Enhancement of Structural Strength High Grade Concrete with Recycled Concrete aggregates and Reinforced with FRP Steel Bars

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Abstract: Portland cement is widely known as the major material used in concrete construction. Cement both in mortar and concrete, is the most important element of the infrastructure and has been recognized as a durable construction material. However, the environmental aspects of cement are now gaining concern of investigators, as cement manufacturing is to be blame for around 2.5% of whole universal waste releases from commercial sources. Using dissimilar types of waste materials in construction trade is currently a rising trend. Reuse of waste materials is a twofold purpose (a) to minimize the amount of waste to be deposited and (b) to preserve natural resources. The present work is focused to improve overall compressive strength and workability of structure by the application of gypsum wall waste and polymer fibre in concrete.

Keywords - Polymer Concrete, Reused concrete, Compressive Strength, Workability.

I. INTRODUCTION

When structures made of concrete are demolished or renovated, concrete recycling is an increasingly common method of utilizing the rubble. Concrete was once routinely trucked to landfills for disposal, but recycling has a number of benefits that have made it a more attractive option in this age of greater environmental awareness, more environmental laws, and the desire to keep construction costs down.

1.1 Necessity of Concrete Recycling:

Millions of tons of waste concrete is generated every year around the world due to following reasons:

1. Demolition of old structure,
2. Destruction of buildings and structures during earthquakes and wars,
3. Removal of useless concrete from structures, buildings, road pavements etc.
4. Waste concrete generated due to concrete cube and cylinder testing, destructive methods of testing of existing structures etc.

1.2 Advantages of Concrete Recycling:

Usually demolished concrete were shipped to landfills for disposal, but due to greater environmental awareness, the concrete is being recycled for reuse in concrete works. There are a variety of benefits in recycling concrete rather than dumping it or burying it in a landfill. Keeping concrete debris out of landfills saves space there. Concrete prepared using recycled aggregates have been used for many years in several countries which go ahead the way in this concept by Pacheco-Torgal and Jalali [1]. Many major projects have been completed in these countries with cheering results. Its utilization is so widely spread worldwide, so, that several countries have adopted it and are preparing regulatory documents about its use. Patil and Sangle [2] Reuse of waste materials from construction industry is a creative step towards sustainable and green construction. Kwan et al. (2012) [3] presented important information over the robustness and design methodology for recycled aggregates. Parameters investigated in this study are compressive strength, ultrasonic pulse velocity, shrinkage, water absorption and intrinsic permeability. It has been observed from results that the in recycled aggregates concrete ultrasonic pulse velocity is higher, and it contains low water absorption intrinsic permeability. The recycle of used concrete not only save the limited raw materials, but also cuts energy expenditure and consequently the overall production costs hs been studied by Peyronnard and Benzaazoua[4]. Olorunsogo and Padayachee (2002) [5] presented the results of investigating the performance of concrete composed using recycled aggregate considering on durability indexes as indicators.

II. EXPERIMENTAL PROGRAM

Experimental investigations had been carried out based on series of laboratory tests. Entire investigation has been divided into two parts. In first part tests were conducted to study the effect of Gypsum wall waste as aggregate over the compressive strength and workability of concrete. In later part an attempt has been made to determine the additional effect of adding polymer to concrete of on the above properties. Ordinary Portland cement of grade 53 has been used as a binder. Fine aggregate used was river sand with fineness modulus 2.27, w/c ratio for each concrete mix is taken as from 0.4 to 0.45.

