

Analysis of Concrete properties by Partially Replacing cement with Dolomite Powder And adding pine fiber as a Reinforcement

¹Ashwani Bhandari, ²Punita Thakur

¹M.tech Student, Sri Sai University, Palampur, Himachal Pradesh

²Assistant Professor, Department of Engineering, Sri Sai University, Palampur, Himachal Pradesh

Date of Submission: 01-07-2025

Date of Acceptance: 10-07-2025

ABSTRACT: The prime element of concrete is Portland cement, i.e. is a versatile and moderately priced. On the contrary, large-scale cement production harms the environment and depletes natural resources, releasing approximately 0.78 tons of CO₂ for every ton of cement produced. This study investigates the mechanical and durability performance of concrete reinforced with natural pine fibers and partially substituted with dolomite powder in place of cement. Dolomite powder and pine fibers can be used as sustainable concrete additives. In addition to lowering cement usage and carbon emissions, their combined use enhances some of the mechanical qualities of concrete, making it a good substitute for ecologically friendly building methods. Concrete is good in compression and weak in tension in order to increase the tensile strength using Pine Fibers treated with the help of 1% of (NaOH) solution for good property. In this study Dolomite powder was partially replaced from 5%, 7.5%, 10% and 12.5% in cement and addition of treated pine fiber at the different proportion of 0.6%, 1.2% and 1.8% are used in the M30 mix and tested for its compressive strength, Split Tensile strength and flexural strength up to 7 days and 28 days of the strength and compared with conventional concrete test results show that by the replacement of cement with Dolomite powder as at 10% and treated pine fiber of 0.6% gives maximum strength.

KEYWORDS: Dolomite Powder, Pine Fiber, Partially Replacing, Carbon Dioxide, Treated, NaOH, M30 mix, Conventional Concrete, Compressive Strength, Split tensile Strength, Flexural Strength.

I. INTRODUCTION

Concrete serves as a vital element in contemporary construction, constantly evolving to address the demands of modern infrastructure. The characteristics of concrete are predominantly shaped by its cement constituent. However, the production of cement, which involves heating limestone and clay to high temperatures, generates considerable carbon dioxide (CO₂) emissions. As the world's second-largest cement producer, India plays a significant role in this environmental challenge, emitting approximately 0.78 tons of CO₂ for every ton of cement manufactured. Given the substantial carbon footprint associated with cement production, there is an urgent need to investigate sustainable alternatives. One promising substitute is dolomite powder, a mineral additive derived from dolomite rock, primarily composed of calcium and magnesium carbonate. Research indicates that incorporating dolomite powder into concrete mixtures can improve strength, durability, and sustainability while simultaneously lowering environmental impact and production costs. Traditional concrete, typically consisting of cement, aggregates, water, and occasionally chemical admixtures, exhibits notable compressive strength but often lacks adequate tensile strength and resistance to cracking. To overcome these shortcomings, natural fibers have emerged as a valuable reinforcement option. This advancement has led to the development of natural fibrous concrete, which demonstrates enhanced mechanical properties, durability, and environmental benefits, marking a significant departure from conventional concrete practices.

II. MATERIALS USED

CEMENT:

Cement is the most important properties of concrete and used as a binding material. OPC43 is the type of cement employed in this study. It has a minimum initial and final setting time of 30 minutes and 10 hours.

FINE AGGREGATE:

Fine aggregate are those materials which are bounded together by cement or concrete. And Fine aggregates passing through 4.75mm IS sieve were obtained from locally available river.

COARSE AGGREGATE:

Coarse aggregate are naturally occurring rounded gravel and irregular broken stone used for making concrete. Coarse aggregate are those materials which retained through 4.75mm IS sieve. Locally available CA were used in this investigation having are minimum and maximum size 10 and 20mm.

DOLOMITE POWDER

Dolomite is a rock and a mineral, calcium magnesium carbonate ($\text{CaMg}(\text{CO}_3)_2$) is their main constituent. The primary component of the sedimentary rock known as dolostone or dolomitic limestone is the mineral dolomite. The use of dolomite powder at the percentage of 5%, 7.5%, 10%, 12.5%. In this study complies with IS: 1237 (2012) and ASTM C25. Dolomite powder is available Surya Min chem. Pvt. Ltd. has a process for dolomite powder of 25kg bag at the cost of Rs75. Concrete's permeability was decreased by the addition of dolomite powder.



