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Flexural Behaviour of RCC Beams Partially Replacing Cement by Dolomite Powder and Sand by Quarry Dust

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Abstract—The present Investigation is aimed at utilizing low cost material Dolomite powder and waste material Quarry dust as partial replacement of cement and sand in concrete. This experimental investigation is carried out in three stages. In 1st stage M_{25} grade of concrete is produced by replacing cement by 0%, 6%, 12% and 18% of Dolomite Powder. In 2nd Stage concrete is produced by keeping the optimum 12% of dolomite powder as constant and sand is replaced by quarry dust in the percentage of 0%, 25%, 35% and 45%. In 3rd stage the optimum percentage of Dolomite Powder and Quarry Dust (DP+QD) Concrete are used to determine the compressive strength, split tensile strength and flexural strength of concrete and to check the flexural behavior of RCC beams. It is found that the concrete made of low cost material dolomite powder and waste material quarry dust increases the compressive strength, split tensile strength and flexural strength of concrete when compared to that of normal concrete. It also concluded that the first crack load and ultimate load of dolomite powder and quarry dust reinforced concrete beams increases when compared with normal reinforced concrete beams. From study it is concluded that the low cost material Dolomite powder & Quarry dust can be used in construction works which results in construction cost. By using natural resources the environment is protected.

Keywords : Dolomite Powder, Quarry Dust, Compressive strength, Split tensile strength, Flexural strength, RCC Beams.

I. INTRODUCTION

Concrete is a basic material used in the construction of most of the structures. Many materials are used to manufacture good quality concrete. Cement, fine aggregate, coarse aggregate, and water are the constituents of concrete. Cement is the most important constituent material, since it binds the aggregates and resists the atmospheric action. However, manufacturing of cement emits about 0.8 tonne of CO_2 into the atmosphere for every tonne of cement manufactured due to which a large amount of CO_2 is released into the atmosphere every year which is one of the green house gas that causes global warming.

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In order to reduce CO_2 emission,the consumption of cement should be reduced in the preparation of concrete without compromising the strength and other parameters which effect the overall performance of concrete during its life period.

To overcome this problem many researchers have carried out experimental investigation by using different material as partial replacement of cement in the manufacturing of concrete. The reduction in the consumption of cement will not only reduce the emission of CO_2 but also reduces the cost of concrete. In order to achieve this dolomite powder can be used as partial replacement of cement. Dolomite powder is a natural form of calcium magnesium carbonate [$CaMg(Co_3)_2$]. It is a common sedimentary rock-forming mineral which has a remarkable wettability and dispersibility. Dolomite has a good weathering resistance and is preferred for construction materials due to its higher surface hardness and density.

The global consumption of natural sand is too high due to its extensive use in concrete. Due to rapid growth in construction industry, the available sources of natural sand are getting exhausted, causing depletion of natural resources resulting increase in scour depth and sometimes flood possibility. Quarry dust is one such material which can be used to replace sand as fine aggregate. Quarry dust is a kind of waste material that is generated from the stone crushing industry which has landfill disposal problem, health and environmental hazards.

II. LITERATURE REVIEW

A. General.

This chapter provides the details of some of the main investigations carried out by different investigations regarding the use of materials dolomite and quarry dust with partial replacement of cement and sand respectively. Most of the studies focus on the mechanical properties of resulting concrete. Brief outlines of these investigations are as follows.

B. Historical Overview.

K. Satish Kumar, K. Anitha Athal. studied that the percentage of cement conversion by dolomite powder is 20%, 25% and 30%, and the fine aggregate through copper slag is 20% by weight of M_{20} grade concrete. The use of dolomite powder and copper slag increased the compressive and tensile strength of concrete.

The compressive strength for M_{20} grade concrete is 27(N/mm^2) and has been increased by replacing 20%, 25% and 30% with 20% copper slag. In this way, the use of environmental friendly materials converted waste into wealth[1]. A. Muthukumar, V. Rajagopalan reported that the replacement of dolomite powder and M-sand is found to improve the strength of concrete. The target for M_{25} grade concrete is 31.6 (N/mm^2). Maximum replacement percentage of cement with dolomite powder is 10% and sand with m-sand is 10%, when compressive strength is 36.5 (N/mm^2), the split tensile strength is 2.96 (N/mm^2) and the flexural strength is 3.84(N/mm^2)[2]. P. P Shanghai, V. G Patwari, described that the replacement of marble powder and quarry-sand is found to improve the strength of concrete. When used 10% replacement of Marble powder with cement, 40% replacement of quarry-sand with fine aggregate with a W/C ratio of 0.46[3]. D. Gowarinskar, S. Aslam, R. Satish Kumar , they stated that cement replaced with lime powder and sand will be replaced with quarry dust. M_{20} grades of concrete are taken into account for the study, with a permanent slump of 60 mm. Test results show that the maximum compressive strength, tensile strength is obtained at only 30% of replacement[4]. T. Srinivas and N. V. Ramana Rao, in this literature they have studied that mechanical properties of concrete and the flexural behavior of Reinforced cement concrete (RCC) beams with high volume fly ash. In this experiment, the M_{20} grade of concrete (1:2.3:3.3) is used with a W/C ratio of 0.556, which uses different combinations (0%, 30%, 50%, and 70%) of fly ash replacement with cement. It was observed that the compressive and flexural strength of the concrete is slightly reduced by 50%, but the strength drops abruptly from 50 to 70% and there is no much variation in deflection and it is under serviceability limits as per IS456-2000 up to 70% replacement of cement[7].