Concrete mix design has been performed for evaluating proportion of ingredients for M30 and M40 concrete grade as per **IS 10262-2009 and admixtures are** confirming to IS-9103. Ingredients in 1 cu. m. of concrete for M30 and M40 concrete grade are shown in tables 1 and 2-

Table 1 – Mix proportions for M30 grade concrete

Mix Proportions for One Cu. M. of Concrete (M30 grade)		
1	Mass of Cement in kg/m^3	**380**
2	Mass of Water in kg/m^3	**160**
3	Mass of Fine Aggregate in kg/m^3	**711**
4	Mass of Coarse Aggregate in kg/m^3	**1283**
5	Mass of Admixture in kg/m^3	**1.90**
6	Water Cement Ratio	**0.42**

Table 2 – Mix proportions for M40 grade concrete

Mix Proportions for One Cum of Concrete (M40 grade)		
1	Mass of Cement in kg/m^3	**400**
2	Mass of Water in kg/m^3	**160**
3	Mass of Fine Aggregate in kg/m^3	**660**
4	Mass of Coarse Aggregate in kg/m^3	**1168**
5	Mass of Admixture in kg/m^3	**2.4**
6	Water Cement Ratio	**0.4**

3.1 Effect of Recycled Coarse (RC) aggregates

Five concrete samples for each concrete grade have been prepared by varying ratio of **RC** and normal aggregate and then workability and 28 days compressive strength have been determined. **RC** aggregates replaced normal aggregates in different proportions approximately such as 0%, 15%, 30%, 45% and 60%. Table 3 presents the ingredients for each grade of concrete.

Table 3- weight of ingredients in each mix

Concrete Mix	**W/C Ratio**	**Mix no.**	**Cement**	**Aggregates**			**RC / Normal Aggregate**
				RC	**Normal**	**Fine**	
M30	0.42	M1	1	0	3.37	1.87	0
		M2	1	0.5	2.87	1.87	0.17
		M3	1	1	2.37	1.87	0.42
		M4	1	1.5	1.87	1.87	0.8
		M5	1	2	1.37	1.87	1.46
M40	0.4	M6	1	0	2.92	1.65	0
		M7	1	0.45	2.47	1.65	0.18
		M8	1	0.9	2.02	1.65	0.45
		M9	1	1.35	1.57	1.65	0.86
		M10	1	1.8	1.12	1.65	1.6

Compressive strength and slump cone tests are applied at these mixes, M1 to M10, results obtained are presented in table 4 and 5

Table 4- Results for Mixes of M30 grade

Mix	Compressive strength (Mpa)	Slump (mm)	RC / Normal Aggregate
M1	28.9	98	0
M2	28.3	92	0.17
M3	27.1	87	0.42
M4	26.7	79	0.8
M5	25.4	71	1.46

Table 5 Results for Mixes of M40 grade

Mix	Compressive strength (Mpa)	Slump (mm)	RC / Normal Aggregate
M1	39.1	95	0
M2	38.6	91	0.18
M3	37.1	84	0.45
M4	36.4	76	0.86
M5	35.2	67	1.6

3.2 Combined effect of Polymer concrete and RC aggregates-

Additional effect of Polymer fibre variation over the effect of **RC** aggregates has been determined by replacing cement by Polymer fibre in different proportions such as 0.5%, 1.0% and 1.5% for each variation of RC aggregate. For each concrete mix presented in table 6, fly ash varied in all the three percentages and concrete mixes are nominated as M11, M12 and M13 for fly ash variations 0.5%, 1.0% and 1.5% in M1 concrete. Similarly concrete mixes have been prepared for all the above mixes i.e. M2 to M10 as shown in table 7.

Table 6 – Concrete mixes with variation in Fly ash and RC Aggregates

MIX	Mix no.	Mixes with Polymer fibre	Polymer fibre	Aggregates			RC / Normal
				RC	Normal	Fine	
M 30	M1	M11	0.5	0	3.37	1.87	0
		M12	1				
		M13	1.5				
	M2	M21	0.5	0.5	2.87	1.87	0.17
		M22	1				
		M23	1.5				
	M3	M31	0.5	1	2.37	1.87	0.42
		M32	1				
		M33	1.5				
	M4	M41	0.5	1.5	1.87	1.87	0.8
		M42	1				
		M43	1.5				
	M5	M51	0.5	2	1.37	1.87	1.46
		M52	1				
		M53	1.5				
M 40	M6	M61	0.5	0	2.92	1.65	0
		M62	1				
		M63	1.5				
	M7	M71	0.5	0.45	2.47	1.65	0.18
		M72	1				
		M73	1.5				
	M8	M81	0.5	0.9	2.02	1.65	0.45
		M82	1				

