An Experimental Investigation On Properties Of Concrete By Partial Replacement Of Cement With Dolomite And Sand With Crushed Sea Shell

C. Venkata Sai Nagendra, C. Venkata Siva Rama Prasad, K. N. Rukmini Florence

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 ingredients of concrete are cement, fine, coarse aggregates and water, which are mixed in a particular proportion to get required strength. Increase in demand of cement around the globe seeks high intention in finding some alternatives to cement in concrete. The inception of new alternative limits the CO_2, a major greenhouse effect causing gas.Research is taking place on all corners of the globe in search of different material options. River sand is collected from river beds to build houses and giant infrastructure to satisfy population growth requirements. The emergence of globalization and advanced technology required to meet the requirements of the worldwide economy at domestically and internationally has become a significant issue in preserving the river sand used as a fine aggregate in concrete manufacturing. In this study a small trial is done to modify the properties of concrete by partial replacement of cement with dolomite powder varying from 0% to 10% with interval of 2.5% and fine aggregate with crushed sea shell powder about 20% as constant. Different tests are done to determine mechanical (Compressive and tensile) and durability properties of concrete.

Keywords— Dolomite powder, Crushed sea shell, physical, mechanical and Durability properties.

1 INTRODUCTION

Concrete is a non-homogeneous material. It consists of cement, sand and water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement has chemically reacted with the water (hydrated), it hardens and binds the whole mix together. The initial hardening reaction usually occurs within a few hours. It takes some weeks for concrete to reach full hardness and strength. Aggregate is the important constituent in concrete. They are providing the concrete to the body, reducing shrinkage and economic effects. Aggregate is a wide category of gross particulate material used in building, including sand, gravel, crushed stone, slag, recycled concrete and geo-synthetic aggregates. Aggregates are the world's most mined materials. Aggregate serves to reinforce the general composite material by adding strength. Among coarse and fine aggregates, material for fine aggregate commonly used is River sand which has much demand and also upcoming days it gets completely depleted. Besides fine aggregate, binding material in concrete is cement in which for production of one ton of cement one ton of Carbon dioxide releases which leads to global warming. Now a days several researches are done to replace cement by alternative materials which modify the properties of concrete as well. In this study the binding material like cement is partially replaced by dolomite powder with different percentages about maximum of 10% with an interval of 2.5% and fine aggregate is partially replaced with Crushed sea shell powder about 20% as constant. Different tests are done to determine the materials(admixtures) effect on mechanical and durability properties on M25 grade of concrete.

- *C V S Nagendra is currently working as an Assistant Professor, school of civil engineering, REVA University, Bangalore, Karnataka, India E-mail: chintalanagendra25@gmail.com*
- *C.Venkata Siva Rama Prasad is currently working as an Assistant Professor in civil engineering in Vignana Bharathi Institute of technology (Autonomous), Ghatkesar, Hyderabad, Telangana, India. E-mail: cvsrprasad90@gmail.com*
- *K N Rukmini Florence currently working as an Assistant Professor, school of civil engineering, REVA University, Bangalore, Karnataka, India E-mail: Nancy.rukku@gmail.com*

A. Dolomite

Dolomite is a prevalent mineral that forms rock. It is a carbonate of calcium magnesium with a CaMg (CO3)2 chemical formula. It is the main element of the dolostone-known sedimentary rock and the dolomitic marble-known metamorphic rock. Limestone containing a certain dolomite is known as calcareous dolomite. In contemporary sedimentary environments, dolomite is rarely discovered, but in rock record dolostones are very prevalent. They can be hundreds to thousands of feet dense and geographically vast. Most rocks rich in dolomite were initially deposited as muds of calcium carbonate, which were modified by magnesium-rich porous water to form dolomite after deposition.

Fig 1.1 Dolomite powder

B. Crushed Sea Shell

Sea shell is usually the exoskeleton of an invertebrate (an animal without a backbone), and is typically composed of calcium carbonate. Most shells that are found on beaches are the shells of marine molluscs. Partly these shells are usually made of calcium carbonate. Sea shells which were used in this study are Heliocostyla. These sea shells majorly contain CaO of 53.72 %. In the Los Angeles Abrasion test, these sea shells were crushed. The crushed shells should pass through a sieve of 2.36 mm. These Sea Shells were washed with water to remove the NaCl from the sea shell as they found in sea and dried under the sunlight remove the water content

from the crushed and washed sea shells. The crushed sea shells should be passed through 2.36mm sieve.