III. EXPERIMENTAL INVESTIGATION

A. Objectives

The objectives of the study are;

- To study the mechanical properties of concrete by using Dolomite powder & Quarry dust in different percentages.
- To decide the optimum percentage of Dolomite powder & Quarry dust in concrete.
- To study the flexural behavior of RCC Beams using Dolomite powder & Quarry dust.

B. Material Used

The materials used in this experiment are cement, river sand, coarse aggregate, conventional steel, dolomite powder, quarry dust and water.

C. Cement

Balaji South India OPC 53 grade cement conforming to IS 12269-1987, from a single batch is used throughout the course of project work. In laboratory various tests are conducted on cement and its results are shown in Table- I.

Table- I: Physical Properties of cement

Sl.No	*Properties*	*Results*	*IS-code recommendation IS:12269-1987*
1	Specific gravity	3.146	3.0-3.15
2	Normal consistency	34%	30-35
3	Soundness test	1mm	10mm
4	Initial setting time	45 min	Min 30 minute
5	Final setting time	240 min	Max 600 minute
6	Fineness	3%	0-10%

D. Dolomite Powder:

The Salient features, Physical properties and Chemical compositions of Dolomite Powder are as tabulated below.

Table- II: Salient features of natural dolomite

Sl.No	*Property*	*Description*
1	Formula	$CaMg(CO_3)_2$
2	Color	White, gray to pink
3	Tenacity	Brittle
4	Crystal System	Trigonal

Table- III: Chemical Composition of Dolomite Powder

Sl.No	*Composition*	*Weight Percentage(%)*
1	SiO_2	9.29
2	CaO	28.28
3	MgO	18.80
4	Fe_2O_3	0.20
5	Al_2O_3	0.53
6	LOI	42.90

Table- IV: Physical properties of Dolomite Powder

Sl.No	*Properties*	*Results*
1	Specific gravity	2.81
2	Fineness modulus	6%

E. Coarse aggregate

Crushed basalt stones of size 20mm down conforming to IS 383-1970, are used. Sieve analysis data and physical properties of coarse aggregate of 20mm down size are shown in Table- V.

Table- V: Sieve analysis data & physical properties for 20 mm Coarse aggregate

SI. No	*IS Sieve size*	*Wt retained*	*Cumulative wt retained*	*Cumulative % wt retained*	*Cumulative% passing*	*% Passing by wt as per IS 383-1970*
1	40 mm	0	0	0	100	100
2	20 mm	396	396	13.2	86.8	85-100
3	10 mm	2017	2413	80.4	19.6	0-20
4	4.75mm	582	2995	99.83	0.17	0-5
				193.43		
Physical properties						
5	Specific gravity	2.93				

S I N o	*IS Sieve size*	*Wt retained (gm)*	*Cumulative wt retained*	*Cumulative % wt retained*	*Cumulative% passing*	*% Passing by wt as per IS 383-1970 Zone-I*
1	4.75 mm	0	0	0	100	90-100
2	2.36 mm	92	92	9.2	90.8	60-95
3	1.18 mm	221	313	31.3	68.7	30-70
4	600micron	370	683	68.3	31.7	15-30
5	300micron	246	929	92.9	7.1	5-20
6	150micron	71	1000	100.0	0	0-10
				301.7		
Physical properties						
7	Specific gravity		2.56			
8	Fineness Modulus		3.01			
9	Water absorption		1.01%			

$$\text{Fineness modulus} = \frac{\text{Cumulative \%weight retained} + 500}{100}$$

$$= (193.43+500)/100 = \mathbf{6.93}$$

F. Fine aggregate

Natural sand: Locally available river sand belonging to zone I of IS 383-1970 is used in this project work. The sieve analysis data and physical properties of fine aggregates tabulated in Table- VI.

Table- VI: Sieve analysis data & physical properties for Fine aggregates

S I N o	*IS Sieve size*	*Weight retained (gm)*	*Cumulative weight retained*	*Cumulative % weight retained*	*Cumulative% passing*	*% Passing by weight as per IS 383-1970 Zone-I*
1	4.75mm	0	0	0	100	90-100
2	2.36mm	96	62	9.6	90.4	60-95
3	1.18mm	234	330	33	67	30-70
4	600micron	375	705	70.5	29.5	15-30
5	300micron	220	925	92.5	7.5	May-20
6	150micron	75	1000	100	0	0-10
				305.6		
Physical properties						
7	Specific gravity		2.64			
8	Fineness Modulus		3.05			
9	Water absorption		0.81%			

$$\text{Fineness modulus} = \frac{\text{Cumulative \%weight retained}}{100}$$

$$= 305.6/100 = \mathbf{3.05}$$

G. Quarry Dust ;

The Physical Properties of Quarry dust is as Tabulated below.

