International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online)
Vol. 2, Issue 1, pp: (7-14), Month: April 2014 - September 2014, Available at: www.researchpublish.com

STRENGTHENING OF ULTRA HIGH PERFORMANCE FIBER REINFORED CONCRETE USING WASTE MATERIALS

[1]G. ASOTHA, [2]Prof. C. MALA

[1]Junior Engineer (MES), [2]Prist University, India

Abstract: The properties of UHPFRC mainly depend on the selection of ingredients with special curing and pre-compression techniques. In this project report, various proportions of materials, curing regimes and materials adopted by many researchers are discussed with special emphasis to the selection of materials as this forms the basis for proportioning of UHPFRC mixtures. The significance of this concrete is that the compressive and flexural strength is 5-10 times greater than the conventional concrete which is an indication of the improved performance of cement matrix interface achieved by various authors. In India very few works have been reported in this field and mass application of these special concretes to practice can be brought about only after rigorous R and D works. Studies were already been done by Advanced Materials Laboratory, CSIR-Structural Engineering Centre(CSIR-SERC), Chennai, to develop various UHPFRC mixture proportions by using indigenously available materials and study the properties of these concretes for their application in practice. Currently Concrete with grade 200MPa has already been developed. In this research work the focus has been given to replace the sand with copper slag in the UHPFRC mix. Other ingredients include cement, silica fume, quartz powder, and micro steel fibers.

Keywords: Strengthening of concrete, M60grade, Density, Slump loss, Compressive strength, Split tensile strength, Flexural strength, CM – Control mixture, CWM – Concrete with waste materials, WM – Waste Material.

I. INTRODUCTION

Concrete is the most widely used man-made construction material in the world. It is obtained by mixing cementitious materials, water, aggregate and sometimes admixtures in required proportions. Fresh concrete or plastic concrete is freshly mixed material which can be moulded into any shape hardens into a rock-like mass known as concrete. The hardening is because of chemical reaction between water and cement, which continues for long period leading to stronger with age.

Improvement in concrete properties such as workability, durability, strength, and dimensional stability should result in long-lasting, safe & economical structures. One method of improving durability is to lower the permeability of the concrete. Low permeability concretes have high durability and are obtained with pozzolans and (w/cm) less than 0.45.

II. MATERIALS AND PROPERTIES OF MATERIALS USED

Material	Mean particle size
Cement CEM I	10–25 µm
Silica fume	0.1–1 µm
Copper Slag	0.1-1mm

Quartz powder	5–25 μm
Quartz sand	150–600 μm
Micro Steel fibers	L:12-14mm, Ø-0.18-0.23mm
Super plasticizer	HRWRA

SILICA FUME:

COPPER SLAG:

STEEL FIBER:

QUARTZ SAND:

QUARTZ POWDER:

III. MIX DESIGN

GRADE OF CONCRETE : M60

MIXING RATIO:

Water Content ,W	**Cement content, C**	**Fine aggregate, F.A**	**Coarse aggregate, C.A**
205 Kg/m3	585.7 Kg/m3	425.33 Kg/m3	1092.85 Kg/m3
0.35	1	0.76	1.86

Super plasticizer : 5ml / Kg of cement

IV. RESULT AND DISCUSSION

Description of mixtures:

Among the 6 mixtures, five mixtures were prepared with natural sand substituted by WM by-product and the remaining one was control mixtures (CM). To identify the mixtures easily, the each mixtures was designated with the names such as CM, CWM 5%, CWM 10%, CWM 15%, CWM 20% and CWM 25%.

Density:

The aggregate densities, mix proportions, water content and degree of hydration are deciding the density of the concrete. It was expected that the substitution of waste material may affect the density of the concrete. Nevertheless the density value of the concrete does not change considerable with the substitution rate of up to 15% in addition the differences in the density values are relatively small and acceptable. However a small reduction in density was observed when increasing the substitution rate beyond 15%. The variation in the density values of the different mixtures can be attributed to the percentage of substitution rate. The increases in the substitution rate reduce the workability of the mixture resulting poor packing of concrete. Density of the hardened concrete given in Table:1