Figure 3.4 Dolomite powder

PINE FIBER:

A naturally occurring lingo cellulosic substance, pine fiber is taken from pine trees. It is frequently utilized in construction as an environmentally friendly reinforcing material. The fibers utilized have a length of 25 mm. To ascertain the impact on the concrete's mechanical qualities (both fresh and hardened), the fiber's length was taken into account. This study also looked at how different fiber dosages affected the concrete's fresh and hardened qualities. 0.6, 1.2, and 1.8 fiber percentages by dry volume of the concrete were taken into account.



Fig. 3.9 Treated pine Fiber

III. MIX DESIGN AND METHODOLOGY

MIX DESIGN:

We aimed for M30 grade concrete, Harden strength properties at 7 And 28 days, following IS 10262:2019 guidelines. The water-cement ratio stayed at 0.40.

SR. NO.	MATERIALS	QUANTITY IN kg/m^3
1.	Cement	493
2	Water	196.12
3	F.A.	630
4	C.A.	1049
5	W/C	0.40
6	Type of exposure condition	Mild

METHODOLOGY

Table3.14 Designation of concrete mix

TRIAL	CEMENT (%)	DP (%)	PINE FIBER (%)	FA (%)	CA (%)	CA (%)	W/C
M	100	0	0	100	40	60	0.40
M0	100	0	0.6	100	40	60	0.40
M1	100	0	1.2	100	40	60	0.40
M2	100	0	1.8	100	40	60	0.40
M3	95	5	0	100	40	60	0.40
M4	92.5	7.5	0	100	40	60	0.40
M5	90	10	0	100	40	60	0.40
M6	87.5	12.5	0	100	40	60	0.40
M7	95	5	0.6	100	40	60	0.40
M8	92.5	7.5	0.6	100	40	60	0.40
M9	90	10	0.6	100	40	60	0.40
M10	87.5	12.5	0.6	100	40	60	0.40

IV. EXPERIMENTATION

SLUMP CONE TEST

Slump test is used to check the workability of the fresh concrete. A slump cone mold is used for the slump test. After setting the mold on a level platform, four equal layers of concrete mix are poured into the mould. A rod is used to tamping each layer in the mold 25 times to reduction of void and air. Finally, use a trowel to level the concrete after removing any extra from the mould. Without damaging the concrete cone, carefully and slowly lift the mould from the concrete in a vertical direction. Then measure the slump height with the help of tamping rod value should be measure in mm.



Fig.4.5 Slump cone Test

COMPRESSIVE STRENGTH

Using a CTM (compression testing machine), the compressive strength of concrete

mixes without and with substitute material Pine fiber and Dolomite powder was evaluated at 7 and 28 days. The samples' compressive strength values after seven and twenty-eight



Fig.4.7 Compression Testing Setup

SPLIT TENSILE STENGTH:

Using a compression testing equipment, the concrete mix's split strength was evaluated at seven and twenty-eight days. The cylinders were 150 x 300 mm in dimension. Concrete's split tensile strength improved after seven and twenty-eight days when pine Fiber and Dolomite powder were added in place of the original material. Split tensile strength was also enhanced by pine Fiber.



Fig.4.9 Split tensile Testing Setup

and 28 days of age. The beam's dimensions were 150 x 150 x 750 mm.