Table- VII: Sieve analysis data & physical properties for

7	Fineness Modulus	6.93
6	Water absorption	1.66%

Quarry Dust

$$\text{Fineness modulus of Quarry Dust} = \frac{\text{Cumulative \%weight retained}}{100}$$

$$= 301.7/100 = \mathbf{3.01}$$

G. **Water;** Potable clean water is used in this investigation for both casting and curing of concrete. Confirming to IS 456-2000.

I. Conventional steel;

Fe 500 grade steel (12mm and 8mm diameter bars). Conforming to IS 1786-1985 is used as conventional reinforcement for RC beams.

J. Selection of Mix Ratio for M25 Grade Concrete

The purpose of this experiment is to evaluate the properties of Dolomite powder and Quarry dust concrete and various aspects such as concrete compressive strength, flexural strength, split tensile strength and flexural behavior of RCC beams developed for concrete using dolomite powder and quarry dust had to study. The mix design is made to achieve M_{25} grade concrete with coded provisions IS 10262-2009. In accordance with IS 456: 2000 and IS 10262: 2009. The mixed ratio becomes M_{25} grade**.**

Table- VIII: Mix proportion

Water (Lts/m^3)	*Cement (kg/m^3)*	*Fine aggregate(kg/m^3)*	*Coarse aggregate (kg/m^3)*
191.6	384	720	1187
0.50	1	1.87	3.09

Table- IX: Details of test specimen

Specimen type	*Size of specimen (mm)*	*Test conducted*	*Total number of specimens*
Cubes	150x150x150	Compressive strength test	21
Plane concrete beam (prism)	100x100x500	Flexural strength test	21
Cylinders	150x300	Split Tensile Strength Test	21
RCC Beams	150x230x1500	Flexural test of two-point loading. 1.Normal beam 2. Beam with optimal % replacement	03 03

K. Beam Details

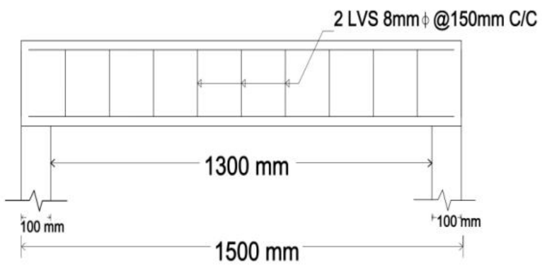

Fig. 1. Longitudinal Section of RCC Beam

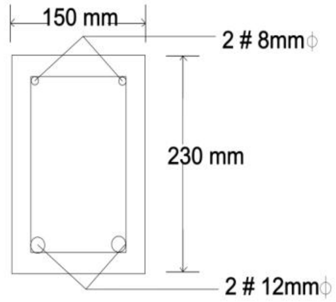

Fig. 2. Cross section of RCC Beam

IV. RESULTS AND DISCUSSION

A. Slump Test

For the determination of concrete, workability Slump test was conducted and results are tabulated in Table- X. W/C =0.5.

Table- X: Slump Test

Batch. No	*Replacement of Materials (%)*		*Slump (mm)*
	Dolomite Powder (%)	*Quarry Dust (%)*	
1	0%	0%	75
2	6%	-	73
3	12%	-	71
4	18%	-	70
5	12%	25%	74
6	12%	35%	70
7	12%	45%	69

B. Compressive strength test

M_{25} grade concrete

The results of compressive strength test for M_{25} grade of conventional concrete after 28 days of curing as tabulated in Table- XI.

Table- XI: Compressive strength results for conventional concrete

Mix designation	*Specimen Identity*	*Load (kN)*	*Compressive strength in N/mm²*	*Average compressive strength N/mm²*
MIX5	Cube41	724	32.17	32.61
	Cube42	781.2	34.72	
	Cube43	696.3	30.94	

C. EXPERIMENT NO 01: Test results for Dolomite Powder (DP) concrete.

In this study Dolomite Powder has been partially replaced in the ratio of 0%, 6%, 12% and 18% by weight of cement in concrete. The strength results obtained from the experimental investigations are shown in tables. The results are discussed as follows.

Table- XII: Compressive strength results for DP concrete (N/mm²)

Mix - ID	*Replacement of Cement with DP*	*Load (kN)*	*28 days Compressive Strength in N/mm²*	*Average 28 days Compressive Strength in N/mm²*	*% of Increase in Compressive Strength in 28 days*
NC	0%	724	32.17	32.61	-
		781.2	34.72		
		696.3	30.94		
D6	6%	736.5	32.73	33.02	1.27
		741.3	32.94		
		751.2	33.38		
D12	12%	782.6	34.78	35.11	7.66
		778.3	34.59		
		809	35.95		
D18	18%	762	33.86	33.49	2.69
		726.3	32.28		
		772.5	34.33		

Note: **NC:** Normal Concrete, **D6:** 6% of Dolomite powder **D12:**12% of Dolomite powder, **D18:** 18% of Dolomite powder.

