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AN EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF RECYCLED AGRREGATES CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY DOLOMITE DUST POWDER

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ABSTRACT

Cement is one of the most important constituent of concrete. It is manufactured using materials like limestone, clay and marl. The dolomite is an anhydrous carbonate mineral made out of calcium magnesium carbonate. Earlier studies indicated that Dolomite Dust Powder (DDP) consist characteristics as of cement and it reduces the cost and increase strength to some extent. The study aims at evaluating of strength properties by partial replacement of cement by DDP and usage of recycled aggregates over conventional aggregates. DDP is used as partial replacement at 0, 10, 20 and 30% by weight of cement and recycled aggregate is completely replaced with conventional aggregate and M30 grade of concrete is used. Fresh properties of concrete are determined by slump cone, compaction factor and Vee-Bee test and further compressive strength, tensile strength and flexural strength of concrete evaluated at 7, 14, 21 and 28 days respectively.

Keywords: Dolomite dust powder, Recycled aggregate, Slump cone, Compaction factor, Vee-Bee, Compressive strength, Tensile strength and Flexural strength.

1. INTRODUCTION

In today's world, concrete stands as the reigning champion among building materials. It finds extensive use in constructing a multitude of structures, including skyscrapers, industrial parks, highways, roadways, and hydro constructions. Concrete is the preferred choice its adaptability to diverse geometric forms. Concrete does pose challenges in terms of disposal, health risks, and aesthetic concerns. The cement production process depletes lime resources globally and consumes substantial energy.

The genesis of Dolomite Dust Powder can be attributed to the weathering of sedimentary rock-generating minerals. Dolostone, up to a certain percentage, can serve as a filler material in cement for concrete. This chemical transformation is termed dolomitization, and it results in the formation of $CaMg(CO_3)_2$, better known as dolomite. Dolomite boasts exceptional flowability and dispersibility, coupled with high resistance to weathering. Its polished surface, strength, and density render it a favored building material. Dolomite presence as a filler element in concrete applications enhances strength and hardness, thereby potentially reducing construction costs and increasing structural durability. It's important to distinguish between cement and concrete; the former refers exclusively to the binding material within concrete. Concrete incorporates various components, including cementitious composites like fly ash and dolomite, coarse aggregates such as crushed stone, sandstone, and granite, as well as sand and water.

Recycled aggregates play a pivotal role in sustainable construction practices. These aggregates are derived from the processing of previously used concrete and construction materials, which are then crushed and repurposed for new building projects. By incorporating recycled aggregates into concrete production, we contribute to resource conservation and reduce the environmental impact of construction. Their utilization not only minimizes waste but also conserves natural resources, making them an essential component in the evolution of eco-friendly construction practices, in alignment with the global efforts to promote sustainability in the built environment.

