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COMBINED EFFECT OF PARTIAL REPLACEMENT OF CEMENT BY RED MUD AND FINE AGGREGATES BY QUARRY DUST ON STRENGTH CHARACTERSTICS OF CONCRETE

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ABSTRACT

The main objective of the project is experimental study of the possibility of utilizing the waste red mud (bauxite residue) and quarry dust in cement concrete. Red mud is a by-product produced in the process of extraction of aluminium from bauxite. The red mud generated by this process is highly alkaline with a pH usually ranging from 10 to 12. It leads to serious environmental problems. Worldwide there are approximately 80 to 90 million tons of red mud is being generated every year. The production of 1 ton aluminium generates 1-2 tonnes of red mud. The storage of red mud is economically and environmentally problematic due to the risk of contamination of natural resources and living organisms. Red mud can be used in replacement of cement in concrete. The quarry dust which is available from local resources can be used as a replacement of river sand in a conventional concrete pavements. This study aims at describing such utilization and their effective usage in concrete. Experiments have been conducted under laboratory conditions to assess the compressive strength, split tensile strength and flexural strength of the concrete cubes made of red mud and quarry dust. By conducting the model tests we can replace the 20% of cement with red mud and upto 50% of fine aggregates with quarry dust

1. INTRODICTION

The concrete is a composite material which is mostly used all over the world. The strength characteristics of concrete depend upon the properties of component material and their collective action. Fine aggregate is one of the important constituent materials as far as strength characteristics of concrete are concerned. Increase in demand and decrease in natural sources of fine aggregate for the production of concrete has resulted in the need to identify news sources of fine aggregate. River and which is most commonly used as fine aggregate in the production of concrete and mortar poses the problem of acute shortage in many areas. Due to industrialization, infrastructure development and soft housing policy of Government of India, the construction industry is in full bloom due to which within short span of time there is a tremendous increase in the utilization of cement and concrete for various construction activities. It is expected that the same rate will continued in the next decade and this may invite the threat to the environment. Availability of raw material required for manufacturing of cement and production of concrete are limited in nature. This increased demand will lead to fast depletion of natural resources and will cause big threat to environment. So as to overcome this problem it is very much essential to utilize the industrial waste materials and by-products generated in manufacturing of cement and in concrete construction.

2. CONSTITUENT MATERIALS USED

The constituent materials used are cement, fine aggregate, coarse aggregate, stone dust and water. The recommended materials have been described below.

Cement

Various types of cement can be used in concrete with stone dust. The cement should be fresh, free from foreign matters and of uniform consistency. Usually ordinary Portland cement is used in normal conditions.

Fine Aggregate

The most common fine aggregate used in concrete is sand. The sand should be clean, hard, strong and free from organic impurities and deleterious substances. It should be capable of producing a sufficiently workable mix with a minimum water-cement ratio.

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Coarse Aggregate

The aggregates are formed due to natural disintegration of rocks or by artificial crushing of the rock or gravels. The properties of coarse aggregate are chemical and mineral composition, spectrographic description, specific gravity, hardness, strength, physical and chemical stability, pore structure and color. Some other properties of the aggregate not possessed by the parent rocks are particle size and shape, surface texture and absorption etc. All these properties may have a considerable effect on the quality of concrete in fresh and hardened states.

Red Mud

Red mud is the iron rich residue from the digestion of bauxite. It is one of major solid waste coming from Bayer process of alumina production. In general, about 2-4 tons of bauxite is required for production of each tone of alumina (Al2O3) and about one tone red mud is generated. Since the red mud is generated in bulk it has to be stored in large confined and impervious ponds, therefore the bauxite refining is gradually encircled by the storage ponds. At present about 60 million tons of red mud is generated annually worldwide which is not being disposed or recycled satisfactorily.

Red Mud

Water

Mixing water should be fresh, clean and potable. Water should be free from impurities like clay, loam, soluble salts which lead to deterioration in the properties of concrete. Potable water is fit for mixing or curing of concrete.

3. MIX DESIGN

Design Mix For M30 Grade Concrete

Grade of concrete	: M30
Cement	: OPC 43 grade
Target Strength	: fck+1.65(s) = 38.25 N/mm2
Cement content	: 375 kg/m3
Water/Cement ratio	: 0.45
River sand content	: 726.91 kg/m3
Coarse aggregate content	: 1145.64 kg/m3

The experimental work includes the following 2 parts:
Part I: Investigating the effect of replacing a part of the cement binder with red mud in Mortar.