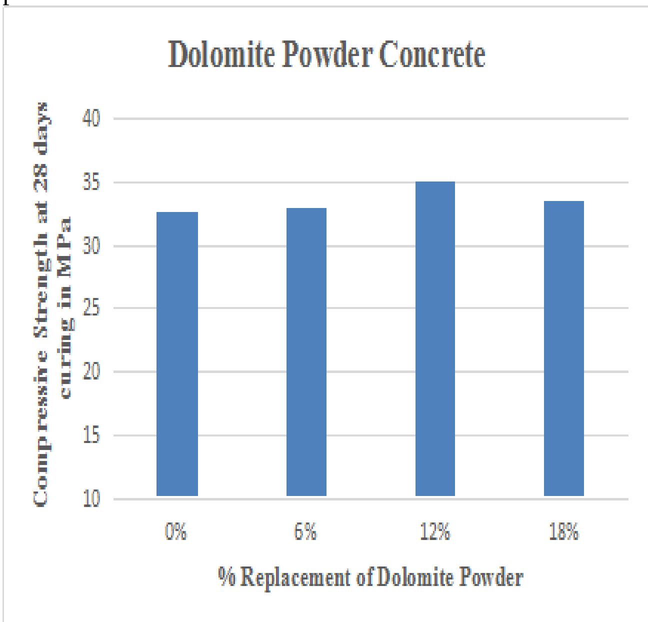

Fig. 3. % Replacement of DP vs Compressive strength at 28 days curing (N/mm²)

The testing cubical specimen is shown in Fig. 4.

Fig. 4. Testing cubical specimen

Table- XIII: Split Tensile strength results for DP concrete (N/mm²)

Mix - ID	*Replacement of Cement with DP*	*Load (kN)*	*28 days Split Tensile Strength in N/mm²*	*Average 28 days Split Tensile Strength in N/mm²*	*% of Increase in Split Tensile Strength in 28 days*
NC	0%	301.2	4.25	4.48	-
		318.6	4.5		
		331	4.68		
D6	6%	371.6	5.25	5.04	12.5
		352.9	4.99		
		346	4.89		
D12	12%	416.71	5.89	6.03	34.59
		425.5	6.01		
		437.5	6.18		
D18	18%	329.66	4.66	4.65	3.79
		316.02	4.46		
		342.12	4.83		

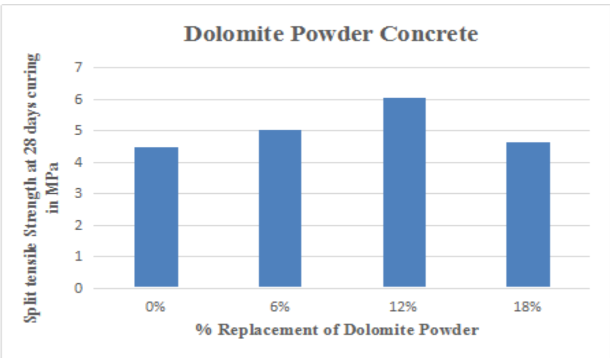

Fig. 5. % Replacement of DP vs Split tensile strength at 28 days curing (N/mm²)

Tested cylindrical specimen is as shown in Fig. 6.

Fig. 6. Tested cylindrical specimen

Table- XIV: Flexural strength results for DP concrete (N/mm²)

Mix -ID	*Replacement of Cement with DP*	*Load (kN)*	*28 days Flexural Strength in N/mm²*	*Average 28 days Flexural Strength in N/mm²*	*% of Increase in Flexural Strength in 28 days*
NC	0%	10.69	4.27	4.22	-
		11.12	4.44		
		9.91	3.96		
D6	6%	12.76	5.1	5.07	20.14
		14.01	5.6		
		11.28	4.51		
D12	12%	15.56	6.22	6.11	44.78
		14.07	5.88		
		16.22	6.48		
D18	18%	11.7	4.68	4.54	7.58
		12.04	4.81		
		10.38	4.15		

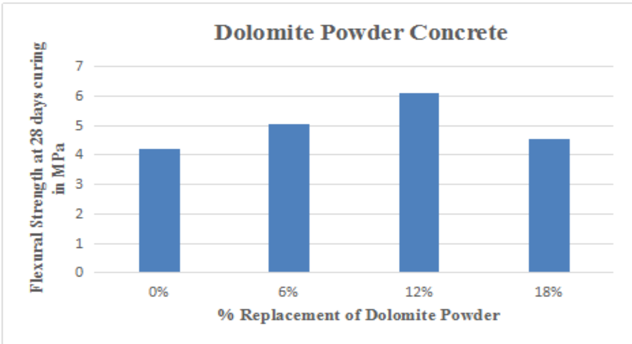

Fig. 7. % Replacement of DP vs Flexural strength at 28days curing (N/mm²)

Fig. 8. Tested prism specimen

D. EXPERIMENT NO 02: Test results for Dolomite Powder (DP) and Quarry Dust (QD) concrete.

Mix -ID	*Replace ment of cement with DP Sand with QD*	*Load (kN)*	*28 days Split Tensile Strength in N/mm²*	*Average 28 days Split Tensile Strength in N/mm²*	*% of Increase in Split Tensile Strength in 28 days*
NC	0%	301.2	4.25	4.48	-
		318.6	4.50		
		331.0	4.68		
D12 +QD 25	12%+25 %	358.2	5.06	5.06	12.94
		372.5	5.26		
		343.6	4.85		
D12 +QD 35	12%+35 %	426.1	6.02	6.11	36.38
		429.5	6.07		
		441.6	6.24		
D12 +QD 45	12%+45 %	319.5	4.51	4.63	3.34
		328.2	4.64		
		335.7	4.74		

