder and micro silica in the ratio of 1:1 gives maximum strength in all 6 mixes studied in this research work. Further in the future total of 9 mix combinations for 10% and 15% cement replacement will be formed with different ratios of dolomite powder to micro-silica with a fixed percentage of polypropylene as 1%. Among 9 more mix combinations, the one giving maximum strength is found and the optimum ratio of dolomite powder: micro silica is decided by comparing test results is the future scope of this experimental study.

Index Terms **- Polypropylene fibre, dolomite powder, micro silica, optimum ratio.**

I.INTRODUCTION

Concrete is an important material widely used in civil engineering structures. Which consists of cement, coarse aggregate, fine aggregate, water along with chemical admixtures according to need. In recent developments, various types of fibres are also included in concrete to form fibre-reinforced concrete. As we know cement production leads to the emission of carbon dioxide on a large scale its use should be reduced or eliminated completely. As per previous research on concrete development by replacement of cement completely will not give good results but if cement is replaced partially with materials like dolomite powder, fly ash, rice husk powder and micro silica it yields good results. So in this project work, we are finding results if dolomite powder and micro silica are used combinedly in fixed proportions as 1:1 to replace some parts of cement and find out how they react and their optimum ratio giving maximum strength, Also the optimum quantity of polypropylene fibre to be used yielding good strength. Polypropylene fibre reduces plastic shrinkage and thermal stresses, improves impact resistance and cohesiveness of concrete and is cost-effective to steel fibre. Dolomite powder is the by-product of preparing raw material in steel plants and is a good alternative to cement and has many advantages as a reduction in cost, higher surface hardness and an increase in strength if used in an optimum proportion. Micro silica is the powdery by-product of the manufacture of silicon and ferrosilicon alloys in dust form from electric furnaces in electrostatic filters available abundantly in India. 26% of the earth's crust is made up of silicon. If used in small quantity shows cementation properties in the mix and makes the concrete mix more impermeable, Improving durability and strength to some extent.

To take advantage of all three materials and study the behaviour of concrete with different percentages of polypropylene fibres, these materials are used combinedly in this project work.

Objectives:

- To compare the test results for different percentages of polypropylene fibre in M20 concrete.
- To find out the optimum percentage of polypropylene fibre used in M20 concrete giving maximum strength.
- To find out the optimum percentage of cement replacement by a combination of dolomite powder and micro silica with the addition of polypropylene fibre in fixed proportion 1:1.
- To compare slump values of concrete.
- To study the behaviour of concrete for different percentages of polypropylene fibres with respect to slump values.

II. RELATED WORK

The approach of replacing cement with other materials started in mid 20th century and was more widely adopted in the construction industry by researchers and engineers due to its potential benefits in improving concrete properties.
In this project, we are more centred on research about concrete manufacture using dolomite powder, micro silica and polypropylene fibres.

[1] Bhavinaben K, et al (2013), The innovative addition of polypropylene fibre in interlocking paver block to improve compressive strength. In this study, fibres were only added in the top 15 mm layer of paver blocks. They reported that the addition of 0.3% and 0.4% of polypropylene fibre gives improved flexural strength and abrasion resistance [1].
[2] Kolli ramujee (2013), Strength properties of polypropylene fibre reinforced concrete. In this research paper, they added polypropylene fibre in 0.5%, 1%, 1.5% and 2% and found strength goes on increasing up to 1.5% and is further reduced. Strength enhancement of 1.5% gives an increase in compressive strength as 34% and split tensile strength as 40% [2].
[3] Preethi G et al (2015), Effect of Replacement of Cement with Dolomite Powder on the Mechanical Properties of Concrete. In this research report, they replaced cement with 5%, 10%, 15%, 20% and 25% of dolomite powder. From their experimental study, it was observed that the ideal replacement of cement with dolomite is 10% giving a 10.4 % increase in compressive strength, and a 17.8% increase in flexural strength. For split tensile strength optimal replacement was found to be 15% leading to notable 39.8% improvement in split tensile strength [3].
[4] Palli Praveen kumar et al (2018), Partial replacement of cement with micro silica. In this study, Micro silica is utilised to replace cement to 10%, 13% and 15%. Optimum cement replacement is observed at 13% further strength goes on decreasing [4].
[5] Mostafa Shaaban (2021), Properties of concrete with binary binder system of calcined dolomite powder and rice husk ash. The focus of this study lies in promoting the utilization of calcined dolomite powder and rice husk as a dual binder system, primarily due to their waste-free and bypass dust-free characteristics. Also helps to reduce CO^2 emissions. The Binary binder system consists of CDP 50% and RHA 50% and provides better properties than OPC [5].

