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AN EXPERIMENTAL INVESTIGATION ON STRENGTH CHARACTERISTICS OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH DOLOMITE AND OYSTER SEA SHELL

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Abstract - *Concrete is most adaptable, durable and reliable construction material over the world and it is the most important basic material in all civil engineering structures. The production of cement in world has greatly increased, due to this emission of CO_2 gas has been increased ultimately leads to environmental pollution. Research is taking place on all corners of the globe in search of different material options. The Present study aims to explore the feasibility and effectiveness of using Dolomite and Oyster Sea Shell as partial replacements of Cement in Concrete Production. Dolomite is an anhydrous carbonate mineral composed of calcium magnesium carbonate ($CaMg(CO_3)_2$). Oysters are the dead remains of Aquatic organisms. The Experimental investigation is carried out on M30 Grade of Concrete. Firstly, the cement is partially replaced with Dolomite powder ranges from 0%, 5%, 10%, 15%, to 20%. Further, find the optimum % of Dolomite powder. Then with that optimum % of Dolomite powder, the cement is replaced with Oyster Sea Shell powder in percentages of 0%, 5%, 10%, 15%, and 20%. The properties of hardened concrete such as Compressive strength, Split tensile strength, Flexural strength, Non-Destructive Tests like Rebound hammer and Ultrasonic pulse velocity are determined by conducting laboratory experiments on concrete samples and the results are compared with conventional concrete. The findings of this study reveal that 10% of Dolomite powder and 10% of Oyster Sea Shell powder are optimum replacements which has significant effect on the strength properties of concrete.*

Key Words: Dolomite powder, Oyster Sea Shell powder, Compressive strength, Split tensile strength, Flexural strength and Non-Destructive Tests, Concrete Mix design M30.

1. INTRODUCTION

Concrete is the most widely used man-made building material in the world, owing to its versatility and relatively low cost, concrete has also become the material of choice for the construction of structures exposed to extreme condition (Lomborg(2001)). Concrete plays a vital role in the development of infrastructure Viz.., buildings, industrial structures, bridges and highways etc, leading to utilization to large quantity of concrete. Cement manufacture contributes greenhouse gases both directly through the production of carbon dioxide when calcium carbonate is heated, producing lime & carbon dioxide and indirectly through the use of energy, particularly if the energy is sourced from fossil fuels. The cement industry produces about 5% of global man made CO_2 emissions, which 50% is from the chemical process, and 40% from burning fuel. The amount of CO_2 emitted by the cement industry is nearly 1.0 tons of CO_2 for every 1.0 ton of cement produced.

In the present era of development due to advanced techniques, material availability and growing standard of living, the construction activities are increasing exponentially with time. The increased construction activities and exploiting the available natural resources drastically are posing serious environmental problem. However construction activities leading to development in social and economic aspects cannot be stopped or reduced for the sake of conservation of natural resources. Therefore, there is a need to explore alternative building materials from industrial, agricultural waste and coastal waste materials. Researchers all over the world today are focusing on ways of utilizing different types of waste materials as a source of raw materials for industry. Replacing alternative materials in cement for concrete production is important to address environmental concerns, conserve natural resources, reduce costs, and improve the performance of concrete. Dolomite powder and oyster sea shell powder are two such materials that have shown potential in replacing cement in concrete production.

1.1 Dolomite Powder

It is a carbonaceous (or) carbonate material which is composed of calcium magnesium carbonate [$CaMg(CO_3)_2$]. Dolomite Powder is the limestone powder with composition of $CaCO_3$ and $MgCO_3$ pertaining to 100% in combination, the proportion being varied as per mining zone. It is formed from limestone, which is subjected to high pressure and temperature in the earth's crust. It is also called as dolostone (Dolomite Rock). It is commonly used as a filler material in a wide range of industrial applications, including in the construction industry, where it is used as a partial replacement for cement in concrete. However, it is important to note that the amount of dolomite powder that can be used as a partial replacement for cement will depend on a variety of factors, including the specific properties of the dolomite, the properties of the cement, and the desired properties of the concrete mix. Additionally, it is important to ensure that the dolomite powder is of high quality and meets the relevant standards and specifications for use in concrete. Dolomite powder has pozzolanic properties, it can react with the calcium hydroxide produced by the hydration of cement to form additional cementitious compounds. This reaction can improve the strength and durability of the concrete.