Table- XV: Compressive strength results for DP+QD concrete (N/mm²)

Mix - ID	*Replace ment of cement with DP Sand with QD*	*Load (kN)*	*28 days Compre ssive Strength in N/mm²*	*Averag e 28 days Compr essive Strengt h in N/mm²*	*% of Increase in Compressi ve Strength in 28 days*
NC	0%	724	32.17	32.61	-
		781.2	34.72		
		696.3	30.94		
D12+Q D25	12%+25 %	745.6	33.13	33.21	1.83
		742.6	33		
		754.1	33.51		
D12+Q D35	12%+35 %	779.6	34.64	35.38	8.49
		783.3	34.81		
		825.9	36.7		
D12+Q D45	12%+45 %	752	33.42	33.51	2.75
		735.6	32.69		
		774.8	34.43		

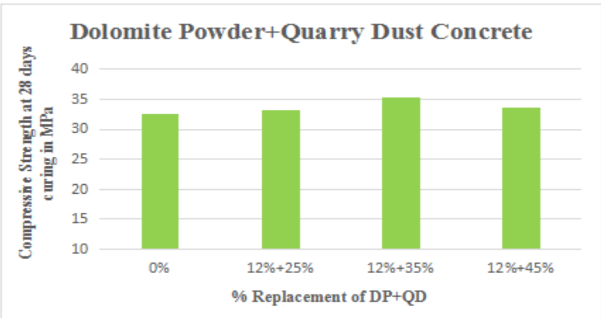

Fig. 9. % Replacement of cement with DP & sand with QD vs Compressive Strength at 28 days curing (N/mm²)

Note: D12+QD25: 12% of Dolomite powder & 25% of Quarry Dust.

D12+QD35: 12% of Dolomite powder & 35% of Quarry Dust.

D12+QD45: 12% of Dolomite powder & 45% of Quarry Dust.

Table- XVI: Split tensile strength results for DP+QD concrete (N/mm²)

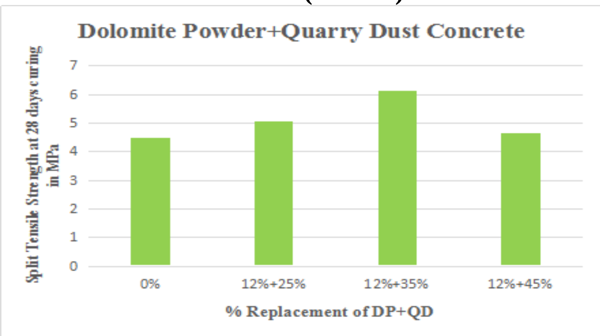

Fig. 10. % Replacement of cement with DP & sand with QD vs Split Tensile Strength at 28 days curing (N/mm²).

Table- XVII: Flexural strength results for DP+QD concrete (N/mm²)

Mix - ID	*Replaceme nt of cement with DP Sand with QD*	*Load (kN)*	*28 days Flexural Strength in N/mm²*	*Average 28 days Flexural Strength in N/mm²*	*% of Increase in Flexural Strength in 28 days*
NC	0%	10.69	4.27	4.22	-
		11.12	4.44		
		9.91	3.96		
D12+ QD25	12%+25%	11.69	4.67	5.21	23.45
		14.21	5.68		
		13.18	5.27		
D12+ QD35	12%+35%	15.86	6.34	6.3	49.28
		15.07	6.02		
		16.32	6.52		
D12+ QD45	12%+45%	12.5	5	4.71	11.61
		11.84	4.73		
		11.03	4.41		

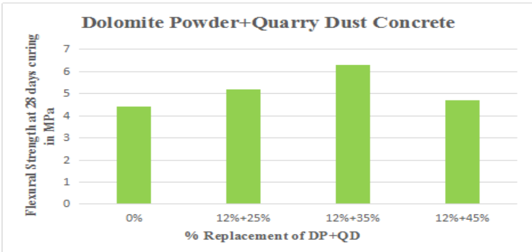

Fig. 11. % Replacement of cement with DP and sand with QD vs Flexural Strength at 28 days curing (N/mm²).

E. Behavior of RC beams under flexure:

F. Normal RC beams

Fig. 12. Test setup of RC Beam

Fig. 13. Failure of RC Beam

G. Normal Reinforced Concrete Beams (NRCB)

Fig. 14. Crack Pattern for Normal RC Beams (NRCB)

The Normal Reinforced Concrete Beams (NRCB), NRCB1, NRCB2 & NRCB3 with reinforcement of 2#8mmϕ at top and 2#12mmϕ at bottom and shear reinforcement of 8mmϕ with spacing of 150 mm c/c failed in flexure or shear. The typical crack pattern of beams NRCB1, NRCB2 & NRCB3 are shown in Fig. 14.

The load deflection results of Normal beams NRCB1, NRCB2 & NRCB3 are shown in Table- XVIII. and the load deflection curve for NRCB1, NRCB2 & NRCB3 are shown in Fig. 15.