Fig.4.11 Flexural Testing Setup

FLEXURAL STRENGTH:

Concrete's tensile strength is also used to measure its flexural strength. In practice, concrete is frequently susceptible to flexural stresses, particularly in beams. One of the structure's flexural elements is the beam. The modulus of rupture is another name for the concrete structure's flexural strength. Using universal testing equipment, the concrete mix's flexural strength was assessed at 7

V. OBSERVATION

WORKABILITY

Table5.1: Shows the slump value (slump cone test)

Mix	M	M0	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Slump (mm)	80	75	68	62	75	73	70	69	76	75	74	73

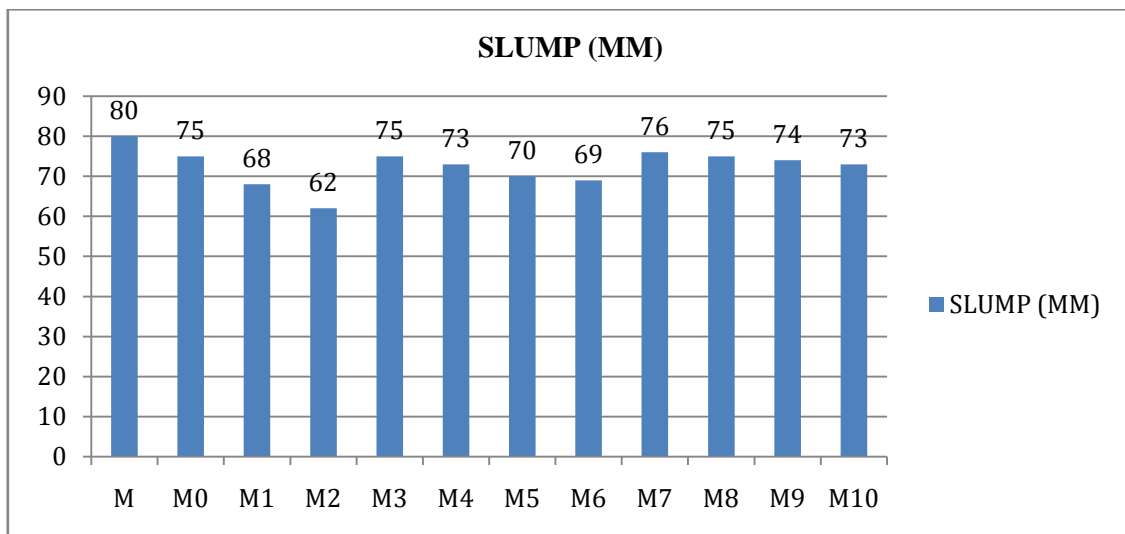


Fig.5.2 Bar chart of Slump

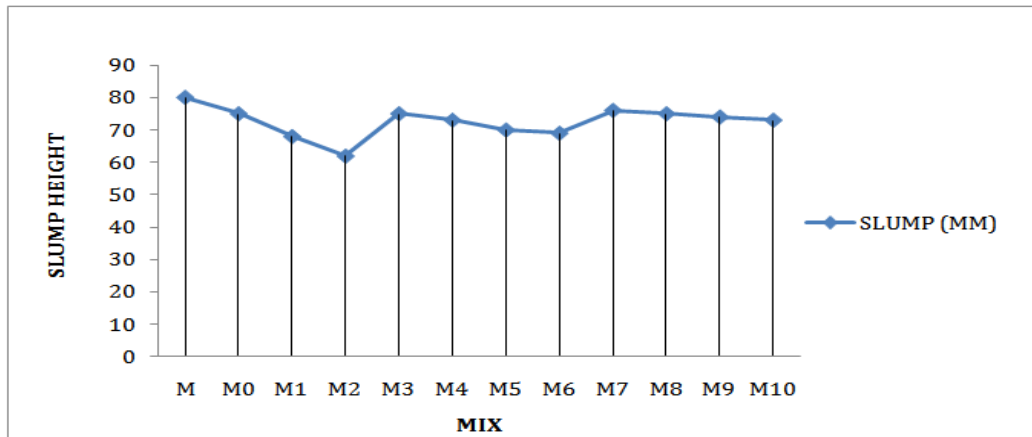


Fig.5.3 Line chart of Slump

COMPRESSIVE STRENGTH

Table 5.4: Shows compressive strength after various ages in N/mm²

MIX	Average Compressive strength of concrete In N/mm ²	
	7 DAYS	28 DAYS
M	20.31	29.44
M0	21.61	29.56
M1	21.18	28.43
M2	19.47	27.74
M3	22.05	30.34
M4	23.45	31.48
M5	24.65	32.09
M6	23.69	31.75
M7	21.83	29.69
M8	22.16	30.65
M9	23.86	31.81
M10	22.41	30.62