Fig 1.2 Sea shell

2 MATERIALS

A. Cement

The Cement used throughout the test program was OPC-Ordinary Portland Cement of 53 grades of Ultratech cement. The cement used in the casting of cubes and cylinders meets the following specifications as per IS: 12269-1987.

Table 1 Properties of Cement

S.No	Property	Values
1	Fineness of Cement	4%
2	Specific Gravity	3.15
3	Normal Consistency	31.5 %
4	Setting Time i) Initial Setting time ii) Final setting time	 40 mins 380 mins
5	Soundness	1mm

B. Dolomite

The Dolomite used in this study is obtained from industry (Vallabha gems & minerals) at rayalacheruvu, Anantapur district. The physical properties like colour and specific gravity is white and 2.75 respectively.

C. Fine aggregate

Locally accessible IS zone II river sand of IS: 383-1970. Table 2 demonstrates the fine aggregate physical characteristics.

Table 2 Properties of Fine Aggregate

S. No	Property	Values
1	Specific Gravity	2.63
2	Fineness modulus	3.2
3	Bulking of sand	15.27%

D. Coarse aggregate

The coarse aggregate maximum size 20 mm and 12.5mm angular types are used. The experimental studies are carried out to find the properties of coarse aggregate. As per IS 383-1970 & IS 2386-1983 and are shown in Table 3.

Table.3 Properties of Coarse Aggregate

S. No	Properties	Value
1	Specific Gravity	2.73
2	Crushing value	27.5%
3	Water Absorption	1.14%
4	Fineness Modulus	7.31

E. 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.

F. Sea shell

Sea shells are obtained from beaches and they are the shells of marine molluscs. These sea shells majorly contain CaO of 53.72 %. These Sea shells were crushed in Los Angeles Abrasion test and sieved through 2.36mm sieve. Later washed to remove NaCl from the surface with water. The physical properties like colour, specific gravity and bulk density are light brown, 2.77 and 2579 Kg/m3 respectively.

3 MIX DESIGN

Mixes of M25grade were designed as per IS 10262-2009 and IS 456-2000 and the specimens were casted based on obtained mix ratios. In this study, the fine aggregate was partially replaced with crushed sea shell about constant percentage of 20% and cement is replaced partially with dolomite powder with different percentages about maximum of 10% with an interval of 2.5%. The specimens obtained from different mixes are tested with conventional concrete of grade M25. The mix details are obtained as follows,

Table 4 Mix Proportion

Proportions	Water	Cement	Fine aggregate	Coarse aggregate
By weight	197	438.13	675.63	1105.34
By ratio	0.45	1	1.54	2.52

4 RESULTS AND DISCUSSIONS

A. Mix Details

The mix details of present study are mentioned below in the table 5 with respect to replacement of cement and River sand.

Table 5 Mix Details

MIX	CEMENT	DOLOMITE %	RIVER SAND	CRUSHED SEA SHELL
C1	100	0	100	0
C2	100	0	80	20
C3	97.5	2.5	80	20
C4	95	5	80	20
C5	92.5	7.5	80	20
C6	90	10	80	20

B. Compressive strength

The cube specimens of size 150mm x 150mm x 150mm were cast and tested in Compression Testing Machine (CTM) after 7, 28, 56 and 90 days of curing period for different proportions of concrete mix. The average of three specimens for each proportion is shown in Table 6.

Table 6 Results of Compressive Strength test

MIX	7 DAYS (MPa)	28 DAYS (MPa)	56 DAYS (MPa)	90 DAYS (MPa)
C1	20.4	29.51	34.23	37.20
C2	**27.37**	**41.11**	**47.11**	**47.33**
C3	28.52	42.67	44.88	45.55
C4	26.04	39.11	46.66	46.22
C5	**26.48**	**39.77**	**39.11**	**48.66**
C6	25.52	38.67	36.88	45.55