1.2 Oyster Sea Shell Powder

Oyster Sea Shell Powder is a fine, white powder made by crushing and grinding the shells of oysters that are harvested for their meat. It is a coastal waste material generated from the seafood industry and is a rich source of calcium carbonate. Oyster Shells are considered as a good alternative to cement, because of their physical and chemical characteristics. In concrete works, oyster sea shell powder is used as a partial replacement for cement. This is because it can act as a filler material, reducing the amount of cement needed in the concrete mixture. Oyster sea shells are often discarded as waste, but they can be repurposed as a valuable in construction materials such as concrete, reducing the amount of waste generated and promoting sustainable resource use. It can be used as a partial replacement for cement up to certain percentage without significantly affecting the mechanical properties of concrete. The percentage of replacement depends on various factors such as the quality of oyster shell powder, water-cement ratio, curing time, and so on. Quicklime is obtained from oyster shells when the $CaCO_3$ in the shell is heated at an excess of 2000°F or about 1100°C and converted to calcium oxide (CaO), otherwise known as lime.

2. LITERATURE REVIEW

Dr. Sachin V Admane, Tabassum sayyad et al. (2020) had examined the strength properties of concrete by partial replacement of cement with dolomite powder, because it has similar configuration as of the cement. Dolomite is a carbonate material composed of calcium magnesium carbonate ($CaMg(CO_3)_2$). Dolomite is preferred for construction material due to its surface hardness and density. M30 grade of concrete was used to prepare the concrete mixes. In this study, the dolomite as replaced in cement in different percentages i.e., 0%, 5%, 10%, and 15%. Concrete cubes, cylinders and prisms are casted and cured for 7 and 28 days. Tests on hardened concrete like compressive strength, split tensile strength and flexural strength were conducted and test results found that 10% replacement of dolomite powder in concrete mix increased the values of compression, split and flexural strengths of concrete.

Abhijeet B.Moghe, G.D. Dhawale et al. (2020) conducted an experimental procedure to investigate the effect of using oyster shell powder as partial replacement of cement. Tabby is a type of concrete made by burning oyster shells to create lime, then mixing it with water, sand, ash and broken oyster shells. The main objective is to support the use of these outwardly waste products as a construction material. In this study, the oyster sea shell powder is partially replaced in cement with various percentages i.e., 0%, 5%, 10% and 15%. M25 grade of concrete was used. The Cubes, Cylinders and Prisms are Casted and Cured for 7, 14 and 28 days and the Compressive Strength, Split Tensile and Flexural Strength tests were conducted. The replacement of oyster shell powder with cement found to be increase in strength with 5% and 10% replacement than conventional concrete. It was observed that, compressive and split tensile Strengths were increased with 10% replacement and Flexural Strength was increased with 5% replacement than the Control Concrete.

3. MATERIALS

3.1 Cement: Ordinary Portland cement of 53 grade conforming to IS: 12269-2013 is used. Name of the Cement bag used is Zuari Cement. Specific Gravity of cement is 3.14.

3.2 Fine Aggregate: Locally accessed Zone 2 Fine Aggregate as per IS:383-1970 is used. Fine aggregate, those fractions from 4.75 mm to 150 micron are termed as fine aggregate. Specific Gravity of Fine Aggregate is 2.57. Fineness Modulus of Fine Aggregate is 2.74.