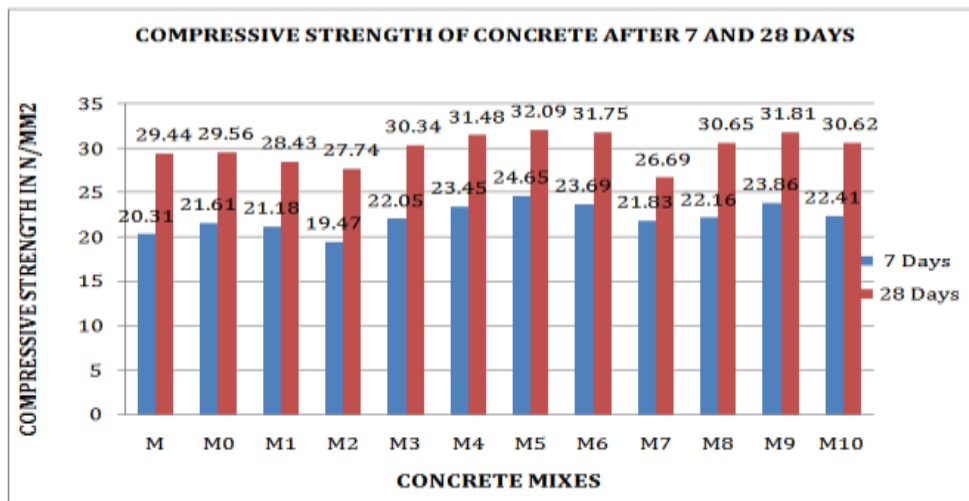


Fig.5.5 Bar chart of compressive strength of concrete

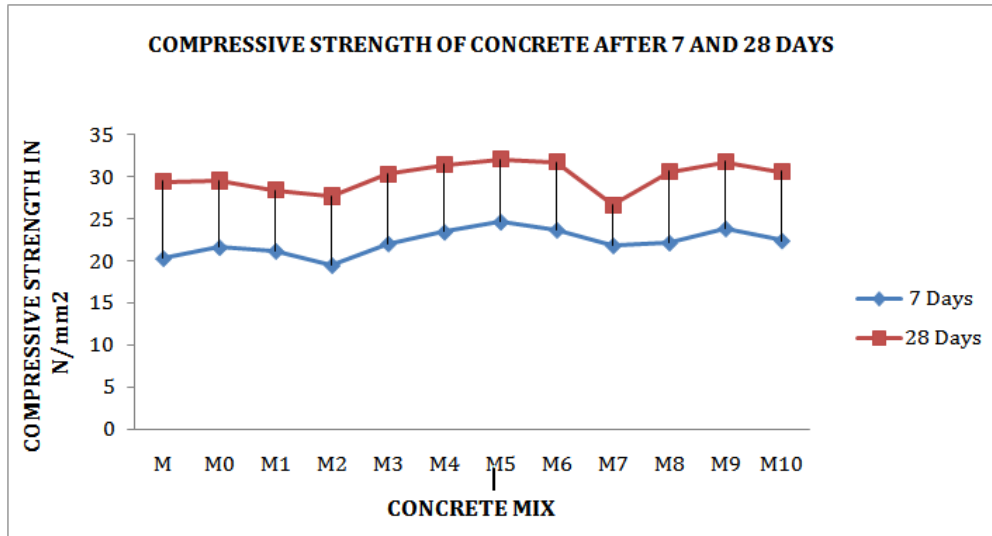


Fig.5.6 Line Diagram of compressive strength of concrete

SPLIT TENSILE STRENGTH

Table 5.7: Shows Average Split Tensile Strength of Concrete after various ages in N/mm²

MIX	Average Split Tensile strength of concrete In N/mm ²	
	7DAYS	28DAYS
M	2.51	3.65
M0	2.23	3.85
M1	1.81	3.42
M2	1.67	2.69
M3	2.56	3.72
M4	2.59	3.73
M5	2.62	3.75
M6	2.59	3.71
M7	1.81	3.52
M8	1.83	3.56
M9	1.88	3.61
M10	1.86	3.25