2. LITERATURE REVIEW

Tran and et.al.,[1] delves into the potential of recycled concrete aggregate for medium-quality structural concrete, shedding light on its suitability for applications beyond the conventional. Their findings not only underscore the feasibility but also the advantages of incorporating Recycled Concrete Aggregate (RCA) into structural projects, ultimately contributing to sustainability goals in construction. Martinez-Echevarria and et.al.,[2] explored a critical aspect of improving the mechanical behavior of recycled aggregates through crushing treatment. Their research investigates methods to enhance the mechanical properties of recycled aggregates, making them not only usable but also advantageous for unbound road layers, demonstrating the versatility of RCA. Diotti, and et.al.,[3] the chemical and leaching behavior of construction and demolition wastes, alongside recycled aggregates. This study highlights the environmental implications of integrating recycled materials into construction practices. Fresh concrete properties are a pivotal consideration in construction, and Lavado, Bogas, and et.al.,[4] focuses precisely on that. Their work provides valuable insights into the workability and performance of concrete mixes containing recycled aggregates, helping to address concerns about practicality and quality. Diotti, Sorlini, and et.al.,[5] explore the valorization of construction and demolition waste in the construction sector. This research advocates for sustainable practices within the industry, emphasizing the potential to transform waste into valuable resources, thereby promoting circular economy principles. Muthukumaran, and et.al.,[6] investigate the strengthening of concrete through partial replacement of dolomite and M-sand for cement and fine aggregate. This research underscores the importance of exploring alternative materials in concrete production, offering potential avenues for enhancing concrete performance while reducing resource dependency. Santosh Kumar and et.al.,[7] delve into the use of a unique two-stage mixing approach for recycled aggregate concrete. Their research provides valuable insights into optimizing the utilization of recycled aggregates to enhance concrete properties while addressing the challenges associated with their incorporation. Kumar and et.al.,[8] investigate the behavior of high-performance concrete when recycled aggregates are used in beams subjected to static and cyclic loading conditions. Their work contributes to understanding the structural performance of concrete with recycled aggregates in demanding situations. C. Sangeetha's and et.al.,[9] research examines the performance of concrete with dolomite and vermiculite as partial replacements for cement and fine aggregate. Respectively this study explores alternative materials and their impact on concrete properties, offering insights into sustainable concrete production. Ramadevi and et.al.,[10] investigate the use of alternative materials in building construction. Their study explores the broader context of sustainability in construction and highlights the importance of considering alternative materials as part of sustainable practices. John K. Makunza and et.al.,[11] research focuses on sustainable concrete production using recycled aggregates. The study emphasizes the potential of recycled materials in achieving sustainability goals in the construction industry. Preethi Getal and et.al.,[12] researched using dolomite powder as a partial cement replacement in M20 concrete. Up to 10% substitution yielded the highest flexural and compressive strength (31.24 N/mm² and 8.48 N/mm², respectively), with peak tensile strength at 15% (4.25 N/mm²). Dolomite powder also reduced mortar costs due to its cost-effectiveness compared to cement. Deepa Bala Krishnan S and Paulose K.C and et.al.,[13] explored self-compacting concrete with fly ash and Dolomite powder. They replaced clinker with fly ash and cement with dolomite powder, yielding improved performance in both fresh and hardened concrete compared to the reference mixture.

3. OBJECTIVES OF RESEARCH

1. The main objective of the current study includes to analyze the influence of recycled aggregates and Dolomite Dust Powder on fresh properties of M30 grade concrete.
2. To examine the consequences of utilizing recycled aggregates as a replacement for coarse aggregates

and DDP as a partial substitute for cement in M30 concrete, particularly concerning factors like compressive strength, splitting tensile strength, and flexural strength.
3. To identify the optimal dosage of DDP and recycled aggregate with desirable properties.

4. MATERIALS AND METHODOLOGY

The blends were created with the goal of giving concrete its maximum strength. The mix proportions of the different materials used in the concrete mixes are provided based on the IS 10262-2019 [17]Code approach.

4.1. MATERIALS USED

4.1.1. Cement

Ordinary Portland Cement (OPC) of 53 grade, supplied by JSW cement Pvt. Ltd., has been used in the present investigation. The specific gravity of cement is determined as 3.15.

4.1.2. Recycled Coarse aggregate

Recycled coarse aggregate are the crushed and processed construction waste used in place of natural coarse aggregates in construction. Process involves collecting, sorting, cleaning, and crushing old construction materials. The specific gravity of recycled aggregates is determined as 2.74

4.1.3. Fine aggregate

Sand is a naturally occurring substance composed of minuscule fragments of rock and mineral. we used the river sand found locally, which was passing through a 4.75mm IS sieve and conforming to grading zone II of IS: 383- 1970[18]. The specific gravity of sand is determined as 2.65.

4.1.4. Dolomite Dust Powder

The dolomite dust powder used in this study has been collected from the quarries located at Rayalacheruvu village, Yadiki Mandal, Ananthapur district, Andhra Pradesh. The specific gravity of dolomite dust powder has been determined as 2.74.

4.1.5. Super plasticizer

Superplasticizers (SP) are added to fresh concrete to enhance its workability. Conplast SP 430 DIS is the Super plasticizer utilized in this investigation. The specific gravity of super plasticizer is achieved as 1.15.

4.1.6. Water

The primary ingredient in making concrete is water. Concrete was mixed and cured using drinkable water. Oils, acids, alkalis, salts, biological matter, and other pollutants that might harm concrete should not be present in the water used to mix concrete, including the free water on the aggregates.

