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Experimental study on concrete by replacing cement and aggregate with ground granulated blast furnace slag and crump rubber

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ABSTRACT

Concrete is most widely used building material in the world, as well as largest user of natural resources with annual consumption of 12.6 billion tons. Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure which is, buildings, industrial structures, bridges and highways etc. Recycled rubber tyre waste is a promising material in the construction industry and the sole reason for this is the lightweight of the resulting concrete when the rubber tyre is incorporated in it as an aggregate replacement .One another such material is Ground Granulated Blast Slag (GGBS). Ground Granulated Blast furnace Slag (GGBS) is a by-product from the blast furnaces used to make iron. GGBS is used to make durable concrete structures in combination with ordinary Portland cement and/or other pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years.

Keywords: *Crump Rubber, GGBS, Compressive Strength, Flexural Strength, Workability of Concrete.*

1. INTRODUCTION

Concrete is a mixture of cement, aggregates, water, etc. which are economically available. Concrete is made up of granular materials. It looks like coarse aggregates embedded in a matrix bound together with cement or binder which fills the space between the particles and glues them together. Almost three quarter volume of concrete is made of aggregates. To meet the global demand of concrete in the future, it is becoming a more challenging task to find sustainable ways of construction. Sustainable construction mainly aims to reduce the negative environmental impacts generated by construction industry. Over a period of time, waste management is becoming one of the most challenging problem in the world. The wastages are divided as Solid Waste Disposal, Liquid Waste Disposal and Gaseous Waste Disposal.

1.1 Crump Rubber

Crumb rubber is recycled rubber produced from automotive and truck scrap. During the recycling process, steel and tire cord are removed, leaving tire rubber with a granular consistency. Using waste rubber in conjunction with Portland cement has many advantages, including a lower unit weight, increased ductility, higher shock resistance, better extensibility, good shock absorption Problem, higher noise and heat insulation coefficients and improved fire resistance. When used in high strength structural concrete slabs, waste rubber can improve fire resistance and improve resistance to the permeation of chloride ions, thereby improving freeze-thaw resistance.

1.2 GGBS

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. Since the metals present in the slag are very minor amount, their recovery may not be economical by many processes. Therefore, its use in the production of different value added products like abrasive tools, pavement, land reclamation, concrete, cutting tools, tiles, glass, roofing granules, cement, asphalt concrete aggregate etc.

2. LITERATURE REVIEW

Jing Lv, et al.[1] presentthe compiled experimental data of slump value, compressive strength, splitting tension strength, flexural strength, static modulus of elasticity and unit weight for eleven different mixtures of rubber lightweight aggregate concretes cured up to 1, 7 and 28 days. The eleven different mixtures cover one fundamental mixture and ten different replacements of rubber particles for sand volume from10% to 100%.Significant reduction in compressive strength, flexural strength and splitting tensile strength was recorded in mixtures containing rubber particles. The addition of rubber particles can decrease the slump value of lightweight aggregate concrete.

S. Mallikarjuna, et al.[2] present a Compressive Strength of Concrete using GGBS and comparison of the effects of replacement of cement by fly ash and GGBS on the 28 days compressive strength and split tensile strength. To evaluate the compressive strength of concrete by replacing cement with GGBS at varying percentages of 0,10,20,30 and 40% for M20 grade of concrete. To evaluate the compressive strength of concrete by replacing cement with GGBS at varying percentages of 0,10,20,30 and 40% for M40 grade of concrete. To evaluate the strength Efficiency factors for GGBS at varying percentages of 0,10,20,30 and 40 for M20 and M40 grade of concretes. To achieve the objectives of the investigation the experimental program was planned to cast and test the cubes to study the compressive Strength. It is seen that for plain concrete the 28-day compressive strength has maintained more the target concrete strength even up to 20% GGBS replacement. The compressive strength of M20 grade of concrete was found to be maximum at 10 % replacement of cement with GGBS when compared with 20%, 30% and 40 % replacement of cement with GGBS. The compressive strength for M40 grade of concrete was found to maximum at 10% replacement of cement with GGBS when compared with 20%, 30% and 40 % replacement of cement with GGBS.