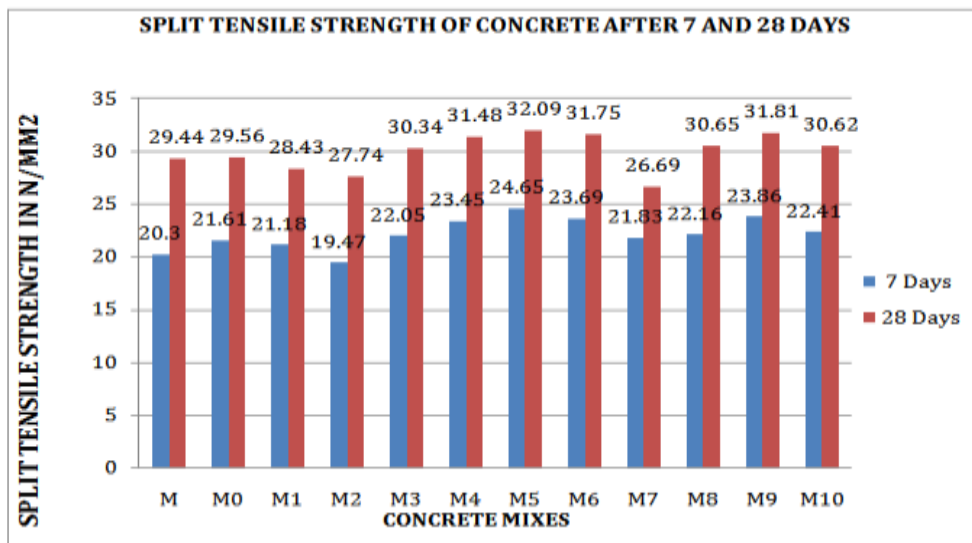


Fig.5.8 Bar chart of Split Tensile strength of concrete

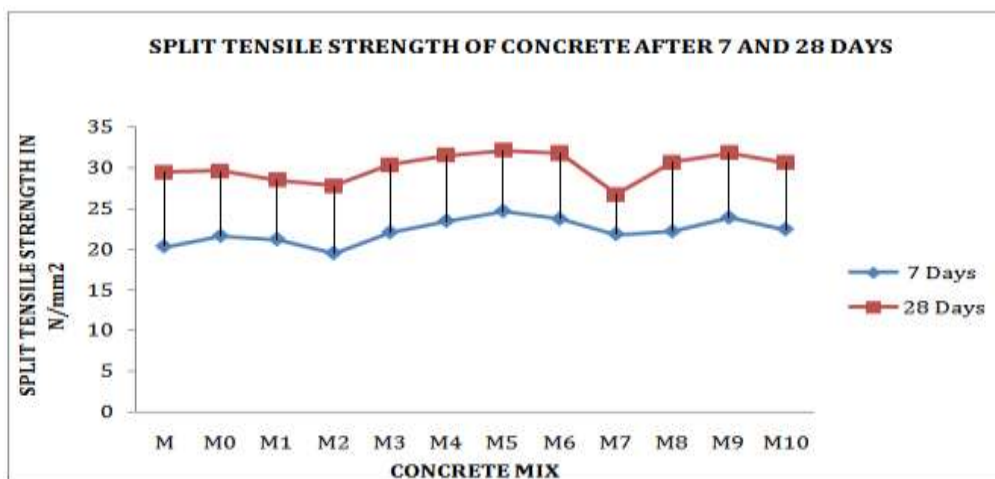


Fig.5.9 Line Diagram of Split Tensile strength of concrete

FLEXURAL STRENGTH

Table 5.10: Shows Average Flexural Strength of Concrete after various ages in N/mm²

MIX	Average Flexural strength of concrete	
	In N/mm ²	
	7DAYS	28DAYS
M	6.19	8.31
M0	8.28	9.81
M1	7.12	8.73
M2	6.47	7.49
M3	6.25	8.56
M4	6.31	9.16