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Mix proportion for various percentage of red mud with cement

S.No.	Type of Mix	W/C ratio	Cement (kg/cum)	Red Mud (kg/cum)	Coarse aggregate (kg/cum)	Fine aggregate (kg/cum)	Water (liter/cum)
1	M-30(0% RM)	0.45	375	0	726.91	1145.64	225
2	M-30(5%RM)	0.45	350	25	726.91	1145.64	225
3	M-30(10%RM)	0.45	325	50	726.91	1145.64	225
4	M-30(15%RM)	0.45	300	75	726.91	1145.64	225
5	M-30(20%RM)	0.45	275	100	726.91	1145.64	225
6	M-30(25%RM)	0.45	250	125	726.91	1145.64	225

Part II: To study the effect of Red mud (Replacement to cement) & Quarry Dust (Replacement to Fine Aggregate) on strength parameters of concrete.

After getting the optimum mortar strength from the above part I, the next procedure is to design M30 grade mix by using as per IS 10262:2009 codal provisions keeping the red mud percentage as constant (optimum obtained) and vary the Quarry Dust as 10%, 20%, 30%, 40% and 50%(replacement to fine aggregates). Further development mixes are studied for both fresh as well as hardened properties.

Mix proportion for various percentage of red mud and quarry dust

S. No.	Type of Mix	W/C ratio	Cement (kg/cum)	Red Mud (kg/cum)	Coarse aggregate (kg/cum)	Fine aggregate (kg/cum)	Quarry Dust (kg/cum)
1	M-30(20% RM+0%	0.45	275	100	726.91	1145.64	0
2	M-	0.45	275	100	654.219	1145.64	72.691
3	M-	0.45	275	100	581.528	1145.64	145.38
4	M-	0.45	275	100	508.837	1145.64	218.07
5	M-	0.45	275	100	436.146	1145.64	290.76
6	M-	0.45	275	100	363.455	1145.64	363.45

4. TESTING OF SPECIMENS

The cubes were tested in compression testing machine after 7 and 28 days with uniformly increasing loads capacity compression testing machine. The loading was transmitted from loading machine to the specimen by rigid steel plates placed on both above and below the specimen. The load was applied until needle started deflecting backward after crushing of the specimen and the last reading was noted.

The beams were tested in a frame having varying capacity with two point load test. The specimens were divided in three parts equally and two point loads were kept at the end of middle third part of specimen and the load was applied through cylindrical iron piece kept below the dial gauge.

The cylinders were tested in compression testing machine with uniformly increasing capacity compression testing machine. The test consists of applying a compressive line load along the opposite generators of a concrete cylinder placed with its axis horizontal between the compressive platens

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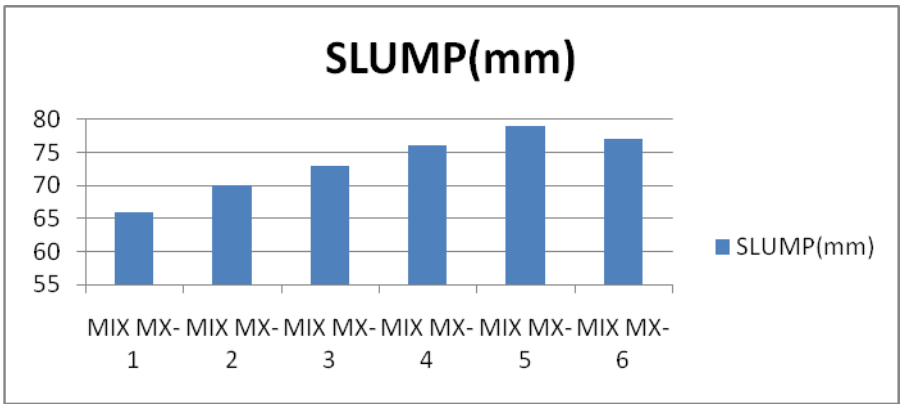
5. RESULT ANAYLSIS

- **Workability Test Results:** Following table gives the workability test results of concrete produced by using Red Mud (RM) and Quarry Dust (QD).

Slump Flow Result

Mix Designation	Replacement of cement by Red mud and Fine aggregate by Quarry dust	Slump(mm)
MIX MX-1	20% RM + 0% QD	66
MIX MX-2	20% RM + 10% QD	70
MIX MX-3	20% RM + 20% QD	73
MIX MX-4	20% RM + 30% QD	76
MIX MX-5	20% RM + 40% QD	79
MIX MX-6	20% RM + 50% QD	77



- **Compressive Strength Of Mortar:** Compressive strength of the mortar design mix was check by casting and testing of cubes after the curing period of 7 days, 14 days & 28days. Following gives the overall results of compressive strength of mortar produced by using Red mud. Also it gives the percentage increase or decrease of compressive strength with respect to control mix (0%).

