Experimental Study on Mechanical Properties of Concrete Containing Waste Glass Powder and Red Mud as Simultaneous Replacement of Cement

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Abstract - *It is a known fact that concrete is the most used construction material globally after water. It is of prime importance of find some suitable replacement materials to reduce the impact of the consumption as the cement industries alone are responsible of 7% of global carbon dioxide emissions. To overcome with this issue, it is necessary to find some alternate material that can be replaced by cement. Red mud and Waste Glass Powder may be replaced with cement. Red Mud is produced during the Bayer Process. Now days, it is stored or dumped on land, or in the oceans near alumina factories. Waste Glass in India alone, 45% of waste glass in non- recyclable. It is dumped in landfills and leads to land pollution. Glass is an anthropogenic material that does not decompose for over 1 million years. In this dissertation the experiment is done for M30, M40 and M50 grade of concrete. Red Mud and Waste Glass Powder is simultaneous replaced with cement in concrete. Red Mud is Replaced by 5% and 10% by weight of cement and Waste Glass powder is Replaced by 5%, 10%, 15% and 20% by weight of cement. In this thesis, several mechanical properties of concrete will be carried out.*

Key Words: **Concrete, Red Mud, Waste Glass Powder, Simultaneous Replacement, Compressive strength, Split Tensile strength, etc.**

1.INTRODUCTION

The climate change is primarily due to human activities is no longer in question. Excessive use of concrete is one of them. The cement is core material in making of concrete. CO_2 is emitted in huge amount during the production of cement. Due to this excessive use the concrete CO_2 is emitted in the environment is in huge Amount. To overcome this problem, it is necessary to find such alternate material that can be act as cement in the making of concrete. Red Mud is a waste by-product generated in the production of alumina from bauxite by bayer process. The red mud is generated in amount of 1-1.5 ton, per ton production of alumina. For most of alumina refineries the red mud is problematic because of its storage issue. The most common form of dumping red mud is into waste ponds on the ground. However, because of the high maintenance costs and the need for continuous monitoring, this approach is not cost effective. The disposal of red mud on waste lands can pose a health and environmental risk to the public. Glass is an industrial substance made by fusing sand with soda and lime, then quickly cooling it. Both recyclable and non-recyclable glass can be produced in the industries. According to a report published in May 2018, about 45 percent of glass in India is recycled, while the rest is discarded in landfills. When the particle size is less than 75m, glass has a high silica content, making it theoretically pozzolanic. Due to rising disposal costs and environmental issues, the use of recycled waste glass in Portland cement and concrete has piqued interest around the world. An experiment was carried out to partly substitute the cement in concrete with red mud for various percentages, as well as its impact on the strength and other properties of the concrete, by taking cementitious action of the red mud into account.

2. MATERIAL PROPERTIES

It's crucial to know the properties of the materials you'll be working with before you begin any experiment. The properties of materials can be used to create a mix design for different concrete grades. Cement, sand, aggregate, water, admixture, and other ingredients are used in the production of concrete.

2.1 Cement

The word 'cement' usually means the Portland cement used in civil engineering works, which sets well under water, harden quickly and attain strength. There are many types of cement, but the most common in use are Ordinary type. In this experiment the cement used to be OPC 53 grade. The cement used shall be conformed to IS 269 up to date. The minimum Compressive Strength of ordinary Portland cement as per IS 269 should be 17.50 MPa. Fineness of cement = 225 m^2/kg

2.2 Fine Aggregate

The Aggregates which are passed through 4.75 IS sieve are called Fine Aggregates. According to IS 383 the Fine Aggregates are divided into four zones, i.e. Zone I, II, III and IV. For preparing concrete mix design the zone of fine aggregates is important and for that sieve analysis of aggregate is necessary. As per IS 2386 part-I Minimum Weight of sample for sieve analysis is 500 gm.

Table -1: Data of Sieve Analysis

Sieve Size	Retained weight	%Retained weight	Passing weight	%passing weight	Zone II
10 mm	0	0	0	100	100
4.75 mm	26	26	5.2	94.8	90-100
2.36 mm	37.75	63.75	12.75	87.25	75-100
1.18 mm	43	106.75	21.35	78.65	55-90
600 µm	89.25	196	39.20	60.80	35-59
300 µm	238.25	434.25	86.85	13.15	8-30
150 µm	55.3	489.55	97.91	2.09	0-10

From Table 4.1 The Zone for Fine Aggregate is II.