M5	6.53	9.40
M6	6.17	7.81
M7	7.41	8.73
M8	7.64	8.82
M9	7.86	8.92
M10	7.52	8.21

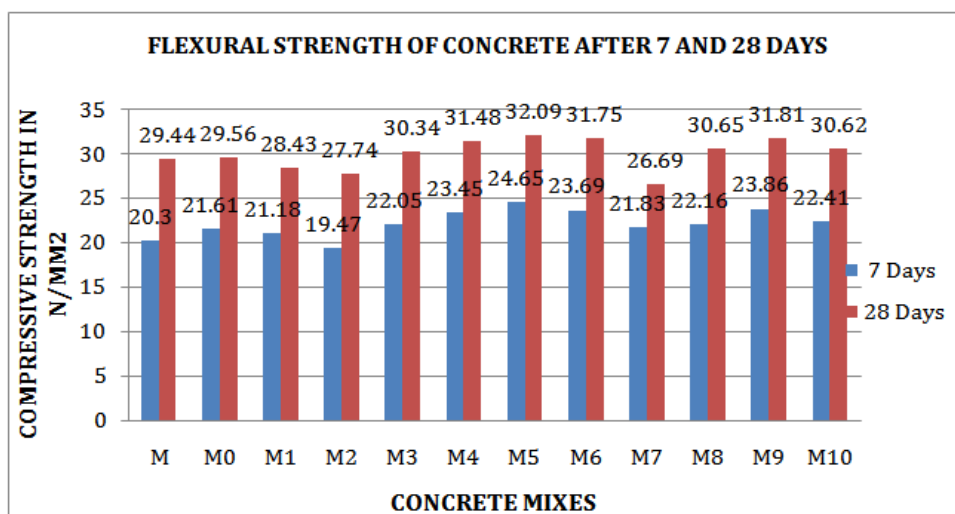


Fig.5.11 Bar chart of Flexural strength of concrete

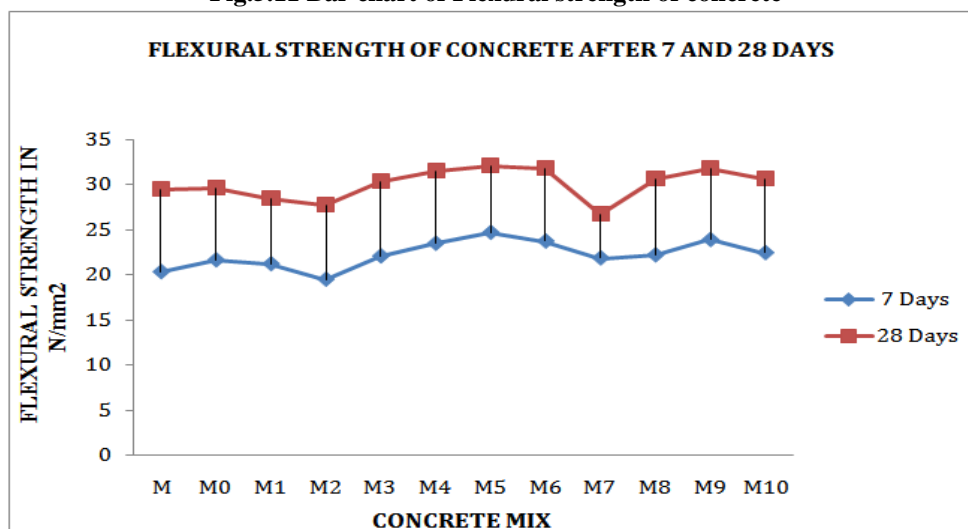


Fig.5.12 Line Diagram of Flexural strength of concrete

VI. CONCLUSION

- In Trial M₁, adding 0.6% treated pine fiber by NaOH show superior strength results when compared to other percentages.
- In Trial M₅, substituting 10% Dolomite by cement weight, show superior compressive strength results when compared to other percentages.
- Increasing the percentage of fiber decrease the compressive strength of concrete in trial M₀ show good compressive strength after that mix M₁, M₂, compressive strength goes to decrease.
- In trial M₅ show the Split tensile strength increased up to 10% dolomite powder replace

partially by total weight of cement then after goes to decrease.