4.2. METHODOLOGY

In this study to evaluate the effects of DDP and Recycled aggregate as partial replacement to cement and complete replacement to coarse aggregate respectively the following process is followed.

1. The materials taken at first fine and aggregates will be thoroughly mixed and then cement and water is added until an uniform concrete paste forms.
2. Determination of workability properties (Slump cone, Compaction factor and Vee-Bee) of M30 grade concrete at fresh state.
3. A total of 48 cubes, 48 cylinders and 48 beam specimens are casted in four groups.
4. Determination of compressive strength properties using cube specimens of 150X150X150mm, Split tensile strength using cylindrical specimens of diameter 150mm and length 300 mm and flexural strength of concrete using beam specimens of 500X100X100 mm with DDP and recycled aggregate at hardened state at 7, 14, 21 & 28 days respectively.

5. RESULTS & DISCUSSIONS

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5.1. FRESH PROPERTIES OF CONCRETE

5.1.1. Slump cone test

The workability properties of freshly mixed concrete were assessed through the slump cone test for all four groups of concrete mixes. The results followed trend for the conventional concrete mix, the slump value measured 74 mm. interestingly, as the proportion DDP gradually replaced cement at rates of 0%, 10%, 20%, and 30%, the slump value decreases. At the 30% of DDP replacement the slump value reached 53 mm as depicted in figure 1.

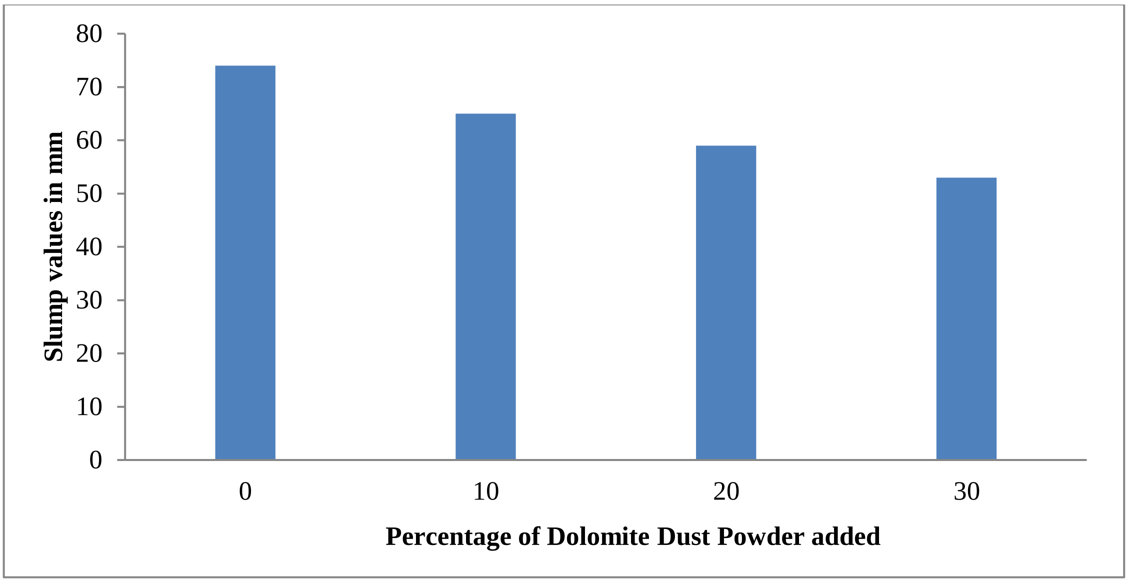

Fig 1. Variation of Slump test

The addition of DDP made the slump was shown to diminish, which indicates a decrease in the concrete's capacity to flow and hold its shape. This drop can be linked to changes in DDP's physical characteristics. These characteristics, such as particle size and shape, probably hampered the movement of concrete particles and reduced the mix's overall flowability. DDP essentially served as a filler substance that impeded the concrete's smooth flow and decreased the slump value.

5.1.2. Compaction factor test

The workability properties of freshly mixed concrete were assessed through the compaction factor test for all four groups of concrete mixes. The results followed trend for the conventional concrete mix, the compaction factor value measured 0.92. Interestingly, as the proportion DDP replaced cement at rates of 0%, 10%, 20%, and 30%, the compaction factor value decreases. At the 30% of DDP replacement the compaction factor value reached 0.68 as depicted in figure 2.