		M83	1.5				
	M9	M91	0.5	1.35	1.57	1.65	0.86
		M92	1				
		M93	1.5				
	M10	M101	0.5	1.8	1.12	1.65	1.6
		M102	1				
		M103	1.5				

Table 6 presented the weight of ingredients for all the thirty cubes casted by varying RC aggregate and polymer fibre proportions in the concrete. Table 7 presents the result of compressive strength and slump cone test over all the 30 concrete cubes.

Table 7 – Results of Compressive strength and slump cone tests

S. No.	Mixes with variation in Fly ash	% of Polymer Fibre	RC/ Normal Aggregate	Compressive strength	Slump
1	M11	0.5	0	29.1	97
2	M12	1		29. 3	95
3	M13	1.5		29.8	94
4	M21	0.5	0.17	28.6	90
5	M22	1		28.9	87
6	M23	1.5		29.4	86
7	M31	0.5	0.42	27.4	84
8	M32	1		27.7	83
9	M33	1.5		28.3	81
10	M41	0.5	0.8	27.1	76
11	M42	1		27.4	75
12	M43	1.5		28.1	72
13	M51	0.5	1.46	25.7	69
14	M52	1		25.9	66
15	M53	1.5		26.6	64
16	M61	0.5	0	39.4	93
17	M62	1		39.7	91
18	M63	1.5		39.9	88
19	M71	0.5	0.18	38.9	89
20	M72	1		39.2	87
21	M73	1.5		39.7	84
22	M81	0.5	0.45	37.4	82
23	M82	1		37.8	79
24	M83	1.5		38.4	77
25	M91	0.5	0.86	36.6	75
26	M92	1		36.9	72
27	M93	1.5		37.7	70
28	M101	0.5	1.6	35.5	66
29	M102	1		35.9	63
30	M103	1.5		36.3	61

III. CONCLUSIONS AND DISCUSSIONS

A study has been performed to evaluate the combined effect of using partially RC aggregates and Polymer fibre over the compressive strength and workability of concrete. Following conclusions are revealed from the present work –

1. It has been observed from that concrete mix formed by only using 15% with RC aggregates, with RC to normal aggregate ratio 0.17, is almost comparable with the values of 100% normal aggregate.
2. With the increase in percentage of RC aggregate values of compressive strength and slump cone reduces.
3. Additional effect of polymer fibre variation over the effect of RC aggregates has been determined by adding polymer fibre in different proportions such as 0.5%, 1.0% and 1.5% for each variation of RC aggregate.
4. Increase in percentage of Polymer fibre increases the compressive strength for a RC aggregate proportion.
5. Increase in percentage of Polymer fibre reduces the slump value for a RC aggregate proportion

IV. REFERENCES

[1] Pacheco-Torgal F., Jalali S. “Compressive strength and durability properties of ceramic wastes based concrete” Materials and Structures (2011) 44:155–167.

[2] Patil D.M., Sangle KK. “Experimental Investigation of Waste Glass Powder as Partial Replacement of Cement in Concrete” International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Volume-2, Issue-1, 2013.

[3] Kwan W.H., Ramli M., Kam K.J. and Sulieman M.Z. “Influence of the amount of recycled coarse aggregate in concrete design and durability properties” Construction and Building Materials 26 (2012) 565–573.

[4] Peyronnard O. and Benzaazoua M., “Estimation of the cementitious properties of various industrial by-products for applications requiring low mechanical strength”, Volume 56, Issue 1, November 2011, P. 22-33.

[5] Olorunsogo F.T., Padayachee N. “Performance of recycled aggregate concrete monitored by durability indexes” Cement and Concrete Research 32 (2002) 179–185.