5. In trial M_0 show the Split tensile strength of increased up to 0.6% adding natural pine fiber then after goes to decrease.
6. In trial M_5 show the Flexural strength increased up to 10% dolomite powder replace partially by total weight of cement then after goes to decrease.
7. In trial M_0 show the Flexural strength of increased up to 0.6% adding natural pine fiber then after goes to decrease.
8. In Trial M_9 show high compressive strength of 7 days is 23.86 N/mm² and 28 days is 31.81 N/mm² when combine addition of 10% dolomite powder replacing by weight of cement and 0.6% of natural pine fiber and after decrease compressive strength days is 22.41 N/mm² and 28 days is 30.62 N/mm² when combine addition of 12.5% dolomite powder replacing by weight of cement and 0.6% of natural pine fiber.
9. In Trial M_9 show high split tensile strength of 7 days is 1.88 N/mm² and 28 days is 3.61 N/mm² when combine addition of 10% dolomite powder replacing by weight of cement and 0.6% of natural pine fiber and after decrease split tensile strength of 7 days is 1.86 N/mm² and 28 days is 3.25 N/mm² when combine addition of 12.5% dolomite powder replacing by weight of cement and 0.6% of natural pine fiber.
10. In Trial M_9 show high flexural strength 7 days is 7.86 N/mm² and 28 days is 8.92 N/mm² when combine addition of 10% dolomite powder replacing by weight of cement and 0.6% of natural pine fiber and after decrease flexural strength 7 days is 7.52 N/mm² and 28 days is 8.21 N/mm² when combine addition of 12.5% dolomite powder replacing by weight of cement and 0.6% of natural pine fiber.
11. Increase the percentage of fiber decrease the workability.
12. Increase the percentage of dolomite powder partially replaced by total weight of cement decrease the workability.
13. When increasing the percentage of both pine fiber and dolomite powder in concrete slightly decrease the workability.

FUTURE SCOPE

1. To add the mineral admixtures in different proportions to pine fiber, more research is needed.
2. Dolomite powder can be used in experimental

research for various natural or manufactured fibers.

3. Dolomite has a lower carbon emission good cementitious property and easily availability, which increases its strength and durability at a lower cost. It is evident from examining several studies that green concrete may replace regular concrete in the future.
4. To evaluate the overall cost-effectiveness of employing pine fiber in comparison to conventional concrete reinforcement, more research is required.
5. Ongoing investigation of the long-term resilience of concrete reinforced with pine fibers in a different environmental conditions.

REFERENCES

- [1]. Preethi,G.&Prince,G.(2010),“Effect of Replacement of Cement with Dolomite Powder on the Mechanical Properties of Concrete” International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 2, April 2010,ISSN 2348 – 7968.
- [2]. JS Kumar et al. (2011), “Experimental\ Physical and Chemical characteristics of Dolomite for Partial Replacement of Cement in M20 Concrete”. Engineering & Technology in India, Vol. 1.5 December 2011, ISSN 2472-8640.
- [3]. Sugathan A. (2011), “Experimental Investigation on partial Replacement of Cement with dolomite powder”. International Journal of Innovative Research in Science, Engineering and Technology. Vol. 6, Issue 7, July 2011. ISSN (Online): 2319-8753.
- [4]. R. Seneviratne & G. Tharmarajah (2011), “Experimental Study on Addition of Pine Fibers to High Strength Concrete”, Academic Journal of Civil Engineering, Volume 20, Issue 2, June 2011, ISSN 1584-5990.
- [5]. Admane. et al., (2012), “Experimental study of performance of concrete with partial replacement of cement by dolomite” International Journal for Research in Applied Science and Engineering Technology, Volume 5 Issue VI Jun 2022, ISSN: 2321-9653.
- [6]. Basha, S. A. et al. (2012) “Impact of quarry dust & dolomite powder on compressive strength of concrete” Journal of Emerging Technologies and Innovative Research (JETIR) ,Volume: 5, 6June 2012 ISSN: 2349-5162 .