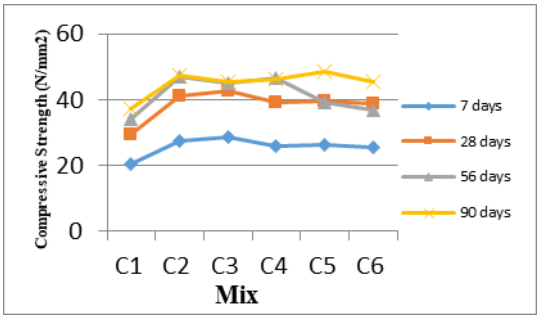

Fig 4.1 Compressive strength results graph

From compressive strength results it is observed that, all mixes shown increment in strength when the age goes on increases. But the mix casted using combination of dolomite about 7.5% and crushed sea shell of about 20% shown higher strength of 48.66 Mpa compare to all other mixes and also the mix casted using only crushed sea shell shown higher strength about 47.33Mpa which is less compared to obtained higher strength. But compared to other mixes with 2.5%, 5% and 10% dolomite combination with sea shell the mix shown higher value.

C. Split Tensile strength

At the age of 28 days, different cylindrical specimens (150mmdia* 300 mm height) were tested for split tensile. By using a 200-ton capacity compression testing machine. The experiment is performed by putting a cylindrical sample horizontally between a compression testing machine's loading surfaces and the load is applied until the cylinder fails along the vertical diameter. The mean split tensile strength test results are shown in Table 7.

Split Tensile Strength == 2P/LDπ

Table 7 Results of Split Tensile Strength (28 Days)

MIX	Tensile strength (N/mm2)
C1	2.55
C2	2.97
C3	3.40
C4	**3.67**
C5	3.11
C6	2.82

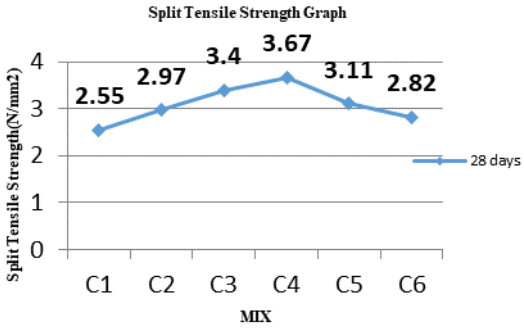

Fig 4.2 Split Tensile Strength results graph

From fig 4.2 - split tensile strength test, it is observed that for the combination like dolomite of 5% and crushed sea shell powder as 20% casted cubes shown higher tensile strength about 3.67Mpa compared to all other mixes.

D. Durability tests

i) Acid attack test

The Acid attack test is conducted after 28 days of water curing done for the specimens. For the Acid attack test, 150 x150x150mm size concrete cubes are used. Before placing of cubes in acid solution the weight of specimens are noted. Then the cubes with different percentage replacements were

immersed in a solution of Hydrochloric acid (HCl) with 0.1M and allow curing for 28 days. After the 28 days curing period, the cubes were removed and weight of those were noted. The results are shown in the table 8.

Fig 4.3 Cubes are under curing in acid solution

Table 8 Acid attack test results

MIX	INITIAL WEIGHT (kg)	FINAL WEIGHT (Kg)	% Loss of Weight	COMPRESSIVE STRENGTH (Mpa)
C1	8.336	7.625	**8.53**	18.66
C2	8.465	7.547	10.84	15.55
C3	8.422	7.368	12.51	23.11
C4	8.393	7.153	14.77	**24.44**
C5	8.380	6.956	16.99	16
C6	8.418	6.810	**19.10**	15.88

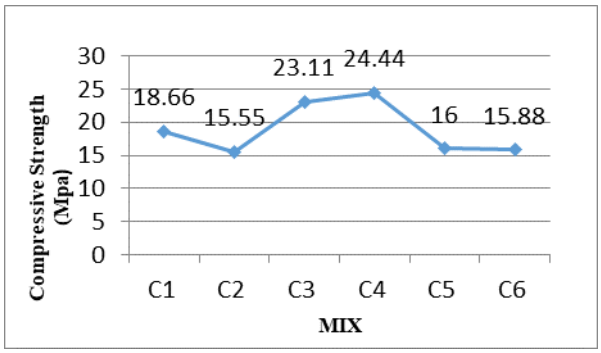

Fig 4.4 Acid attack test results graph

After 28 days, the samples were removed from acid curing and the proportion of weight loss is observed and the compressive strength of these samples was calculated and the outcomes are shown in Table 8. From the obtained results it is observed that, the percentage loss of weight among all the specimens, the specimens casted using 10% of dolomite and 20% of crushed sea shell powder shown maximum weight loss about 19.10%. But in compressive strength test the cubes casted using combination of 5% dolomite and 20% crushed sea shell shown higher value about 24.44 Mpa compared to other mixes.