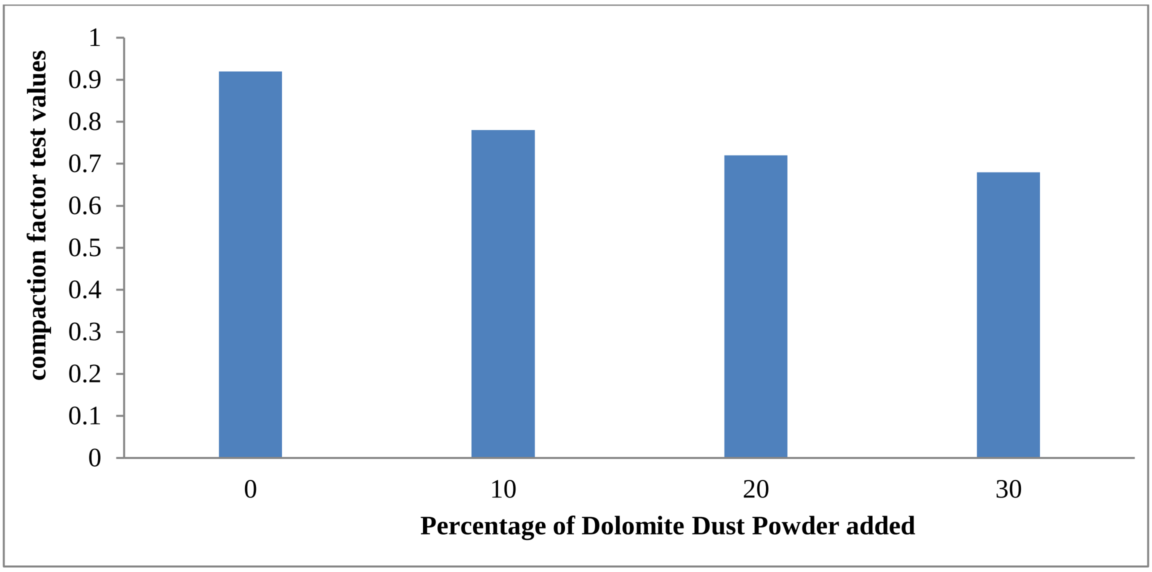

Fig 2. Variation of Compaction factor test

The addition of DDP made the compaction factor was shown to diminish, which indicates a decrease in the concrete's capacity to flow and hold its shape. This drop can be linked to changes in DDP's physical characteristics. These characteristics, such as particle size and shape, probably hampered the movement of concrete particles and reduced the mix's overall flowability. DDP essentially served as a filler substance that impeded the concrete's smooth flow and decreased the compaction factor value.

5.1.3. Vee-Bee test

The workability properties of freshly mixed concrete were assessed through the Vee-Bee test for all four groups of concrete mixes. The results followed trend for the conventional concrete mix, the Vee-Bee value measured 4.5 sec. Interestingly, as the proportion DDP gradually replaced cement at rates of 0%, 10%, 20%, and 30%, the Vee-Bee value increased. At the 30% of DDP replacement the Vee-Bee value reached 6.5 sec as depicted in figure 3.