III. RESEARCH METHODOLOGY

In this experimental study, the optimum percentage of a combination of polypropylene fibre along with the ratio of dolomite powder and micro-silica 1:1 partially replacing cement is found by comparing test results of different proportions of mixes with M20 concrete. From previous research papers analysis cement replacement is about 10 to 13 % is beneficial, polypropylene fiber should be used about 0.5 to 1.5%. Taking into consideration these previous studies various trial mixes will be taken to get the optimum amount of cement replacement to a combination of dolomite powder and micro silica with the addition of polypropylene fibre content.

- Firstly, 10% and 15% cement were replaced by dolomite powder and micro silica (1:1) in addition to polypropylene fibre in various percentages as 0.5%, 1% and 1.5% of concrete and optimum amount of fibre content giving maximum strength are found out and noted.
- Then the test results are compared for slump, compressive strength and flexural strength for varying percentages of polypropylene.

Variables

The main variables in this study are:

- Polypropylene fibre in 0.5%, 1% and 1.5%
- The proportion of dolomite powder to micro silica (1:1) for 10% cement replacement and 15% cement replacement.

The following parameters were kept constant in the study as we used M20 concrete (1:1.5:3) [8]

- The total amount of powder content (cement +dolomite powder +Micro silica) = 395 kg/m^3
- Water cement ratio = 0.55
- The ratio of coarse aggregate to fine aggregate = 1:2
-

Table 1: Designations of mixed proportions

Mix Designation	Cement replacement %	Polypropylene fiber %	Ratio of Dolomite powder to Micro silica	
			Dolomite powder	Micro silica
Mix 1	10	0.5	1	1
Mix 2		1	1	1
Mix 3		1.5	1	1
Mix 4	15	0.5	1	1
Mix 5		1	1	1
Mix 6		1.5	1	1

Table 2: Mix proportions (Kg/m^3)

Mix ID	Cement	Dolomite Powder	Micro silica	Polypropylene fibre	Aggregate		W/C ratio
					Crush sand	Coarse aggregate	
Mix 1	355.5	19.75	19.75	6.992	621.81	1243.63	0.55
Mix 2				13.984			
Mix 3				20.976			
Mix 4	336	29.5	29.5	6.992			
Mix 5				13.984			
Mix 6				20.976			

Six M20 concrete mixes with different proportions of polypropylene fibre with dolomite powder and micro silica in a fixed proportion of 1:1 with the same water-cement ratio of 0.55 were tested in this study. From each concrete mix, nine cubes and six beams were cast. Properly cured after demolding and removed from the water before testing and tested after wiping off surface water for compressive strength test and flexural strength test respectively for 3, 7, and 28 days. Before casting these cube and beam mixes were also checked for the slump by performing a slump cone test on concrete mixes. Test results of all 3 tests are noted down and analysed to get the optimum strength-giving mix. As all three tests are well known no need to give a detailed explanation of test procedures.