Table 1: Density of the hardened concrete

Mixture		**Density(Kg/m^3)**	
Description	**Specimen no.**	**Value**	**Average**
CM	1	2503.70	2526.41
	2	2542.22	
	3	2533.30	
CWM 5%	1	2509.63	2504.69
	2	2494.82	
	3	2509.63	
CWM 10%	1	2512.60	2480.86
	2	2482.96	
	3	2477.03	
CWM 15%	1	2557.04	2517.50
	2	2530.37	
	3	2465.19	
CWM 20 %	1	2456.30	2506.67
	2	2506.67	
	3	2557.04	
CWM 25%	1	2388.15	2416.79
	2	2453.33	
	3	2408.89	

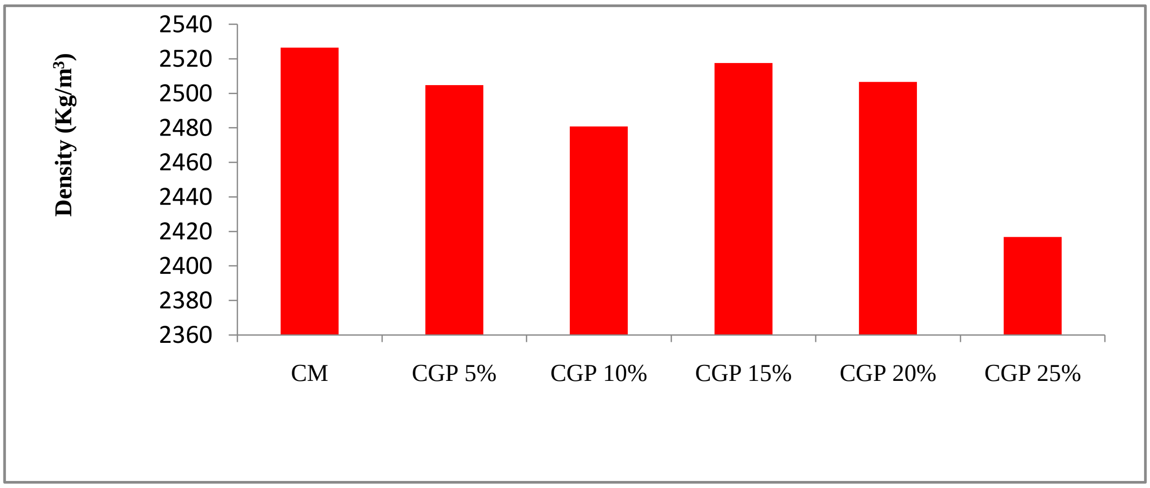

Fig 1. Density of concrete mixtures – comparison

Slump loss:

The workability of the fresh concrete was measured by slump cone test, time ranged from immediate after mixing, 30min and 60min, it is the convenient method and useful to control the quality of the concrete. The slump loss of the WM substituted fresh concrete are given in Table 2 and the Figure 2 explain the effect of WM waste on the workability of the fresh concrete.