Table -2: Physical Properties of Fine Aggregates

Specific Gravity	2.69
Water Absorption	1.5%
Zone	II

2.3 Coarse Aggregates

The aggregates which passed through 75mm mesh and are entirely retained on 4.75mm sieve are called Coarse Aggregates. The function of coarse aggregates is to make the concrete strong and weather resistant. In this dissertation project the 20mm size crushed angular aggregate is used.

Table -3: Physical Properties of Coarse Aggregates

Specific Gravity	2.89
Water Absorption	1%
Shape	Angular

2.4 Red Mud

Red mud is a combination of solid and metallic oxide-bearing impurities that poses one of the most serious waste disposal issues in the aluminium industry. The oxidised iron in the red mud, which can account for up to 60% of the total mass, is responsible for the colour. Other prominent particles are silica, residual aluminium, and titanium oxide, in addition to iron. The red mud is difficult to get rid of.

Table -4: Physical Properties of Red Mud

Specific Gravity	2.91
Fineness	342 m^2/kg
Appearance	Red

2.5 Waste Glass Powder

"Silicate glasses," built on the chemical compound silica (silicon dioxide, or quartz), the main constituent of sand, are the most familiar and traditionally the oldest forms of processed glass. Soda-lime glass, which contains about 70% silica, accounts for about 90% of all imported glass. The physical properties of waste Glass Powder is Shown in Table-5.

Table -5: Physical Properties of Waste Glass Powder

Specific Gravity	2.83
Fineness	174 m^2/kg
Appearance	White

2.6 Admixture

Admixture is defined as a material, other than cement, water, Coarse and fine aggregates that is used as a component of concrete and is added to the batch immediately before or during mixing to modify the properties of concrete in the fresh or harden state. The details of admixture that is used are as follows:
Product Specification in Shown in Table-6.
CONFLOW-MPC is MID range polycarboxylic Ether based Superplasticiser of a new generation conforming to IS 9103: 1999.

Table -6: Physical Properties of Waste Glass Powder

Name	CONFLOW-PC
Specific Gravity	1.110±0.02
Appearance	Dark Brown Liquid

2.7 Water

Cement combines with water to form a paste. It is because of the hydration of cement that it gains strength. Water also lubricates the aggregates used in the cement paste to form concrete. Water used shall be clean and free from harmless quantities of deleterious material such as oils, acids, salts and vegetable growth.

3. EXPERIMENTAL WORK

The experiment is carried out on concrete grades M30, M40, and M50. This experiment tests various concrete mechanical properties such as compressive strength, split tensile strength, slump test, compaction factor test, and acid attack. Red Mud and Glass Powder is simultaneous replaced by cement in Various Proportion Shown in Table -6.

Table -7: Mix Proportions

Mix	Glass Powder (%)	Red Mud (%)
P1	0	0
P2	5	5
P3	10	5
P4	15	5
P5	20	5
P6	5	10
P7	10	10
P8	15	10
P9	20	10

4. RESULTS

4.1 Compressive Strength Test

The compressive strength of concrete is determined at 28 days. the cube of size of 150mm × 150mm × 150mm is casted. IS 516: 1959 is used as reference for testing.

Table -8: Compressive strength result

Mix	M30 (N/mm^2)	M40 (N/mm^2)	M50 (N/mm^2)
P1	33.63	43.70	53.63
P2	34.52	45.33	53.33
P3	36.30	47.70	55.85
P4	32.15	44.15	51.56
P5	30.22	39.41	49.19
P6	33.04	44.15	50.07
P7	30.07	40.59	47.85
P8	28.30	36.30	47.56
P9	26.67	34.37	32.26

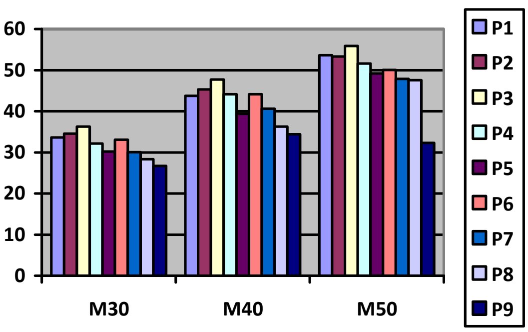

Chart - 1: Compressive Strength

4.2 Split Tensile Strength

The cylinder of size of 150mm diameter and 300mm height is casted and tested for 28 days. IS 5816: 1999 is used as reference for testing.