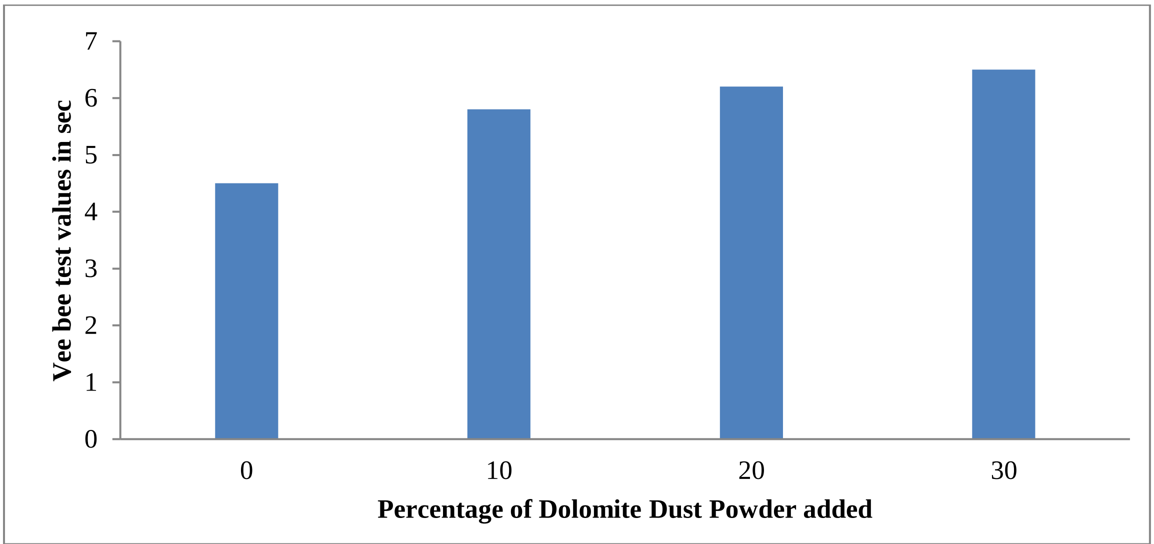

Fig 3. Variation of Vee-Bee test

The presence of DDP may have made the concrete mix more viscous or resistant to compaction, as indicated by the increase in the Vee-Bee value, which indicates a longer time needed for compaction. This increased viscosity may have resulted from DDP's interaction with the other concrete ingredients, which changed the rheological properties of the mix. The concrete became less compaction-friendly as a result, and the Vee-Bee test took longer to reach the appropriate amount of compaction.

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5.2. HARDENED PROPERTIES OF CONCRETE

From the explanation above, it is clear that adding Dolomite powder as a replacement to cement and recycled aggregate as complete substitution to coarse aggregate shows reasonable influence on the workability of concrete when it is still fresh. Therefore, it is crucial to consider whether this effect will lead to changes in the varying characteristics of concrete during its hardened condition when the experimental program was carried out as a consequence.

5.2.1. Compressive strength test

Table 1 presents the compressive strength data for curing periods of 7, 14, 21 and 28 days. The conventional mix achieved a compressive strength of 38.55 N/mm² at 28 days. Notably, the mix incorporating 10% DDP replacement in conjunction with 100% recycled aggregates as a substitute for coarse aggregates surpassed all other mixtures, attaining a compressive strength of 41.45 N/mm², shown in figure 4. This represents an enhancement of 7.52% in compressive strength at 28 days.

Table 1. Variation of Compressive strength (N/mm²)

Percentage replacement of Dolomite Dust Powder	7 days	14 days	21 days	28 days
0	13.02	24.44	30.25	38.55
10	16.11	28.92	34.12	41.45
20	13.99	26.54	32.11	39.45
30	12.10	24.86	30.11	37.55