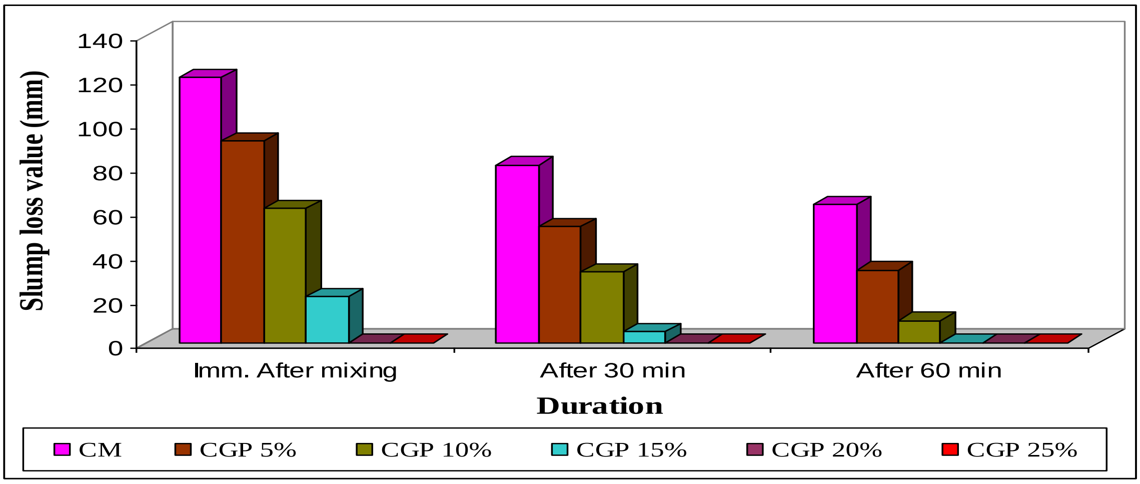

Figure 2. Slump loss value of concrete versus duration at different substitution rate of WM by-product

Table 2. Properties of fresh concrete

Mixture No	**Slump Loss**		
	Immediate after mixing (mm)	**After 30 minutes (mm)**	**After 60 minutes (mm)**
Control Mixture	121	81	63
CWM 5%	92	53	33
CWM 10%	61	32	10
CWM 15%	21	5	0
CWM 20%	0	0	0
CWM 25%	0	0	0

For all the mixtures there was a significant losses in slump was observed with time in addition to that the workability of the concrete decreases with the increases in the substitution rate. The poor workability was observed for mixture of CWM 20% and CWM 25% when compared to the other mixture. This is a result of the fact that, the workability and the water demand of the concrete depends upon the particle shape, particle size distribution and surface texture. Compared to the natural sand, the WM has a very rough and angular geometry and more than 90% particle size are less than 50 microns.

Compressive strength:

Compressive strength is the most important property of the hardened concrete. The concrete cubes were cast, cured and tested accordance with the IS standard and the 7 and 28 compressive strength results are listed in Table 3.

Table 3 compressive strength of all mixtures

Mixture		**Compressive strength**			
		7 days		**28 days**	
Description	**Specimen no.**	**Strength**	**average**	**Strength**	**Average**
CM	1	43.48	43.58	63.25	63.23
	2	43.71		63.22	
	3	43.54		63.23	

CWM 5%	1	43.34	43.27	63.15	63.12
	2	43.21		63.12	
	3	43.27		63.08	
CWM 10%	1	41.75	41.68	61.75	61.66
	2	41.67		61.67	
	3	41.63		61.56	
CWM 15%	1	40.66	40.62	60.53	60.47
	2	40.57		60.66	
	3	40.62		60.27	
CWM 20 %	1	38.10	38.10	58.15	58.13
	2	38.16		58.10	
	3	38.04		58.13	
CWM 25%	1	34.24	34.32	54.12	54.08
	2	34.27		54.08	
	3	34.45		54.03	

The main objective of this research is to utilize the waste material in concrete making with conform to the concrete production standards and not to enhance the concrete properties. As expected the addition of Waste Material by-product does not affect the compressive strength of the concrete up to 15% of substitution rate and the compressive strength of the concrete increased upon aging. Figure 3 clearly shows that in all ages the compressive strength values of the mixtures CWM 5%, CWM 10%, CWM 15% were neither close nor little higher than the control mixture (CM). However the lowest compressive strength obtained for CWM 20% and CWM 25% mixtures that have a poor workability.