3.3 Coarse Aggregate: The aggregate retained over IS sieve 4.75mm is termed as coarse aggregate. The Shape of the coarse aggregate used for the concrete is angular. Machine crushed granite aggregate confirming to IS: 383-1970 consisting 20mm maximum size of aggregates has been obtained from the local quarry. In this study, 60% of 20mm and 40% of 12mm is used to prepare the concrete mix. The Specific Gravity and Water Absorption of Coarse Aggregate is 2.73 and 0.23% respectively. Fineness Modulus of Coarse Aggregate is 7.17.

3.4 Dolomite Powder: Dolomite powder is procured from Astrra Chemicals in Chennai in which it is capable of passing through a 90µm sieve. The following table shows the chemical composition of dolomite powder. The physical properties like colour and specific gravity is white and 2.85 respectively.

Table-1: Chemical Composition of Dolomite Powder

Particulars	Results
Calcium Carbonate ($CaCO_3$)	54%
Magnesium Carbonate ($MgCO_3$)	45%
Silica (SiO_2)	2% max
Mix Oxides	1 to 3%
Water Solubles	0.80%
Heavy Metals	Traces

3.5 Oyster Sea Shell powder

Oyster sea shell powder is procured from Astrra Chemicals in Chennai in which it is capable of passing through a 90µm sieve. The following table shows the chemical composition of oyster sea shell powder. The physical properties like colour and specific gravity is white and 2.45 respectively.

Table-2: Chemical Composition of Oyster Sea Shell Powder

Particulars	Results
Silica (SiO_2)	1%
Calcium Oxide (CaO)	92.56%
Alumina (Al_2O_3)	0.2%
Magnesium Oxide (MgO)	0.43%
Sodium Oxide (Na_2O)	0.8%
Potassium Oxide(K_2O)	0.6%
Iron Oxide (Fe_2O_3)	0.1%
Sulphur Trioxide (SO_3)	0.31%

3.6 Water: For experimental studies and for curing purposes, ordinary water available in the laboratory was used. Water is a significant component in cement concrete response. For mixing and curing, tap water accessible in a college premises is used.

3.7 Super Plasticizer: Super plasticizers are admixtures that increase the workability and flow ability of concrete without the need to add excess water. Super plasticizers allow a reduction in water content of 30% or more. In this research work, Conplast Sp-430 is used as a super plasticizer. Specific Gravity is 1.2.

4. METHODOLOGY

The materials required for this research work is collected from different sources and the properties of the materials are analyzed as per IS code of standard procedures. The Mix design of M30 grade of concrete using ordinary Portland cement is carried out for this study as per concrete mix proportioning guidelines specified by IS456-2000 and IS-10262-2009. Firstly, the Dolomite mixes were prepared by replacing it with cement in different proportions i.e., 5%, 10%, 15% and 20% and the optimum percentage of dolomite powder is determined. Then the concrete mixes were prepared by keeping optimum percentage of dolomite powder and the oyster sea shell powder is replaced in cement with different percentages i.e., 5%, 10%, 15% and 20%. Mixes were prepared at room temperature.

The Cubes of size 150mm x 150mm x 150 mm, Cylinders of size 150mm x 300mm and prisms of size 500mm x 100mm x 100mm were casted and cured for all the mixes of concrete. The tests were conducted on hardened concrete to determine the strength properties and the results obtained of all the mixes were compared with control concrete mix to obtain the optimum percentage of dolomite and oyster sea shell powder.

5. RESULTS AND DISCUSSION

Tests which are conducted on the hardened properties of Control concrete, Dolomite mixes (Cement + Dolomite powder) and Oyster sea shell mixes (Cement + Optimum Dolomite powder + Oyster sea shell powder) and comparison of the results are drawn out. The results obtained from all the concrete mixes are drawn out and compared with the control concrete to investigate the difference between its effect on the cement concrete properties after adding Dolomite and Oyster sea shell powder.