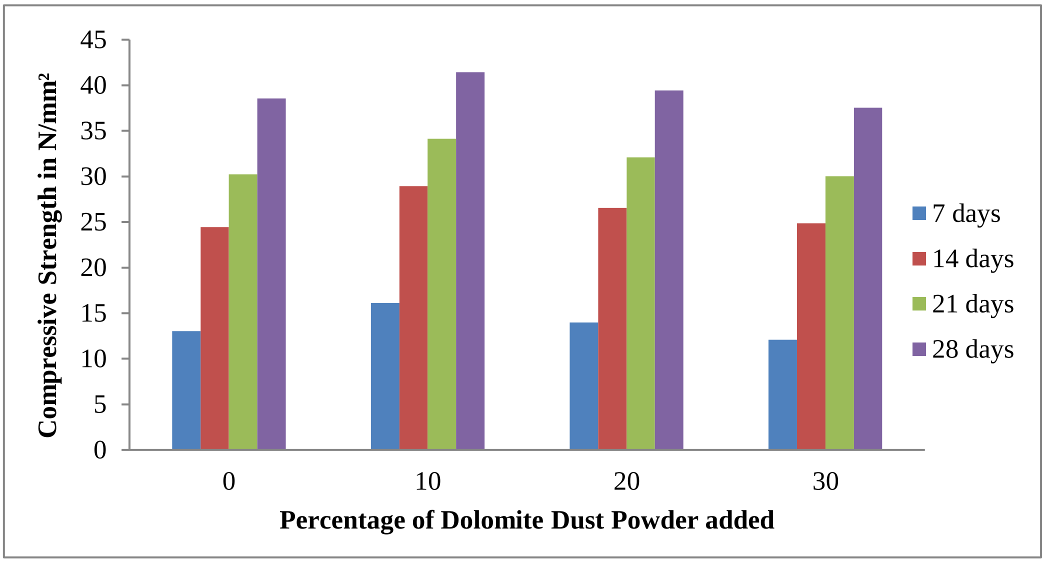

Fig 4. Variation of Compressive strength

5.2.2. Split tensile strength test

Table 2 presents the split tensile strength values for curing periods of 7, 14, 21 and 28 days. The conventional mix exhibited a split tensile strength of 3.70 N/mm². Remarkably, the mix incorporating 10% DDP replacement in conjunction with 100% recycled aggregates as a substitute for coarse aggregates outperformed all other mixtures, achieving a split tensile strength of 4.32 N/mm², shown in figure 5. This represents an enhancement of 16.67% in split tensile strength at 28 days.

Table 2. Variation of Split tensile strength (N/mm²)

Percentage replacement of Dolomite Dust Powder	7 days	14 days	21 days	28 days

0	1.30	2.56	3.20	3.70
10	1.75	3.14	4.01	4.32
20	1.41	2.70	3.45	4.10
30	1.27	2.55	3.1	3.75

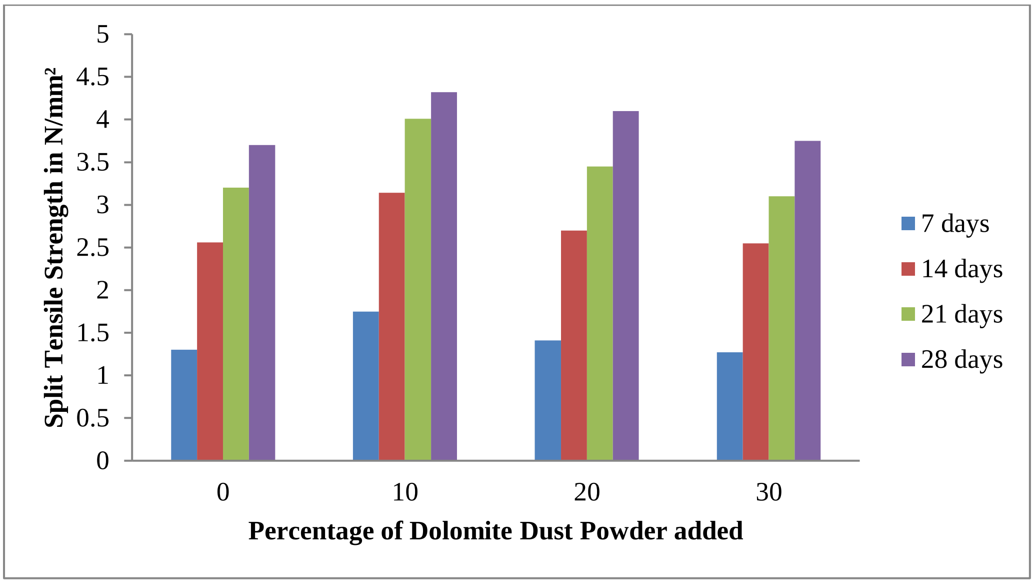

Fig 5. Variation of Split tensile strength

5.2.3. Flexural strength test

Table 3 presents the flexural strength values for curing periods of 7, 14, 21 and 28 days. The conventional mix achieved a flexural strength of 8.00 N/mm². Notably, the mix incorporating 10% DDP replacement in conjunction with 100% recycled aggregates as a substitute for coarse aggregates surpassed all other mixtures, attaining a flexural strength of 9.10 N/mm², shown in figure 6. This represents an enhancement of 13.75% in flexural strength at 28 days.