- [7]. VK Thakur & AS Singha, (2012), "Natural fibers'-based polymers: part I mechanical analysis of Pine needles reinforced bio composites "Bulletin of Materials Science. Volume: 33 Issue: ISSN: 0250-4707.
- [8]. Dong, C., et al. (2014) "Tensile strength of pine needles and their feasibility as reinforcement in composite materials" Journal of Materials Science, volume 49, issue 23, August 7, 2014, ISSN 0022-2461.
- [9]. Milosz S. & Wiesława N. W. (2015) "Experimental investigation on strength properties of self curing concrete using sodium lignosulphonate as self-curing agent" Procedia Engineering, volume 108, July 2015, ISSN 1877-7058.
- [10]. Deepthi, C. G., & Shindon, B. (2016) "Study on compressive strength of concrete with dolomite powder and crushed tiles" International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), volume -5, issue-9, September 2016, ISSN 2319-8753
- [11]. Ballesteros et al. , (2017) "Potential of the hornification treatment on eucalyptus and pine fibers for fiber-cement applications" Cellulose, volume-25, issue-5, May 2017, ISSN 0969-0239
- [12]. Udhayasakthi, M. R., & Sarath kumar , M. K. P. (2018) "Experimental investigation of glass fiber reinforced concrete with partial replacement of cement by dolomite powder" International Research Journal of Engineering and Technology (IRJET), volume-5,issue-11, November 2018, ISSN 2395-0056
- [13]. F. Jove -Sandoval et al., (2018) "Assessment of the mechanical performance of three varieties of pine needles as natural reinforcement of adobe" Construction and Building Materials, May 2018, ISSN 0950-0618
- [14]. Sandeep. G. et al. , (2019) "Impact behavior of pine needle fiber/pistachio shell filler based epoxy composite" Journal of Physics: Conference Series, volume-1240, December 2019, ISSN 1742-6588
- [15]. Dhamne, P. et al. , (2019) "Experimental Investigation on replacement of cement in Concrete partially by using dolomite powder" International Journal of Trend in Scientific Research and Development (IJTSRD), volume-3,issue-3, April 2019, ISSN 2456-6470
- [16]. P.Bhusare & P. B. Ghodake 2019"Experimental study of effect concrete properties with partial replacement of cement by Dolomite powder "International Journal for Research in Applied Science & Engineering Technology (IJRASET), volume-7,issue-10, October 2019, ISSN 2321-9653
- [17]. Zain-Ul-Abdin & Anwar Khitab, (2020) "Effect of pine needle fibers on properties of cementitious mortars "Proceedings of the Pakistan Academy of Sciences: Part A, volume-57, issue-4, july2020, ISSN 2518-4261
- [18]. K.C. Gund & V.G. Patwari, (2020) "Effect on concrete strength due to partial replacement of cement in concrete with dolomite powder" International Journal for Research in Applied Science & Engineering Technology (IJRASET) , Volume 7, Issue X, October 2020. ISSN 2321-9653
- [19]. Chen & Wang (2021) "Complete stress-strain curves for pine needle fiber reinforced concrete under compression "Construction and Building Materials, volume-302, Article no. 124387, October 4, 2021, ISSN 0950-0618
- [20]. J. Sree Naga Chaitanyaetal. , (2022) "An experimental investigation on properties of concrete by partial replacement of cement with dolomite powder by using abaca fiber" International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), Volume 2, Issue 6, June 2022. ISSN 2581-9429.
- [21]. Mustafa.T.C. , (2022) "Investigation of mechanical properties of red pine needle fiber reinforced self-compacting ultra high performance concrete" Case Studies in Construction Materials, July 2022, ISSN 2214-5095
- [22]. Harish K S. et al. (2023) "An experimental investigation on aramid fiber concrete by partial replacement of cement with dolomite powder"International Journal of Engineering Research & Technology (IJERT), Volume 11, Issue 05.ISSN2278-0181
- [23]. Jagadisha C.E, J. M Nkj (2023) "An experimental study on partial replacement of cement by Dolomite powder" International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 11, Issue VI, June 2023. ISSN 2321-9653.