5.1 Compressive Strength

The Compressive Strength test was conducted on cement concrete cubes of size 150mm x150mm x 150mmm at 3, 7, 28, 56 days of curing. Results of the compressive strength of concrete mixes of M30 grade are listed. The results were also compared with control concrete in order to determine variations in compressive strength due to addition of Dolomite powder and Oyster sea shell powder.

Table-3: Compressive Strength Results

S.NO	Type of Mix	Compressive Strength at different ages of curing (MPa)			
		3 days	7 days	28 days	56 days
1	CC	20.41	26.75	40.65	43.40
2	DP 5%	22.29	28.37	42.25	44.90
3	DP 10%	23.57	29.33	43.64	46.15
4	DP 15%	19.90	25.86	40.13	42.74
5	DP 20%	18.65	24.67	37.56	39.44
6	DP 10% OSP 5%	25.51	30.77	45.13	47.66
7	DP 10% OSP 10%	27.28	33.17	47.85	50.33
8	DP 10% OSP 15%	22.62	28.70	43.27	45.30
9	DP 10% OSP 20%	20.74	27.22	41.06	43.86

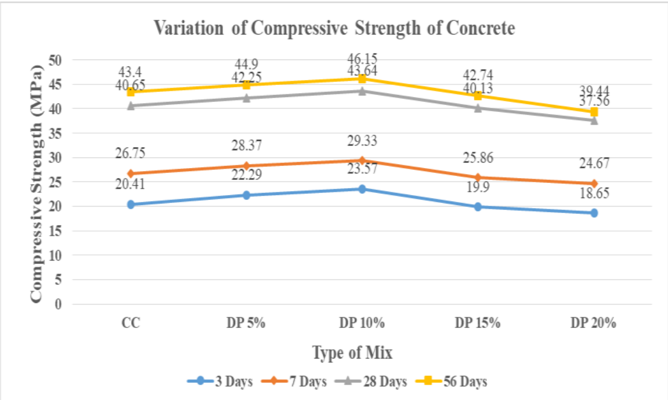

Chart-1: Compressive Strength for different mix proportions of dolomite powder

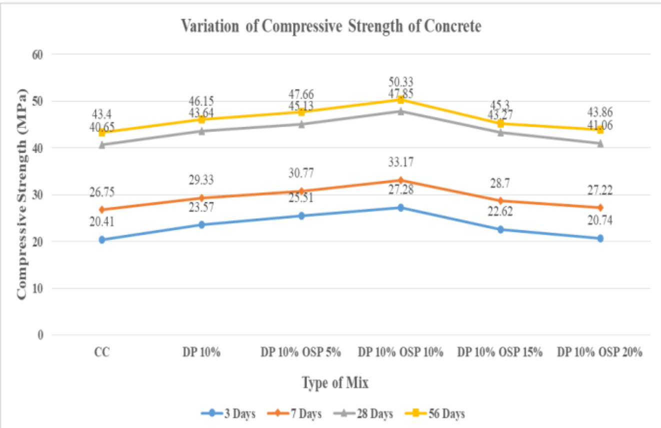

Chart-2: Compressive Strength for different mix proportions of Oyster sea shell powder.

5.2 Split Tensile Strength

The Split Tensile Strength test was conducted on cement concrete cylinders of size 150mm x 300 mm at 28 and 56 days of curing. Results of the split tensile strength of concrete mixes of M30 grade are listed. The results were also compared with control concrete in order to determine variations in split tensile strength due to addition of Dolomite powder and Oyster sea shell powder.