Table 3. Variation of Flexural strength (N/mm²)

Percentage replacement of Dolomite Dust Powder	7 Days	14 Days	21 Days	28 Days
0	2.67	5.44	6.80	8.00
10	3.12	6.35	7.91	9.10
20	3.00	5.55	6.98	8.70
30	2.81	5.12	6.45	8.01

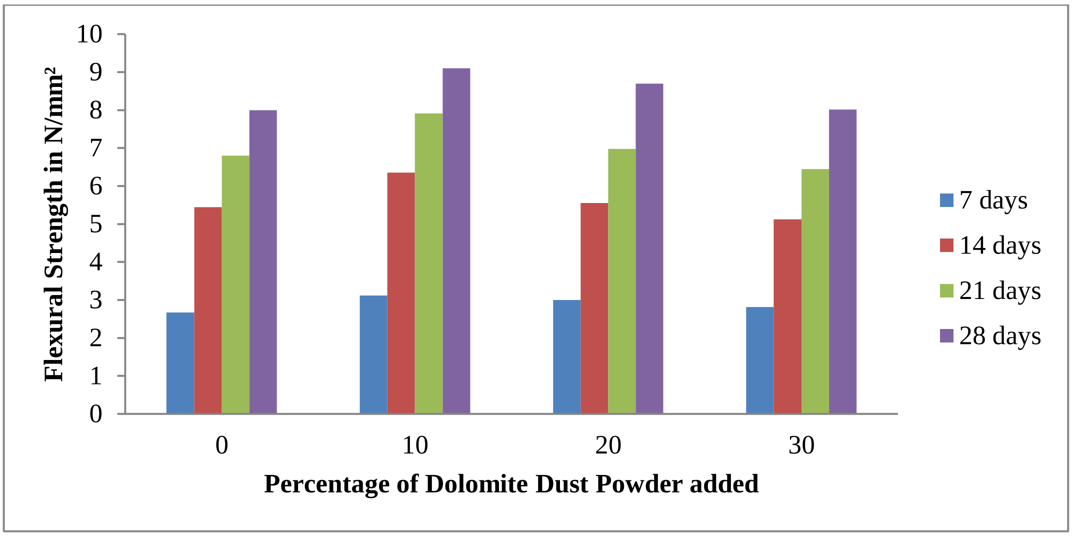

Fig 6. Variation of Flexural strength

DDP can serve as a filler and increase the packing density of the concrete mixture. Additionally, the presence of DDP has helped to create a stronger microstructure with a more refined microstructure that has fewer voids and better interfacial bonding. The greater adherence of the aggregates to the cement matrix may have been helped by DDP, boosting the concrete's ability to support more weight and its tensile strength. The presence of DDP, which increased the interfacial transition zone between the cement matrix and the aggregates. DDP has helped the mix pack the particles more tightly, which improved the concrete's ability to withstand bending loads. The combined effect of DDP and recycled aggregates is responsible for these notable increases in concrete strength qualities. Recycled aggregates increased particle packing, whereas DDP served as an additional cementations ingredient to improve the matrix structure and interfacial bonding.

6. CONCLUSIONS

These findings have been customized for this research project and have the potential to significantly improve our understanding of how Dolomite Dust Powder impacts the properties of concrete. Below, we present the key discoveries from this study.

1. The Workability results performed by slump cone test, compaction factor test and Vee-bee test shows that, the workability of concrete is decreased when DDP is replaced with cement.
2. From the findings, after a 28-day testing period, the analysis of hardened concrete containing DDP showed notable improvements in compressive strength, with the maximum increase recorded as 7.52%.
3. It was observed that the greatest enhancement in split tensile strength occurred at a 10% DDP substitution rate alongside 100% recycled aggregates, resulting in an impressive 16.67% increase compared to the conventional concrete mix after 28 days.
4. Similarly, the maximum flexural strength was achieved at a 10% DDP replacement rate, combined with 100% recycled aggregates, leading to a 13.35% increase in flexural strength compared to the standard concrete mix after 28 days.
5. The findings strongly suggest that the most favorable combination for achieving maximum compressive, split tensile and flexural strengths in concrete involves substituting 10% of cement with DDP while completely replacing coarse aggregates with recycled aggregates.

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