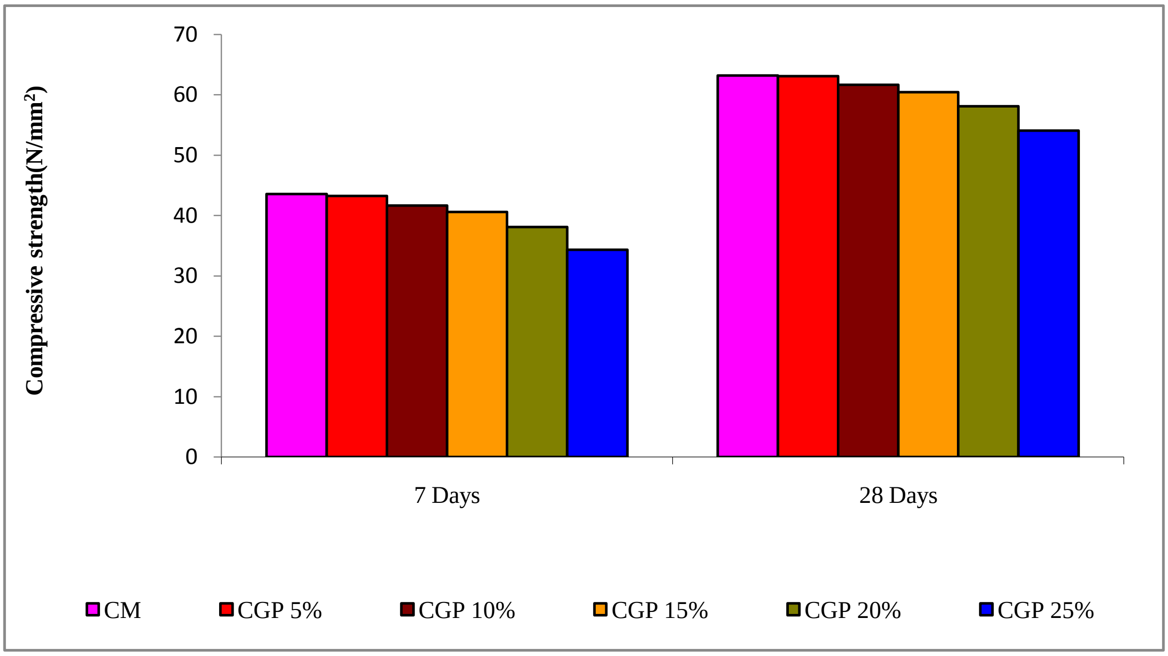

Fig 3 Compressive strength of concrete mixtures at different ages-Comparison

Split tensile strength and flexural strength:

The split tensile strength and flexural strength of the concrete measured at the age of 7 and 28days and the strength values are listed in Table 2 and 3 Figure 3 and 4 clearly shows that substitution of GP waste much not affect the tensile and flexural strength and the strength values of the mixtures CGP 5%, CGP 10%, CGP 15% and somewhat equal or little lower than the control mixture. However a close observation of Figure 3 exhibits that the increases in substitution rate of GP waste affect strength and the decrease in strength was significant beyond 15% (mixtures CGP 20% and CGP 25%). As said earlier the decreases in strength can be attributed to the demand in cement paste volume which is contributed to the poor interlocking between the aggregate and cement paste.

Table:4 Split tensile strength of all mixtures

Mixture no.		Split tensile strength			
		7 days		28 days	
Description	Specimen no.	Strength	average	Strength	average
CM	1	2.91	2.85	7.32	7.36
	2	2.79		7.40	
	3	2.84		7.36	
CGP5%	1	2.54	2.58	7.47	7.54
	2	2.62		7.60	
	3	2.57		7.54	
CGP10%	1	2.42	2.42	7.16	7.16
	2	2.46		7.13	
	3	2.38		7.19	
CGP15%	1	2.02	2.11	6.92	6.92
	2	2.13		6.87	
	3	2.18		6.98	
CGP20%	1	1.97	1.91	6.25	6.22
	2	1.93		6.18	
	3	1.87		6.22	
CGP25%	1	1.23	1.32	6.12	6.01
	2	1.32		5.97	
	3	1.41		5.93	