Table-4: Split Tensile Strength Results

S.NO	Type of Mix	Split Tensile Strength at different ages of curing (MPa)	
		28 Days	56 Days
1	CC	3.77	3.94
2	DP 5%	3.91	4.03
3	DP 10%	4.08	4.22
4	DP 15%	3.64	3.75
5	DP 20%	3.42	3.50
6	DP10% OSP 5%	4.19	4.28
7	DP10% OSP 10%	4.32	4.47
8	DP 10% OSP 15%	3.98	4.11
9	DP 10% OSP 20%	3.83	3.96

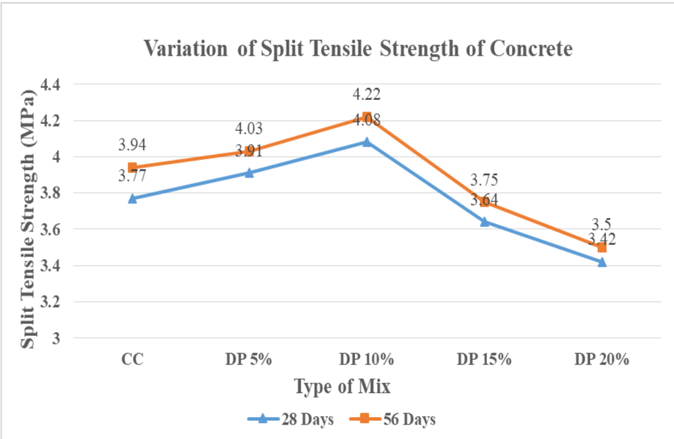

Chart-3: Split Tensile Strength for different mix proportions of Dolomite powder

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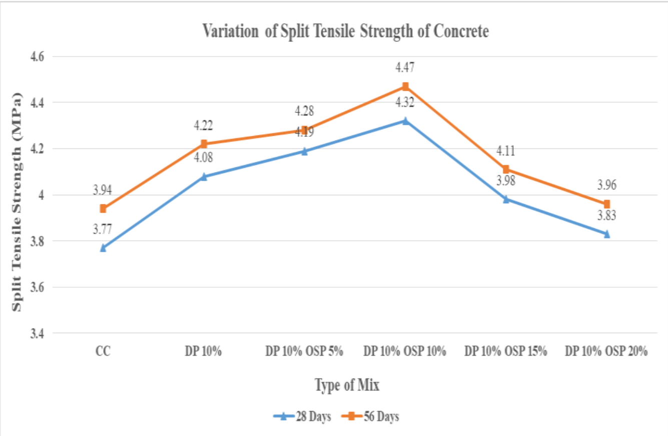

Chart-4: Split Tensile Strength for different mix proportions of Oyster sea shell powder.

5.3 Flexural Strength

The Flexural Strength test was conducted on cement concrete cylinders of size 500mm x 100 mm x 100mm at 28 and 56 days of curing. Results of the flexural strength of concrete mixes of M30 grade are listed. The results were also compared with control concrete in order to determine variations in flexural strength due to addition of Dolomite powder and Oyster sea shell powder.

Table-5: Flexural Strength Results

S.NO	Type of Mix	Flexural Strength at different ages of curing (MPa)	
		28 days	56 days
1	CC	4.72	4.96
2	DP 5%	4.98	5.11
3	DP 10%	5.13	5.29
4	DP 15%	4.65	4.77
5	DP 20%	4.49	4.58
6	DP 10% OSP 5%	5.31	5.46
7	DP 10% OSP 10%	5.48	5.63
8	DP 10% OSP 15%	5.05	5.24
9	DP 10% OSP 20%	4.88	5.07