Mix Designation	7-days Compressive strength of concrete (N/mm^2)	14-days Compressive strength of concrete (N/mm^2)	28-days Compressive strength of concrete (N/mm^2)
MIX M-1	31.41	33.58	40.18
MIX M-2	31.74	34.42	43.65
MIX M-3	32.58	35.25	43.99
MIX M-4	33.23	36.87	44.17
MIX M-5	34.42	37.89	45.96
MIX M-6	32.53	36.21	43.08

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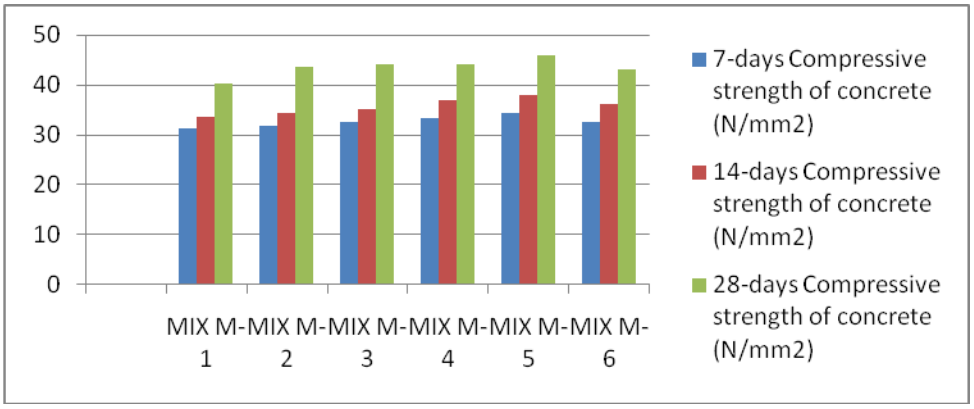
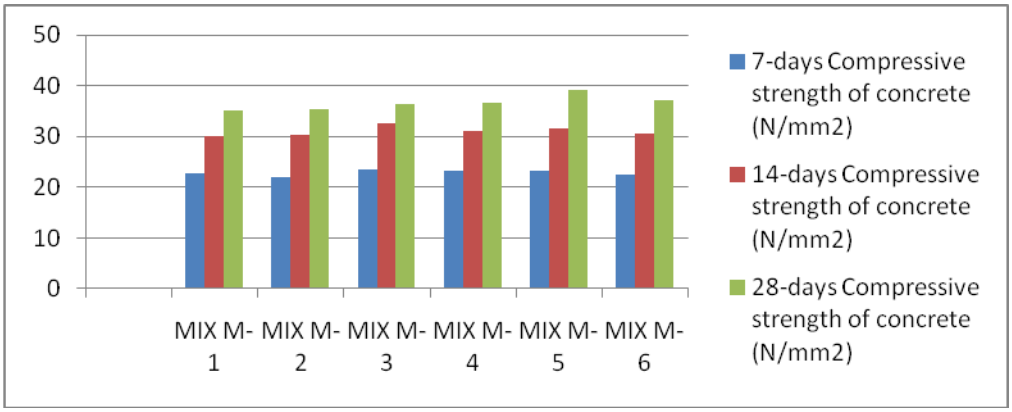


Compressive Strength results of Mortar for 7-Days, 14 Days and 28-Days

- **Compressive Strength Of Concrete:** Compressive strength of the concrete design mix was check by casting and testing of cubes after the curing period of 7 days, 14 days & 28days

Mix Designation	7-days Compressive strength of concrete (N/mm^2)	14-days Compressive strength of concrete (N/mm^2)	28-days Compressive strength of concrete (N/mm^2)
MIX M-1	22.62	30.17	35.18
MIX M-2	22.08	30.34	35.28
MIX M-3	23.51	32.7	36.36
MIX M-4	23.26	31.17	36.69
MIX M-5	23.32	31.51	39.2
MIX M-6	22.48	30.53	37.2



Compressive Strength results of Concrete for 7-Days, 14 Days and 28-Days

- **Flexure strength test:** Although the concrete is not designed to resist tension, the knowledge of tensile strength of concrete is of value in assessing the load at which crack will start appearing in concrete. Flexural Strength of specimen at 7 Days, 14 days and 28 days are shown in Table