IV. RESULTS AND DISCUSSION

Properties of fresh concrete: A slump test is performed on all 6 concrete mixes showing a pattern of changing slump with change in polypropylene fibre content and partial cement replacement content as shown in Fig (a) and Fig (b). With the increase in polypropylene fibre content mix becomes a little harsh reducing slump value and further reducing slump value with an increase in the percentage of cement replacement from 10% to 15%. Slump values of mix 1 to mix 6 are 80, 75, 72, 75, 70 and 68 respectively.

Fig 1: slump of concrete

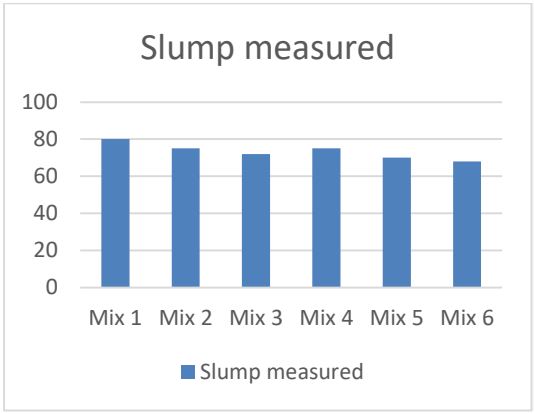

Fig (a)

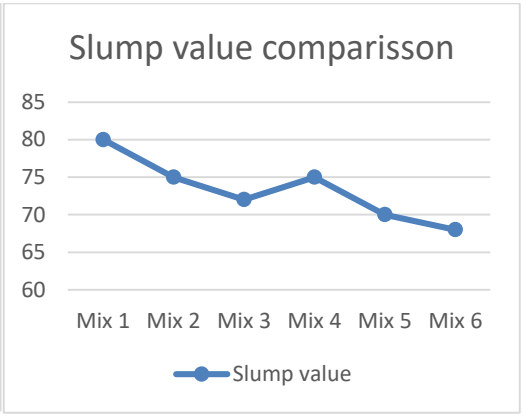

Fig (b)

Compressive strength of concrete: For Mix 1 to Mix 6, the compressive strength of concrete increases with an increase in polypropylene fibre quantity and after 1% of polypropylene fibre quantity, the strength again decreases with an increase in fibre quantity further above 1% as shown in Fig (c) and Fig (d). hence it shows that 1% of polypropylene fibre gives maximum strength. It is also seen that strength for 10% cement replacement gives maximum strength compared to 15% cement replacement. Hence, we fixed the polypropylene fibre quantity to 1% and in future mixes will be prepared with the same quantity to compare changes due to the change in the ratio of dolomite powder to micro-silica.

The optimum percentage of cement replacement is between 10 to 15% only as 10% cement replacement results are giving maximum strength results but for 15% replacement strength results are not decreased by a considerable amount compared to 10% cement replacement.

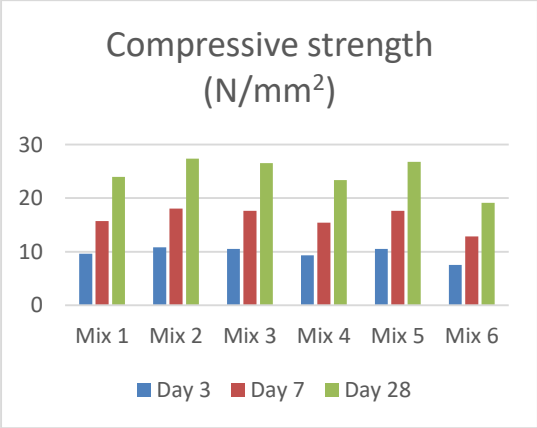

Fig (c)