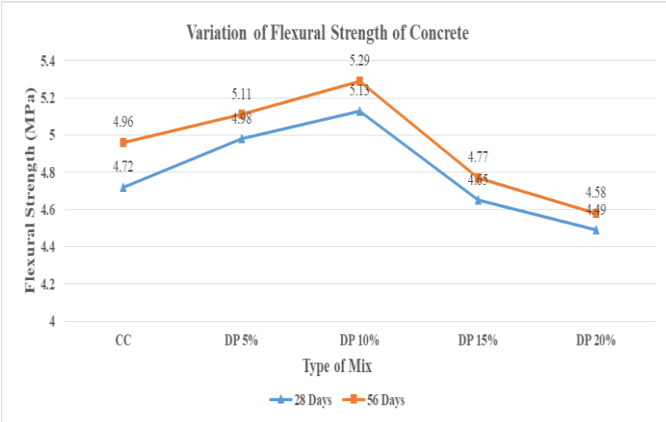

Chart-5: Flexural Strength for different mix proportions of Dolomite powder

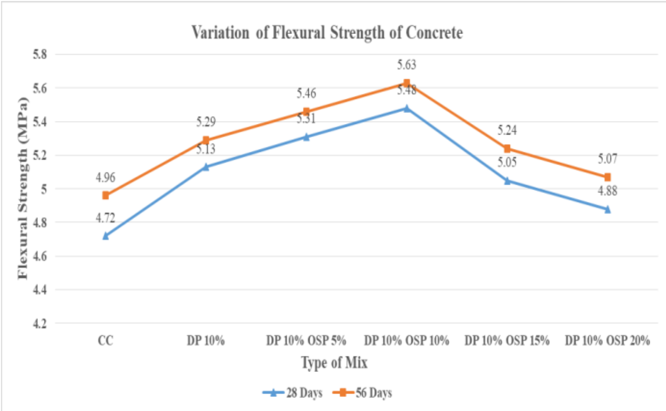

Chart-6: Flexural Strength for different mix proportions of Oyster Sea Shell powder

5.4 Rebound Hammer Test

The Rebound Hammer test was conducted on cement concrete cubes of size 150mm x 150mm x 150mmm at 28 and 56 days of curing. Results of the Rebound compressive strength of Optimum mixes and control concrete mix of M30 grade are listed below.

Table-6: Approximate Compressive Strength based on Rebound Number

Type of Mix	Curing Period	Mean Rebound Number	Approximate Compressive Strength (MPa)
CC	28 days	34	34.50
	56 days	36	37.10
DP 10%	28 days	36	37.10
	56 days	38	40.40
DP 10% OSP 10%	28 days	38	40.40
	56 days	40	43.85

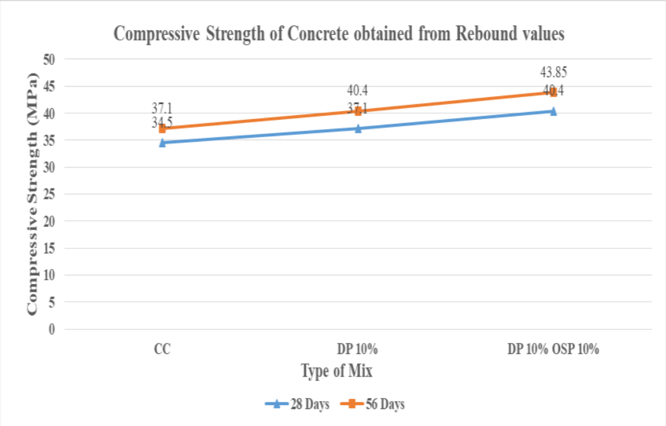

Chart-7: Variation of Compressive Strength obtained from Rebound Number

5.5 Ultrasonic Pulse Velocity Test

The Ultrasonic pulse velocity test was conducted on cement concrete cubes of size 150mm x 150mm x 150mmm at 28 and 56 days of curing. Ultrasonic pulse velocity is done on Optimum mixes and control concrete mix of M30 grade are listed below.