Table -9: Split Tensile strength result

Mix	M30 (N/mm^2)	M40 (N/mm^2)	M50 (N/mm^2)
P1	4.01	4.67	5.19
P2	4.15	4.77	5.14
P3	4.72	4.86	5.33
P4	3.96	4.62	5.00
P5	3.87	4.34	4.91
P6	4.06	4.62	4.91
P7	3.87	4.48	4.77
P8	3.77	4.15	4.48
P9	3.63	4.20	4.62

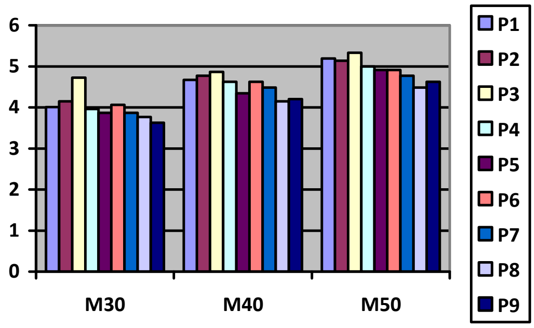

Chart - 2: Split Tensile Strength

4.3 Slump Test

This method of test specifies the procedure to be adopted, either within the laboratory or during the progress of work within the field, for determining, by the slump test, the consistency of concrete is determined where the nominal maximum size of the mixture doesn't exceed 38 mm. IS 1199: 1959 is used for reference.

Table -10: Slump Test result

Mix	M30 (mm)	M40 (mm)	M50 (mm)
P1	100	105	90
P2	110	105	100
P3	110	100	100
P4	150	130	150
P5	150	135	140
P6	100	95	95
P7	110	110	100

P8	140	130	140
P9	160	150	150

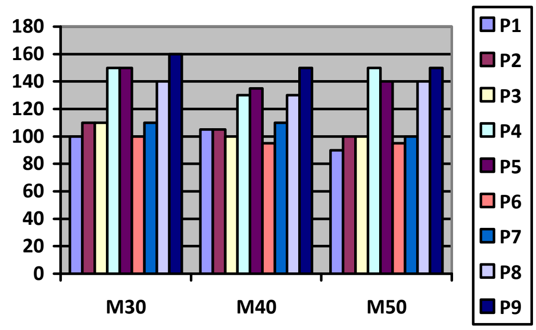

Chart - 3: Slump Results

4.4 Compaction Factor Test

This test is designed for laboratory work only. But if required can also be used on the site. By the compaction factor test, the consistency of concrete is determined where the nominal maximum size of the mixture doesn't exceed 38 mm. IS 1199: 1959 is used for reference. The result of compaction factor test is shown in Table-11.

Table -11: Compaction Factor Test result

Mix	M30 (mm)	M40 (mm)	M50 (mm)
P1	0.911	0.905	0.897
P2	0.904	0.915	0.907
P3	0.921	0.922	0.914
P4	0.924	0.923	0.923
P5	0.945	0.937	0.929
P6	0.906	0.907	0.899
P7	0.922	0.917	0.910
P8	0.944	0.926	0.919
P9	0.953	0.938	0.930

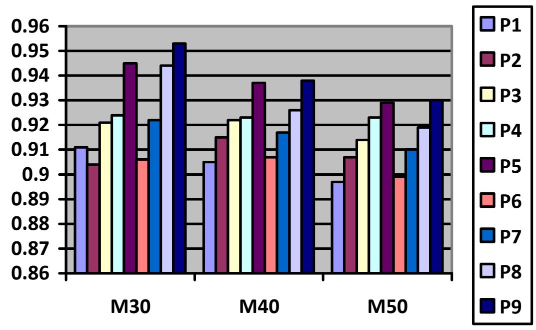

Chart - 4: Compaction Factor Results

4.5 Durability (Acid Attack)

The test is carried out for 56 days. The specimens are immersed in a solution of 5% H_2SO_4 by weight. The durability is determined in terms of reduction in weight as well as in compressive strength.