ii) Calorimetric Chlorination Technique

Calorimetric chlorination is one of the tests to find out the chlorine penetration depth in the concrete cube specimens. For this study the specimens of size150x 150× 150 mm were casted with and without admixtures (Dolomite and crushed sea shell powder). After 28 days water curing i.e. from the period of casting are removed and are placed in water which contains sodium chloride (NaCl) about 3.5 % of water. After 28 days chlorine water curing, specimens are removed. After 10 minutes, the specimens are split into two equal pieces each. Immediately, the chemical called Silver Nitrate (AgNO3) of 0.1M is sprayed on those specimens (broken part) as shown in fig 4.5. Due to chemical reaction between sodium chloride and silver nitrate, a white precipitate is formed on the specimens and the depth up to which it indicates white precipitate as shown in figure below will provide the penetration of chlorine for that period of time. Based on the depth of white precipitate on the cubes, the quality of the cube was decided. That means when the penetration depth is more, it is not good and when depth is low cube is considered as good.

Fig: 4.5 chorine penetration depth (after spraying 0.1M AgNO3)

Table 9 Chlorination Depth for different mixes of Concrete specimens

S. No	Sample	Penetration depth (mm)
1	C1	6.90
2	C2	**19.5**
3	C3	9.62
4	C4	**6.75**
5	C5	7.62
6	C6	10.75

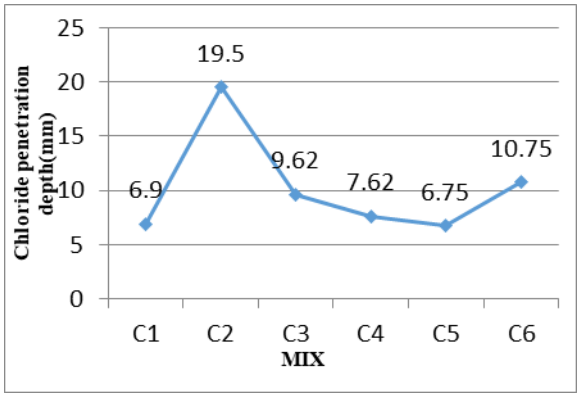

Fig 4.6 Chloride Penetration test results graph

From table 9 of chlorination depth results, it is observed that the cubes casted using admixture of only crushed sea shell powder shown high penetration depth about 19.5mm and the cubes using combination of both dolomite and crushed sea shell powder shown lesser value compared to mix with only crushed sea shell. The mix with 5% dolomite and 20% crushed sea shell shown lesser value about 6.75 mm compared to all other mixes.

5 CONCLUSIONS

In this present study, the concrete ingredients like cement and fine aggregate are partially replaced by Dolomite powder and Crushed sea shells respectively. Crushed sea shells is kept constant as 20% and dolomite powder is varied with different percentages like 0%,2.5%, 5%, 7.5% and 10%. By these percentages different concrete specimens are casted and tested for mechanical and durability properties and the following conclusions are drawn.

1. It is observed from all mixes that by addition of sea shell powder in concrete mix it demands more water compare to conventional mix.
2. At 20 % replacement of fine aggregate by sea shells and 7.5% of cement by dolomite shows more compressive strength which was 48.66 Mpa and is about 30.8% additional strength obtained compared to conventional concrete cubes.
3. It is observed that, from split tensile strength test the specimens casted using 20 % replacement of fine aggregate by sea shells and 5% of cement by dolomite shown high strength about 3.67Mpa compared to conventional concrete and is about 43.9% additional strength obtained compared to conventional concrete cubes.
4. From durability tests like acid attack and chloride penetration test, It is observed that the specimens casted using 5% dolomite and 20% sea shell shown better results like high strength in acid test about 24.4Mpa, less penetration depth about 6.75mm and less water absorption compare to all other mixes.
5. From this study it is observed that, dolomite powder of about 5% maximum and crushed sea shell about 20% can be considered in concrete which helps in enhancement in properties of concrete in both mechanical and durability aspects.
6. From this study it concluded that the materials like dolomite and sea shell powder can be used to modify the properties of concrete about 5% and 20% respectively.

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