NRCB1:

A gradual load is applied with increment of 2kN/sec to the beam and for every increment of the load, deflection is recorded. The first crack has developed in the Flexural zone at a load of 71.5kN. As the load increased, the beam deflected more with formation of more number of flexural cracks.

The beam has failed at a load of 108.4kN with maximum deflection at mid span is 5.23mm with the development of wider flexural cracks.

NRCB2:

Repeating the same procedure of loading in this specimen the first crack is observed at 85.7kN in flexural zone .The specimen failed at a maximum load of 157.5kN and the maximum deflection was recorded 5.75mm at mid span.

NRCB3:

Repeating the same procedure of loading in this specimen the first crack was developed at 70.3kN.

At the load 107.6kN the specimen failed suddenly with formation of wider flexural cracks at mid span with a deflection of 5.11mm was observed.

Table- XVIII: Load deflection results of Normal RC Beams.

NRCB1			*NRCB2*			*NRCB3*		
Load In kN	*Deflection In mm*	*Crack*	*Load In kN*	*Deflection In mm*	*Crack*	*Load In kN*	*Deflection In mm*	*Crack*
0	0		0	0		0	0	
10.9	0.46		10.8	0.07		4.1	0.09	
12.6	0.6		17.7	0.38		12	0.42	
12.8	0.61		18.3	0.42		14.1	0.54	
12.8	0.62		18.3	0.47		14.7	0.64	
12.9	0.63		18.3	0.49		15.1	0.78	
24.3	0.79		18.4	0.51		15.6	0.86	
39.6	1.81		18.4	0.52		16.1	0.88	
42.1	2.01		18.4	0.54		16.4	0.96	
43	2.12		18.4	0.56		16.6	0.98	
44.6	2.16		18.5	0.57		17.4	1.02	
46.9	2.3		19.4	0.58		17.9	1.13	
48.3	2.45		43.4	1.18		18.6	1.33	
50.8	2.47		58.5	2.14		20.3	1.54	
51.5	2.49		75.5	3.15		24.6	2.03	
54.9	2.74		78.2	3.35		30.9	2.39	
59.2	2.78		85.5	3.64		36.3	2.71	
64.5	3.08		88.2	3.69		41.2	2.95	
66.2	3.38		89.7	3.87		43.1	3.06	

70.5	3.96		87.6	3.95		44.6	3.31	
71.5	3.98	**first crack**	85.7	3.99	**first crack**	50.6	3.62	
74.9	4.08		85.6	4.1		54.2	3.87	
75	4.21		84.2	4.15		57.6	3.87	
75.58	4.36		84.2	4.21		70.3	4.01	**first crack**
83.6	4.62		92	4.35		72.4	4.1	
108.4	5.23	**ultimate load**	110.9	4.55		74.1	4.18	
99.6			111.3	4.83		75	4.25	
96.4			138.7	4.96		80.1	4.32	
			143.9	5.13		86.3	4.51	
			150.1	5.61		92.1	4.95	
			156.2	5.63		107.6	5.11	**ultimate load**
			157.5	5.75	**ultimate load**	106.2		
			121.1			105.3		
			116.2					

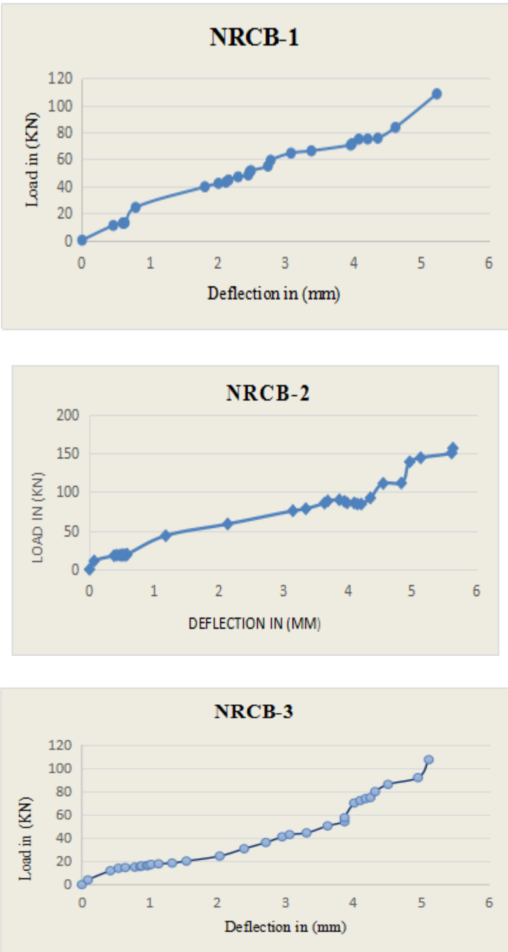

Fig . 15. Load Deflection curve of Conventional RC Beams

H. Dolomite Powder+Quarry Dust Reinforced Concrete Beams (DP+QD RC BEAMS)

Fig. 16. Crack Pattern for DP+QDRC Beams.