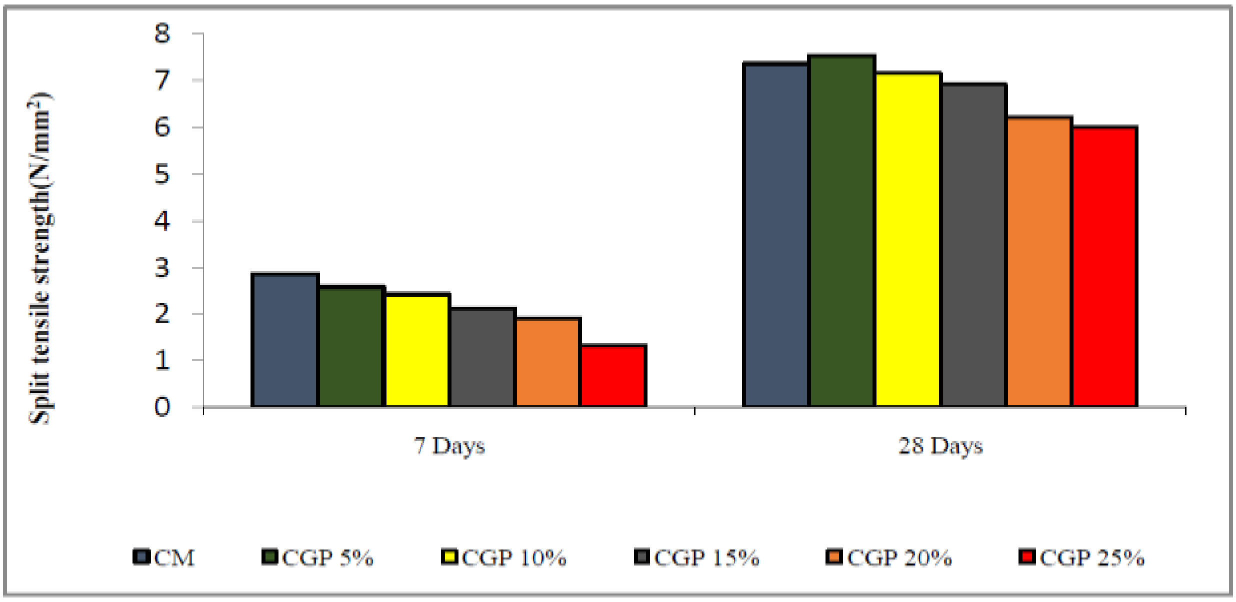

Fig 4. Split tensile strength of concrete mixtures at different ages-Comparison

Table 5. Flexural strength of concrete mixtures

Mixture		Flexural strength			
		7 days		28 days	
Description	**Specimen no.**	**Strength**	**average**	**Strength**	**average**
CM	1	4.38	4.32	9.59	9.51
	2	4.28		9.52	
	3	4.31		9.43	
CGP 5%	1	4.13	4.18	9.23	9.15
	2	4.19		9.15	
	3	4.21		9.07	
CGP 10%	1	4.27	4.25	9.41	9.41
	2	4.25		9.37	
	3	4.23		9.45	
CGP 15%	1	3.98	4.04	9.23	9.26
	2	4.02		9.29	
	3	4.12		9.26	
CGP 20 %	1	3.57	3.54	8.45	8.39
	2	3.42		8.28	
	3	3.63		8.43	
CGP 25%	1	3.31	3.11	7.92	7.97
	2	3.03		8.08	
	3	2.98		7.97	