Table -12: Weight Reduction Results for M30

Mix	Normal weight (Kg)	Reduced weight (kg)	% Reduction in weight
P1	8.873	8.845	0.32
P2	8.807	8.763	0.49
P3	8.683	8.607	0.88
P4	8.690	8.582	1.25
P5	8.658	8.520	1.60
P6	8.720	8.653	0.76
P7	8.680	8.592	1.02
P8	8.843	8.715	1.45
P9	8.760	8.603	1.79

Table -13: Weight Reduction Results for M40

Mix	Normal weight (Kg)	Reduced weight (kg)	% Reduction in weight
P1	8.877	8.855	0.24
P2	8.912	8.865	0.52
P3	8.673	8.597	0.88
P4	8.820	8.717	1.17
P5	8.642	8.512	1.50
P6	8.850	8.782	0.75
P7	8.653	8.564	1.04
P8	8.693	8.563	1.50
P9	8.793	8.634	1.82

Table -14: Weight Reduction Results for M50

Mix	Normal weight (Kg)	Reduced weight (kg)	% Reduction in weight
P1	8.820	8.791	0.33
P2	8.922	8.875	0.52
P3	8.900	8.828	0.81
P4	8.835	8.729	1.20
P5	8.900	8.767	1.49
P6	8.860	8.791	0.78
P7	8.970	8.880	1
P8	8.760	8.624	1.55
P9	8.817	8.655	1.84

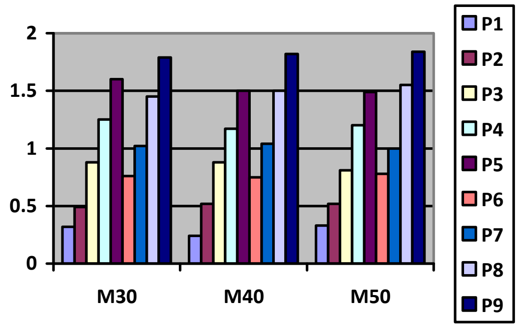

Chart - 5: Weight reduction

Table -15: Reduction in compressive strength for M30

Mix	Normal strength (N/mm²)	Reduced strength (N/mm²)	% Reduction strength
P1	33.63	32.89	2.20
P2	34.52	33.93	1.72
P3	36.30	34.96	3.67
P4	32.15	29.63	7.83
P5	30.22	27.11	10.29
P6	33.04	31.85	3.59
P7	30.07	28.89	3.94
P8	28.30	25.93	8.38
P9	26.67	23.11	13.33

Table -16: Reduction in compressive strength for M40

Mix	Normal strength (N/mm²)	Reduced strength (N/mm²)	% Reduction strength
P1	43.70	42.96	1.69
P2	45.33	43.85	3.27
P3	47.70	45.93	3.73
P4	44.15	40.89	7.38
P5	39.41	35.56	9.77
P6	44.15	42.67	3.36
P7	40.59	38.67	4.74
P8	36.30	33.93	6.53
P9	34.37	30.81	10.34

Table -17: Reduction in compressive strength for M50

Mix	Normal strength (N/mm²)	Reduced strength (N/mm²)	% Reduction strength
P1	53.63	52.74	1.66
P2	53.33	51.85	2.78
P3	55.85	53.04	5.04
P4	51.56	47.85	7.18
P5	49.19	44.89	8.73
P6	50.07	48.74	2.66
P7	47.85	44.89	6.19
P8	47.56	43.11	9.35
P9	43.26	38.37	11.30

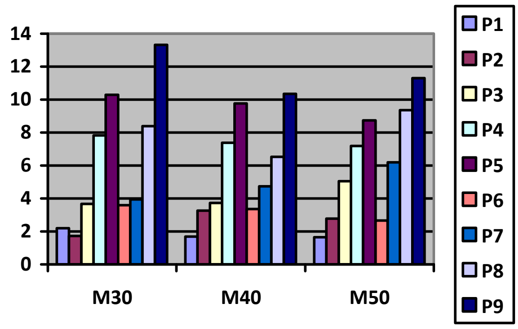

Chart - 6: Reduction in compressive strength

5. CONCLUSIONS

- For compressive strength of M30, M40 and M50 grade of concrete has achieved 8%, 9% and 4% increment respectively at 10% replacement with Waste Glass Powder and 5% replacement with Red Mud.
- For split tensile strength of M30, M40 and M50 grade of concrete has achieved 17%, 4% and 3% increment respectively at 10% replacement with Waste Glass Powder and 5% replacement with Red Mud.
- Workability of concrete is increasing by an increase in percentage of replacement in cement.
- Workability of concrete is increased with the increase in Glass content, but decreases with the increase in content of Red Mud.

- In the durability test the compressive strength is decreased with increase of percentage replacement.
- The weight of concrete cube is reduced with increase in percentage of replacement due to effect of H_2SO_4.

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