The beam DP+QDRCB1, DP+QDRCB2 & DP+QDRCB3 (Optimum percentage of 12% Dolomite powder and 35% of Quarry dust) with reinforcement of 2#8mmϕ at top and 2#12mmϕ at bottom and shear reinforcement of 8mmϕ with spacing 150 mm c/c failed in flexure or shear. The typical crack pattern of beams DP+QDRCB1, DP+QDRCB2 & DP+QDRCB3 are shown in Fig. 16. The load deflection results of beams DP+QDRCB1, DP+QDRCB2 & DP+QDRCB3 are shown in Table- XIX. and the load curve for DP+QDRCB1, DP+QDRCB2 & DP+QDRCB3 are shown in Fig. 17.

DP+QDRCB1:

A gradual load is applied with increment of 2kN/sec to the beam and for every increment of the load, deflection is recorded. The first crack has observed at a load of 87.2kN. As the load increases, the specimen deflected more with formation of more number of flexural cracks.

The beam has failed at load of 173.5kN with maximum deflection at mid span 4.68mm with the development of wider flexural cracks was observed.

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DP+QDRCB2:

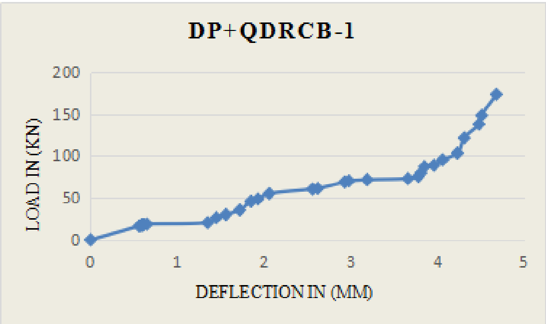
Repeating the same procedure of loading in this specimen the first crack is developed at 86.2kN in flexural zone. As the load the increases the beam deflected more with formation of more number of flexural and shear cracks.

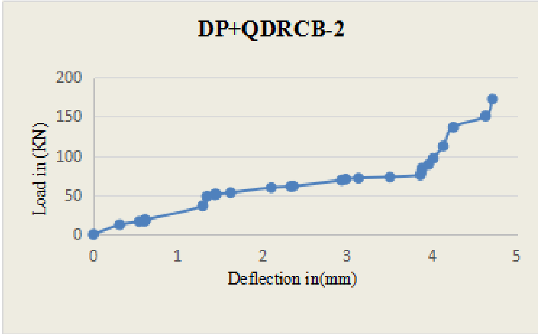
The specimen failed at a maximum load of 172.1kN and the maximum deflection was recorded 4.71mm at mid span.

DP+QDRCB3:

Repeating the same procedure of loading in this specimen the first crack is developed at 88.5kN in flexural zone. As the load the increases the beam deflected more with formation of more number of flexural and shear cracks.

At the load of 175.5kN the beam has failed with the formation of wider flexural cracks at centre with deflection of 4.51mm.





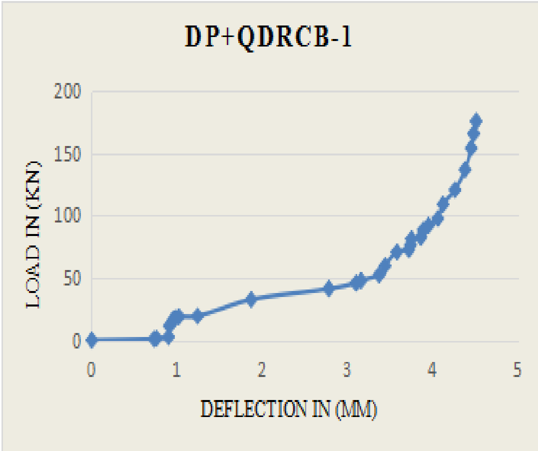


Fig. 17. Load Deflection curve of Optimum percentage of DP+QDRC Beams

Table- XIX: Load deflection results of Optimum percentage (12%DP+35%QD) Beams

DP+QDRCB1			*DP+QDRCB2*			*DP+QDRCB3*		
Load In kN	*Deflection In mm*	*Crack*	*Load In kN*	*Deflection In mm*	*Crack*	*Load In kN*	*Deflection In mm*	*Crack*
0	0		0	0		0	0	
16.5	0.56		12.3	0.31		1.02	0.73	
17.3	0.58		16.4	0.54		2.6	0.76	
17.9	0.59		16.7	0.6		4.53	0.9	
17.2	0.6		17.8	0.61		11.5	0.91	
18.4	0.61		18.4	0.61		15.6	0.95	
18.8	0.65		18.5	0.61		16.9	0.96	
20.5	1.35		36.5	1.29		17.8	0.98	
26.3	1.45		48.4	1.34		18.9	1.02	
30.1	1.56		50.8	1.43		19.4	1.24	
35.6	1.72		51	1.44		32.6	1.87	
46	1.85		51.1	1.45		41.3	2.78	
48.7	1.93		53.1	1.62		45.8	3.1	
55.2	2.06		59.5	2.1		47.9	3.16	
60.6	2.56		61	2.33		52.4	3.37	
61.3	2.62		61.3	2.36		59.6	3.44	
69.02	2.93		69	2.93		70.8	3.58	