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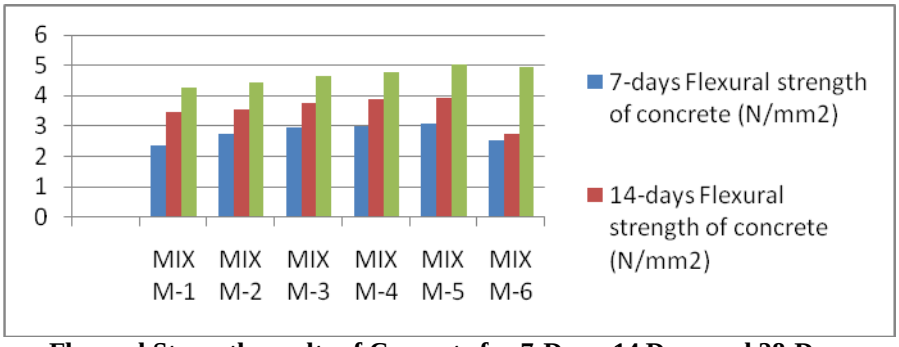
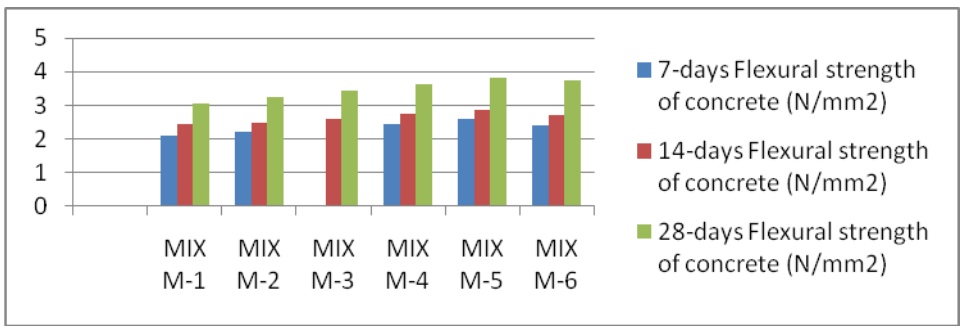
Mix Designation	7-days Flexural strength of concrete (N/mm^2)	14-days Flexural strength of concrete (N/mm^2)	28-days Flexural strength of concrete (N/mm^2)
MIX M-1	2.37	3.48	4.27
MIX M-2	2.73	3.54	4.45
MIX M-3	2.95	3.77	4.66
MIX M-4	2.98	3.87	4.78
MIX M-5	3.07	3.93	5.03
MIX M-6	2.53	2.74	4.93



Flexural Strength results of Concrete for 7-Days, 14 Days and 28-Days

- **Split tensile strength test :** The split tensile strength of concrete was conducted on various mixes as per guidelines of IS 516-1970.Split Tensile strength of 7, 14 and 28 days are shown in Table

Mix Designation	7-days Flexural strength of concrete (N/mm^2)	14-days Flexural strength of concrete (N/mm^2)	28-days Flexural strength of concrete (N/mm^2)
MIX M-1	2.11	2.44	3.07
MIX M-2	2.21	2.48	3.23
MIX M-3	2..36	2.61	3.43
MIX M-4	2.45	2.76	3.62
MIX M-5	2.58	2.88	3.83
MIX M-6	2.39	2.71	3.75



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6. CONCLUSIONS

A series of laboratory experiments was conducted to find the fresh properties of concrete like Workability and also the testing on hardened concrete is also done to find compressive strength, split tensile strength, and flexural strength of concrete with several percentage of marble powder. The effects of red mud and quarry stone on these properties are studied. The following are the conclusions that can be drawn from the experimental investigation:

- Slump flow test is conducted with a fix partial replacement cement of 20% with red mud.
- As shown from the values obtained the slump value increased for partial replacement of quarry dust upto 40% and the it decreased.
- Compressive strength of the mortar design mix was check by casting and testing of cubes after the curing period of 7 days, 14 days & 28days.
- As the optimum value is obtained from the replacement of 20% so the partial replacement with 20% red mud is taken as standard.
- Compressive strength of the concrete was check by testing of cubes after the curing period of 7 days, 14 days & 28days with a fix red mud percentage of 20%
- The optimum value is obtained from the replacement of 40%.
- The optimum value for flexural strength is obtained from the replacement of 40%.
- The optimum value for split tensile testis obtained from the replacement of 40%.

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