Ramesh Chandra Gupta, et al. [3] present a waste tyre rubber in the form of crumb rubber was used as a partial replacement for natural fine aggregates in high strength cement concrete. Crumb rubber was replaced for fine aggregates from 0% to 20% in multiples of 2.5%. Tests were done to determine the depth of carbonation, water absorption of acid attacked specimens, compressive strength of acid attacked specimen. The ratio of cement, fine aggregates, coarse aggregates and water by weight are 1:1.48:2.67:0.3. Crumb rubber was replaced for natural sand from 0% to 20% in multiples of 2.5%. There was more loss in compressive strength and weight of the control mix concrete specimens when compared to the rubberized concrete specimens. Only the water absorption had shown higher values in rubberized concrete. So the high strength rubberized concrete can be applied in the areas where there are possibilities of acid attack. George Salem, et al.[4]present of recycled materials crumb rubber as valuable substitute for fine aggregates ranging from 0% to 100% in replacement of crushed sand in concrete mixes is investigated. An acceptable compressive strength was obtained with up to 25% by volume replacement of fine aggregates with crumb rubber. Lower weight. Up to 8% reduction in density was recorded at 25% rubber in substitution of crushed sand. Enhanced ductility of concrete, which could be positively interpreted if usage is in highway barriers or other similar shock resisting elements. Enhanced insulation properties, as proved by the conductivity test. Enhanced damping properties, since rubber absorbs vibration too large extent. Beyond 25% rubber content in replacement of crushed sand in fine aggregates, compressive strength drops enormously such that the usage in structural and non-structural elements becomes excluded. Gaurav Singh, et al. [5] present the sand is replaced from 10% to 100% by GGBS and its effect on compressive strength of concrete is studied. Along with that the economic study is also done to suggest the most optimum percentage of GGBS to be used in industry. The compressive strength of concrete increases with increase in GBFS percentage up to a certain percentage and after that it decrease. The most optimum percentage of GBFS to be used in normal conditions considering both strength and economy factor is from 40% to 50% and for marine conditions it's from 50% to 60%.

3. EXPERIMENTAL

Table -1: M25 Mix Proportion

Water	Cement	Fine Aggregate	Coarse Aggregate
186	413	802	1176
0.45	1	1.94	2.85

Table -2: M30 Mix Proportion

Water	Cement	Fine Aggregate	Coarse Aggregate
186	433	795	1165
0.43	1	1.84	2.69

Table -3: No. of cubes casting

Mix (GB % - RB %)	Compressive Test (no. of Cube)			Flexural Test (no. of Beam)
	7 days	14 Days	28 Days	28 Days
RB0 (0%-0%)	3	3	3	3
RB1 (5%-4%)	3	3	3	3
RB2 (5%-8%)	3	3	3	3
RB3 (5%-12%)	3	3	3	3
RB4 (5%-16%)	3	3	3	3
RB5 (10%-4%)	3	3	3	3
RB6 (10%-8%)	3	3	3	3
RB7 (10%-12%)	3	3	3	3
RB8 (10%-16%)	3	3	3	3
RB9 (15%-4%)	3	3	3	3
RB10 (15%-8%)	3	3	3	3
RB11 (15%-12%)	3	3	3	3
RB12 (15%-16%)	3	3	3	3

4. RESULTS

Table -4: Workability Results

Mix	Proportion	M 25 Slump (mm)	M 30 Slump (mm)
RB0	0%-0%	75	70
RB1	5%-4%	75	70
RB2	5%-8%	80	72
RB3	5%-12%	88	89
RB4	5%-16%	115	117
RB5	10%-4%	77	77
RB6	10%-8%	83	79
RB7	10%-12%	98	97
RB8	10%-16%	126	127
RB9	15%-4%	83	92
RB10	15%-8%	98	107
RB11	15%-12%	120	142
RB12	15%-16%	135	160

Table -5: Compressive Strength of Concrete M-25 Grade

Sr. No.	Proportion	**7 Days Strength(MPa)**	**14 Days Strength(MPa)**	**28 Days Strength(MPa)**
RB0	0%-0%	20.74	28.84	31.78
RB1	5%-4%	20.44	28.59	31.53
RB2	5%-8%	20.65	28.30	31.20
RB3	5%-12%	19.58	27.55	30.20
RB4	5%-16%	19.35	27.25	29.75
RB5	10%-4%	20.84	28.99	31.88
RB6	10%-8%	20.69	28.34	31.43
RB7	10%-12%	20.10	27.95	30.50
RB8	10%-16%	19.10	26.95	29.30
RB9	15%-4%	20.62	28.2	30.95
RB10	15%-8%	20.45	28.05	30.72
RB11	15%-12%	18.55	26.55	28.28
RB12	15%-16%	18.05	25.85	27.53