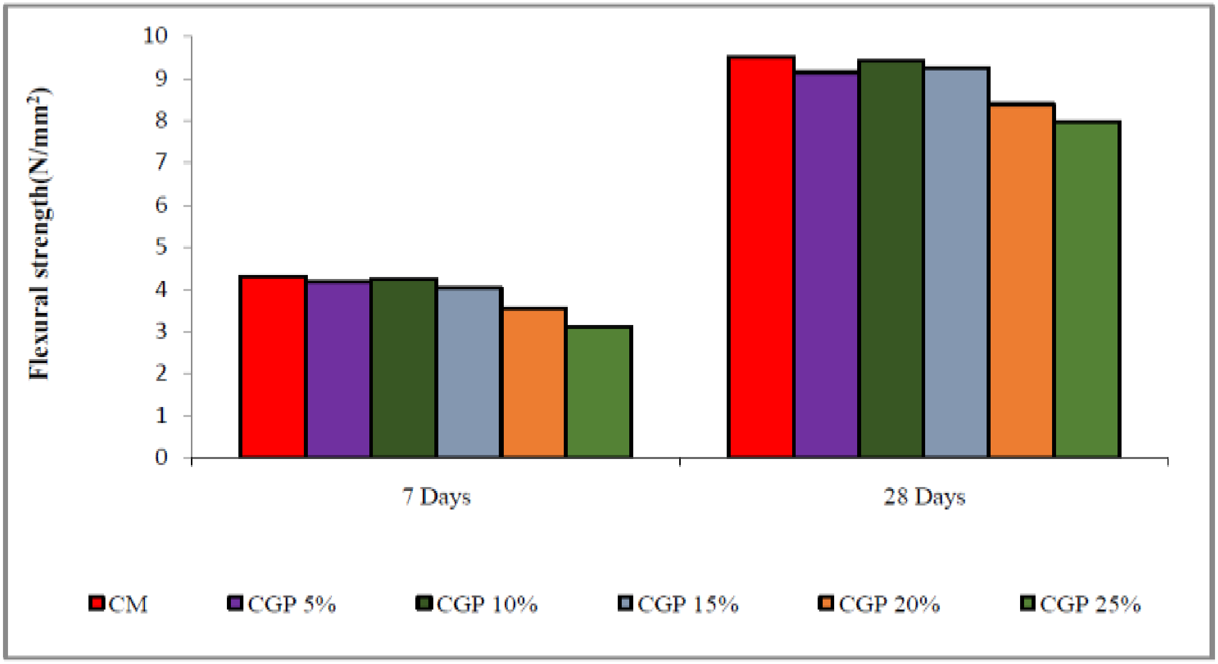

Fig 5. Flexural strength of concrete mixtures at different ages-Comparison

V. CONCLUSION

The study was conducted to evaluate the mechanical properties of the Waste Material concrete to ensure the reliability of its usage in aggressive environments. Based on the extensive experimental test results of six mixtures the following conclusion can be made.

- The high surface specific area and rough and angular texture of the WM, have led to the significant losses in slump in addition the workability of the concrete decreases with the increases in the substitution rate.
- For all the mixtures there was a significant losses in slump was observed with time in addition to that the workability of the concrete decreases with the increases in the substitution rate. The poor workability was observed for mixture of CWM 20% and CWM 25% when compared to the other mixture.
- Compared to the natural sand, the WM has a very rough and angular geometry and more than 90% particle size are less than 50 microns i.e.) very fine powder. The rough and angular texture of the granite powder increase the friction between the coarse aggregate and paste and the increased specific surface area of the powder increasing the water demand by increased water absorption.
- Hence the water required for the mixtures need correction based on the amount of WM added
- The early age (i.e. 7 days) compressive strength of the mixtures CWM 5%, CWM 10%, CWM 15% showed better gain in strength when compared to the CM. The reason may be attributed to the denser matrix of the WM by-product and the better dispersion of the cement grains.
- The split tensile and flexural strength of the concrete mixtures CWM 5%, CWM 10%, CWM 15% were somewhat equal or little lower than the control mixture however significant losses in tensile and flexural strength was observed beyond the substitution rate of 15%.

REFERENCES

1. Benjamin A. Graybeal, Behavior of UHPC connections between precast bridge deck elements, FHWA 2010.
2. Cornelius oesterlee, Emmanuel denarie, Eugen bruehwiler, “Strength and deformability distribution in UHPFRC panels”, Division of Maintenance and Safety (MCS).
3. Enzo Vicenzino, Berry Gulham,Vic.H.Perry,Don Zakariasen,Terry.C.Chow, “First use of UHPFRC in thin precast concrete roof shell for Canadian LRT Station”,PCI Journal,Oct 2005.
4. G.A. Parsekian, N.G. Shrive & T.G. Brown, J. Kroman, P.J. Seibert & V.H. Perry, A,Boucher, “Innovative ultra-high performance concrete structures”, Tailor Made Concrete Structures,2008.
5. Husham Hammadi Almansour, Zoubir Lounis, “Simplified flexural design approach of UHPC bridge girders”, Proceedings of 8th International Conference on Short and Medium Span Bridges,2010.
6. Jerneja suput, Pierre Rossi, “Recommendations for the tailoring of UHPFRC recipes for rehabilitation”, Strategic Targeted Research Project, Nov11, 2009
7. Nguyen Van Tuan, Guang Ye, Klaas van Breugel, Alex L.A. Fraaij , Bui Danh Dai, “The study of using rice husk ash to produce ultra high performance concrete”, Construction and Building Materials 25 (2011) 2030–2035.
8. Thierry Thibaux, “Strengthening of Huisne bridge using UHPFRC”, Tailor Made Concrete Structures,2008.