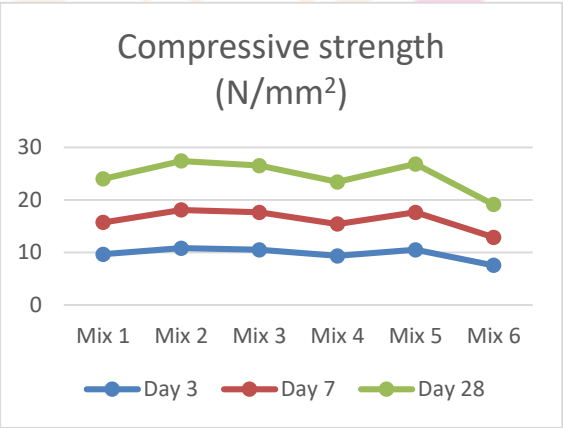

Fig (d)

Flexural strength of concrete: The flexural strength of normal M20 grade concrete is 3.13 N/mm^2 (0.7√Fck) according to IS456:2000 [4]. As we increase the percentage of polypropylene fibre flexural strength goes on increasing up to 1% of fibre content and above that strength again starts decreasing. Similar to compressive strength as we increase the percentage of cement replacement above 10% strength slightly decreases. But there is no considerable change in strength so we can say that flexural strength is maximum when cement replacement percentage ranges from 10 to 15%. The optimum fibre content is 1% with 10% cement replacement as shown in Fig (e) and Fig (f) gives maximum strength results. Mix 2 gives a maximum flexural strength of 4.48 N/mm^2 showing an enhancement of about 43% over conventional concrete of same grade M20.

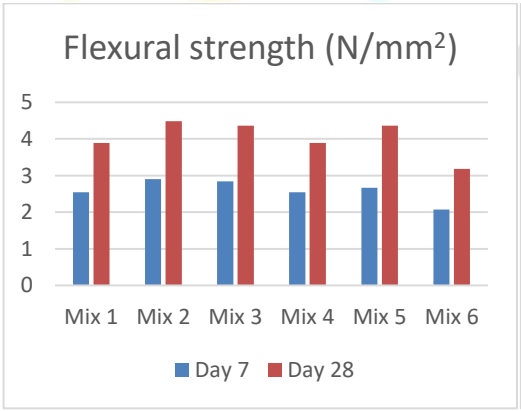

Fig (e)

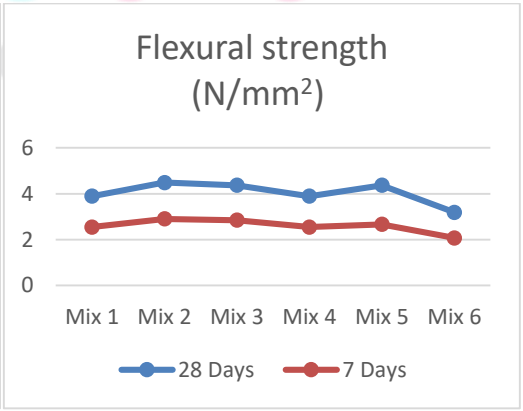

Fig (f)

Fig 2: Flexural strength test and compressive strength test

V. CONCLUSION

From the tests that I have performed, I came to the following conclusions

- As we increase the percentage of polypropylene fibre slump value goes on decreasing and in slump changes main factor responsible is polypropylene fibre content.
- The slump given by the addition of polypropylene fibre, dolomite powder and micro-silica is a true slump.
- As we go on increasing the percentage of polypropylene fiber concrete becomes a little harsh.
- The optimum amount of polypropylene fibre in concrete is 1% which gives maximum strength compared to other mixes.
- The optimum percentage of cement replacement is between 10 to 15% only as 10% replacement results are giving maximum strength results and for 15% replacement strength results are not decreased by a considerable amount compared to 10% cement replacement.
- For M20 concrete the addition of optimum materials combination of polypropylene fibre, dolomite powder and micro silica (i.e., Mix 2) gives about a 37% increase in compressive strength.
- For M20 concrete the addition of optimum materials combination of polypropylene fibre, dolomite powder and micro silica (i.e., Mix 2) gives an increase in flexural strength from 3.13 N/mm^2 to 4.48 N/mm^2.