70.35	2.98		70.32	2.98		72.8	3.72	
71.69	3.19		71.62	3.13		76.5	3.74	
73	3.66		73	3.5		81.3	3.75	
75.6	3.78		75.5	3.86		82.6	3.86	
79.8	3.81		79.3	3.87		88.5	3.89	**first crack**
87.2	3.85	**first crack**	84.2	3.88	**first crack**	92.01	3.95	
88.9	3.96		89.2	3.96		97.62	4.06	
95.36	4.06		96.45	4.01		109	4.12	
103.3	4.23		112.3	4.13		120.6	4.26	
121.6	4.31		136.2	4.25		136.9	4.38	
137.9	4.48		150.6	4.63		154.1	4.45	
148.3	4.51		172.1	4.71	**ultimate load**	165.8	4.48	
173.5	4.68	**ultimate load**	168.3			175.7	4.51	**ultimate load**
			156.1					

Note:
DP+QDRCB: Dolomite Powder & Quarry Dust Reinforced Concrete Beams with 12% of Dolomite and 35% of Quarry dust.

I. COMPARISON OF NRCB & DP+QD REINFORCED CONCRETE BEAMS

The beams test results are tabulated in table- XX**.**

Table- XX: RC Beams test results

Beam Type	***Beam designation***	***Cracking Load in (kN)***		***Average of Cracking Load in (kN)***		***Deflection in (mm)***	***Average Deflection in(mm)***	***Mode of Failure***
		First Crack	***Ultimate Load***	***First Crack***	***Ultimate Load***			
Normal Reinforced Concrete Beams	NRCB-1	71.56	108.4	75.83	124.5	5.23	5.36	Flexure
	NRCB-2	85.7	157.5			5.75		Flexure
	NRCB-3	70.3	107.6			5.11		Flexure
Optimum Percentage of DP+QDRC Beams	DP+QD RCB1	87.2	173.5	87.3	173.76	4.68	4.63	Flexure
	DP+QD RCB2	86.2	172.1			4.71		Flexure
	DP+QD RCB3	88.63	175.7			4.51		Flexure

The comparison of ultimate load for Normal RC beams and DP+QD RC Beams is shown in Fig. 18.1 and the combined load v/s deflection curve for Normal RC beams and DP+QD RC Beams is shown in Fig. 18.2.

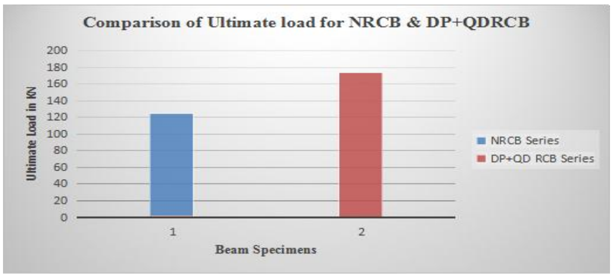


Fig. 18.1. Comparison of ultimate load for the set of beams.

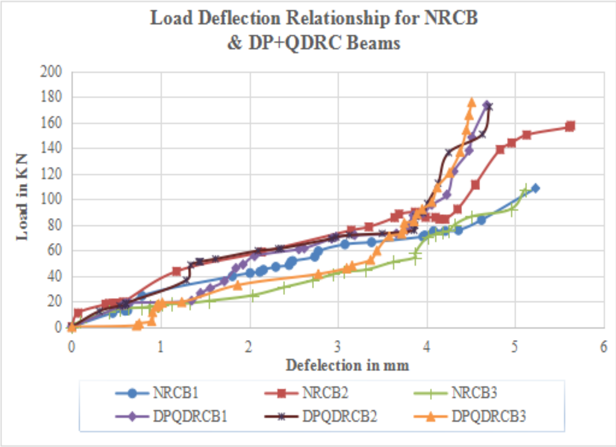


Fig. 18.2. Combined graph of load v/s deflection curve for NRCB & DP+QDRCB Beams

From the load v/s deflection curves it is observed that there is delay in formation of first crack for DP+QD RC beams when compared with the Normal RC beams.

V. CONCLUSION

Based on the experimental investigations the following conclusions are drawn.

1. Replacement of cement by dolomite powder and fine aggregate by quarry dust has shown improvement in the strength parameters of concrete.
2. It is observed that the maximum compressive strength, split tensile strength and flexural strength of concrete is increased by 7.66%, 34.59% and 44.78% respectively, as compared with that of conventional concrete when 12% (optimum percentage) of cement is replaced by Dolomite Powder.
3. The test results indicates that the increase in compressive strength, split tensile strength and flexural strength of concrete by 8.49%, 36.38% and 49.28% respectively, at optimum percentage of replacement of cement 12% by dolomite powder and 35% of sand by quarry dust in comparison with conventional concrete.
4. It is concluded that by using Dolomite powder & Quarry dust at optimum percentage the ultimate load is increased by 39.56% in comparison with conventional RC beams.
5. The percentage of deflection of RC beams with Dolomite Powder & Quarry Dust is reduced by 13.61% in comparison with conventional RC beams.
6. From study it is concluded that low cost material Dolomite powder & Quarry dust at optimum percentage (12% of Dolomite powder & 35% of Quarry dust) can be used in construction works, which results in construction cost. And by using natural resources the environment is protected from waste disposal materials.

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