Table-7: Ultrasonic Pulse Velocity Values

Type of Mix	Curing Period	Mean Pulse Velocity (Km/sec)	Quality of Concrete
CC	28 days	4.77	Excellent
	56 days	4.69	Excellent
DP 10%	28 days	4.72	Excellent
	56 days	4.58	Excellent
DP 10% OSP 10%	28 days	4.69	Excellent
	56 days	4.51	Excellent

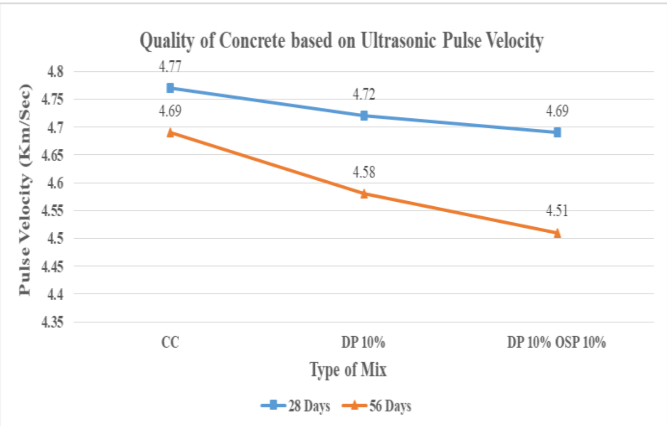

Chart-8: Quality of concrete based on Ultrasonic Pulse Velocity Values

6. CONCLUDING REMARKS

- The Compressive Strength of Concrete is gradually increasing with the replacement of Dolomite powder up to 10% and then decreases after further increase of Dolomite powder and the percentage increase when compared to control concrete is 15.48%, 9.64%, 7.35% and 6.34% for 3 days, 7 days, 28 days and 56 days respectively.

- The Compressive Strength of Concrete using Oyster shell powder by keeping the optimum replacement of Dolomite powder as constant is found to be increased up to 10% replacement and further decrease with the increase of Oyster shell powder. The percentage increase when compared to control concrete is found to be 33.66%, 24%, 17.71% and 15.96% for 3 days, 7 days, 28 days and 56 days respectively.

- For Split Tensile Strength of concrete the optimum replacement of dolomite powder is 10% and percentage increase when compared to control concrete is 8.22% and 7.10% for 28 days and 56 days respectively.

- The Split Tensile Strength of Concrete using Oyster shell powder by keeping the optimum replacement of Dolomite powder as constant is found to be increased up to 10% replacement and further decrease with the increase of Oyster shell powder. The percentage increase when compared to control concrete is found to be 14.58% and 13.19% for 28 days and 56 days respectively.

- For Flexural Strength of concrete the optimum replacement of dolomite powder is 10% and percentage increase when compared to control concrete is 8.68% and 6.65% for 28 days and 56 days respectively.

- The Flexural Strength of Concrete using Oyster shell powder by keeping the Optimum replacement of Dolomite powder as constant is found to be increased up to 10% replacement and further decrease with the increase of Oyster shell powder. The percentage increase when compared to control concrete is found to be 16.10% and 13.51% for 28 days and 56 days respectively.

- In the Case of Rebound Hammer Test, the Rebound strength for the mix with Dolomite powder of 10% and Oyster shell powder of 10% replacements is achieved more compared to the Control Concrete.

- In the case of Ultrasonic Pulse Velocity Test of concrete, the quality of concrete is excellent for all the optimum mixes including Control Concrete.

- The use of dolomite and oyster sea shell as partial replacements for cement in concrete can help in reducing the carbon footprint and utilizing waste materials.

- So, it can be concluded that the optimum percentage replacements of both Dolomite powder and Oyster sea shell powder is found to be 10%.

7. REFERENCES

1. **Ishita Gusain, Saurav Sharma, Samrat Debarma, Amit Kumar Sharma, Nitin Mishra**, Study of concrete mix by adding Dolomite in conventional concrete as partial replacement with cement, Journal of science direct materials today by Elsevier.

2. **Kausal Prajapati, Dr. Valsson Varghese**, Experimental Investigation on Strength of concrete by partial replacement of cement by dolomite powder, International Journal for Research in Applied Science and Engineering Technology, Volume 7/Issue 5/ May-2019.