Future scope of the study:

As we know there is an enhancement in the strength of concrete due to the replacement of cement to some extent by dolomite powder and micro silica in combination with 1% polypropylene fibre. We will do future studies with respect to the following points:

- To compare the test results for different combinations of dolomite powder and micro silica as (1:2, 2:1, 3:1, 1:3) in M20 concrete with optimum polypropylene fibre content.
- To find out the optimum ratio of dolomite powder and micro-silica giving maximum strength to M20 concrete with respect to compressive and flexural strength with the addition of an optimum amount of polypropylene fibre as 1%.
- To study the long-term properties of concrete as durability and creep for such new material.

VI. REFERENCES

[1] K. Bhavin, Kashiyani, Jayeshkumar pitroda, and K. Bhavnaben Shah, "Effect Of Polypropylene Fibers on Abrasion Resistance and Flexural Strength for Interlocking Paver Block", International Journal of Engineering Trends and Technology(IJETT), Volume. 4, 2013.

[2] Kolli. Ramujee "strength properties of polypropylene fiber reinforced concrete" Associate Professor, Department of Civil Engineering, VNR Vignana jyothi Institute of Engineering & Technology, Hyderabad, Andhra Pradesh, India, 2013.

[3] Preethi G, Prince Arulraj G **"**Effect of replacement of cement with dolomite powder on mechanical properties of concrete". Dept of Civil Engineering, S.N.S College of Technology, Coimbatore, Tamil Nadu, India, 2015.

[4] Palli Praveen Kumar , B.Sahithi , G.Murali Krishna , K.Reshma Sindhu Assistant Professor "Partial replacement of cement with micro silica" Department of Civil Engineering, Guru Nanak Institutions, Hyderabad, Telengana, 2018.

[5] Mostafa Shaaban "Properties of concrete with binary binder system of calcined dolomite powder and rice husk ash", giza higher institute for engineering and technology, Egypt, 2021.

[6] M. M. Kamal, M. A. Safan, and M. A Al- Gazzar, "Experimental Evaluation of Steel-Concrete bond Strength in Low-Cost Self-Compacting Concrete", Concrete Research Letter, volume. 3(2), 2012.

[7] Salim Barbhuiya, "Effects of fly ash and dolomite powder on the properties of self-compacting concrete", Construction and Building Materials, Volume. 25, 2011.

[8] IS 456:2000, Recommended code of practice for plain and reinforced concrete, Bureau of Indian Standard.

[9] IS 10262-2019, Recommended guide lines for concrete mix, Bureau of Indian Standard.

[10] Faseyemi Victor Ajileye "Investigations on Microsilica (Silica Fume) As Partial Cement Replacement in Concrete" Global Journal of researches in engg. civil and structural engg.Volume 12 Issue 1Version 1.0 January 2012.

[11] Magudeaswaran, Eswaramoorthi "Experimental -Investigations of Mechanical properties on Micro silica (Silica Fume) and Fly Ash as Partial Cement Replacement of High Performance Concrete". IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320- 334X, Volume 6, Issue 4 (May. – Jun. 2013).

[12] Milind V. Mohod "Performance of Polypropylene Fiber Reinforced Concrete". Department of Civil Engineering ,Prof. Ram Meghe Institute of Technology And Research, Badnera, Amravati, India, 2015.

[13] Daman K. Panesar, in Developments in the Formulation and Reinforcement of Concrete (Second Edition), 2019, science direct.

[14] AROOBA RAFIQ BHAT, AJAY VIKRAM, "PERFORMANCE OF CONCRETE WITH POLYPROPYLENE FIBRE AND POLYVINYL CHLORIDE FIBRE, MARCH 2023, SCIENCE DIRECT.

[15] MAZHARUL ISLAM KIRON, POLYPROPYLENE FIBER: PROPERTIES, MANUFACTURING PROCESS AND APPLICATIONS, 2013, TEXTILE LEARNER.