Table -6: Compressive Strength of Concrete M-30 Grade

Sr. No.	Proportion	**7 Days Strength(MPa)**	**14 Days Strength(MPa)**	**28 Days Strength(MPa)**
RB0	0%-0%	25.01	34.78	38.32
RB1	5%-4%	25.06	34.83	38.47
RB2	5%-8%	25.01	34.83	38.35
RB3	5%-12%	24.93	34.20	37.75
RB4	5%-16%	22.80	32.55	35.25
RB5	10%-4%	24.96	34.83	38.27
RB6	10%-8%	24.81	34.68	38.12
RB7	10%-12%	23.55	33.10	36.25
RB8	10%-16%	21.75	31.45	34.28
RB9	15%-4%	24.45	33.96	37.15
RB10	15%-8%	22.15	32.65	34.96
RB11	15%-12%	21.18	30.95	32.45
RB12	15%-16%	18.18	28.29	29.96

Table -7: Split Tensile Strength of Concrete M-25 Grade

Sr. No.	Proportion	**7 Days Strength(MPa)**	**14 Days Strength(MPa)**	**28 Days Strength(MPa)**
RB0	0%-0%	2.02	2.37	2.50
RB1	5%-4%	2.00	2.36	2.49
RB2	5%-8%	1.99	2.35	2.48
RB3	5%-12%	1.97	2.34	2.47
RB4	5%-16%	1.96	2.33	2.46
RB5	10%-4%	2.02	2.37	2.49
RB6	10%-8%	1.99	2.35	2.48
RB7	10%-12%	1.98	2.35	2.47
RB8	10%-16%	1.95	2.32	2.45
RB9	15%-4%	1.99	2.35	2.48
RB10	15%-8%	1.99	2.35	2.48
RB11	15%-12%	1.95	2.31	2.44
RB12	15%-16%	1.93	2.30	2.43

Table -8: Split Tensile Strength of Concrete M-30 Grade

Sr. No.	Proportion	**7 Days Strength(MPa)**	**14 Days Strength(MPa)**	**28 Days Strength(MPa)**
RB0	0%-0%	2.21	2.60	2.74
RB1	5%-4%	2.20	2.59	2.73
RB2	5%-8%	2.18	2.58	2.72
RB3	5%-12%	2.17	2.57	2.71
RB4	5%-16%	2.16	2.56	2.70
RB5	10%-4%	2.20	2.59	2.73
RB6	10%-8%	2.18	2.58	2.72
RB7	10%-12%	2.18	2.57	2.72
RB8	10%-16%	2.15	2.55	2.69
RB9	15%-4%	2.19	2.58	2.72
RB10	15%-8%	2.18	2.58	2.71
RB11	15%-12%	2.14	2.54	2.69
RB12	15%-16%	2.13	2.53	2.67

Table -9: Flexural Strength of Concrete

Sr. No.	Proportion	M 25 28-Days Strength (MPa)	M 30 28-Days Strength (MPa)
RB0	0%-0%	3.55	3.83
RB1	5%-4%	3.44	3.77
RB2	5%-8%	3.39	3.73
RB3	5%-12%	3.36	3.70
RB4	5%-16%	3.34	3.68
RB5	10%-4%	3.51	3.80
RB6	10%-8%	3.39	3.73
RB7	10%-12%	3.37	3.71
RB8	10%-16%	3.33	3.67
RB9	15%-4%	3.42	3.76
RB10	15%-8%	3.38	3.73
RB11	15%-12%	3.33	3.67
RB12	15%-16%	3.30	3.64

5. CONCLUSIONS

Experiments have been conducted on concrete cubes by replacing Cement and Aggregate with Ground Granulated Blast Furnace Slag and Crump Rubber. Results shows that with addition of Granulated Blast Furnace Slag, Compressive strength of concrete is increased. Maximum strength obtain by replacing GGBS and crumb rubber by 10% and 4% respectively. Workability of concrete is increased with increase in crumb rubber content. Obtain concrete can be use in machine foundation due to its high vibration absorption capability.

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