3. **Bassam A. Tayeh, A.M.Zeyad**, Properties of Concrete containing recycled sea shells as cement partial replacement, Journal of Cleaner Production (2019).

4. **Preethi, Prince Arulraj**, Effect of replacement of cement with dolomite powder on the mechanical properties of concrete, JETIR, Volume 2, Issue 4, April 2015.

5. **Abhijeet B.Moghe, G.D. Dhawale**, Experimental Investigation on Partial replacement of cement by oyster shell in plain concrete, Journal of emerging Technologies and innovative research, Volume 7, 2020.

6. **Kim Hung Mo, U.Johnson Alengaram, Mohd Zamin Jumaat, Siew chenglee, Wan Inn Goh, Choon, Wah Yuen**, Recycling of Seashell waste in concrete, Construction and Building Materials 162 (2018).

7. **Dr. Sachin V. Admane, Tabassum Sayyad, Yogesh gurav, Prasad Ghodake**, Experimental Study of performance of concrete with partial replacement of cement by dolomite, International Research Journal of Modernization in Engineering Technology and Science, Volume:02/Issue:04/April-2020.

8. **S. Abhinaya and S. Prasanna Venkatesh,** An Effect on Oyster Shell Powder's Mechanical Properties in Self Compacting Concrete, International Journal of Innovative Research in Science, Engineering and Technology, Volume 5, June 2016.

9. **Kiran Kumar Poloju, Vineetha Anil, Sara Hamed Nasser Ali Al-Yahmadi, Ruwa Malik Nasser AI Maaman**, Investigating Possibilities for using sea shell on compressive strength properties of concrete, International Journal of Engineering and Technology, 7(1), (2018).

10. **Pramod Dhame, Dr.P.B. Nagarnaik**, Experimental Investigation on Replacement of cement in concrete partially by using Dolomite Powder, International Journal of Trend in Scientific Research and Devolopment, Volume 3, Issue 3, Mar-Apr 2019.

11. **Bille Pradeepkumar, Dr. Vaishali G Ghorpade, Dr. H. Sudarsana Rao,** An Experimental Study on strength properties of Tabby Concrete with Sea Shell Coarse Aggregate, Journal of Northeastern University, Volume 25, 2022.

12. **C.Venkata Sai Nagendra, C.Venkata Siva Ramaprasad, K.N.Rukmini Florence**, An Experimental investigation on properties of concrete by partial replacement of cement with dolomite and sand with crushed sea shell, International Journal of Scientific and Technology Research, Volume 8, Issue 10, October 2019.

13. **J.Sree Nagachaitanya, Dr.K.Chandramouli, M.Anil kumar, Dr.N.Pannirselvam**, An Experimental investigation on properties of concrete by partial replacement of cement with dolomite and sand with crushed sea shell, JETIR Volume 8, Issue 8, August 2021.

14. I.S: 10262 – 2009: Recommended guide lines for concrete mix design.

15. I.S: 2386 – 1963: Test procedures of aggregates.

16. I.S: 383 – 1970: Specification for coarse and fine aggregate from natural resources.

17. IS 12269:1987 "Ordinary Portland Cement Specification - Part 1: Fly Ash Based", Bureau of Indian standard institution, New Delhi.

18. IS 2720 part 3, "Determination of specific gravity of cement".

19. IS: 10262:2009 "Recommended guidelines for concrete mix design", Bureau of Indian standards, New Delhi.

20. IS: 2386-1963 "Indian standards code of practice for methods of test for Aggregate or concrete", Bureau of Indian standard Institution, New Delhi.

21. IS: 383-1970 "Specification for Coarse and Fine Aggregates from natural sources or concrete"(Second revision).

22. IS: 456-2000 "Specifications for plain and reinforced concrete". New Delhi, India.

23. Concrete technology by M.S. Shetty – S Chand & co; 2004.

24. Concrete technology by A.M. Neville – Pearson publication.