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Laboratory Work on Design Mix Concrete Improvised with GGBS and Plastic Polypropylene Cut Shreds-A Green Approach

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Abstract:

Concrete is a wonderful material being used since long. Its components are crucial for strength else disproportion can lead to structure failures along with economic losses. The production of concrete is being done since the roman and Egyptians times, but the proportions and usage are varied. By them C_2S and C_3S composition is changed to attain study strength along times and the later leads to quick setting along with suitability along reinforcements. The industrial production has lead to depletion of natural resources along with ecological pollution. Since the last few decades has seen enormous development in types of concrete along with replacement of binders, aggregates, and fine particles with their successors like supplementary cementitious compounds, robo sand or M-sand and slag along with multiple industrial wastes in their inclusion. These supplementary materials either fill the ways through replacement in partial or in full forms or try their suitability to fit the standard mix as per design criteria. Grinded blast furnace slag, fume remains of silica, fly ash, along with ceramic waste has good potential as a waste to resource in concrete. The alkali sludge and GGBS along with sodium hydroxide or sodium silicates can form good combinations for concrete and the strength along with other parameters is good. Plastic being a headache can be effectively used to mild reinforce the concrete through thin threads of good thickness along with chemicals supporting the acceleration process in concrete can perform very good to enhance strength and remove pollution of plastics. In this work plastic ribbons are being cut through daily waste plastics glasses commonly used as household and industrial item along the lifeline in India and later on the discard of the same causes headache like pollution of land. The plastic polypropylene ribbons are mixed uniformly along with admixture in the concrete which is prior mixed with GGBS and other slag. Compressive strength, tensile strength along with mixibility or workability is evaluated. The optimal results are obtained at 28 percent replacement with GGBS to cement the tensile strength is best with a mix at 20 percent replacement to cement that of GGBS. When all results are inferred the outcomes are best and optimal for a gradual replacement of overall twenty percent to cement with that of GGBS. The advantages are apparent with the reduction in pollution and economies of scale of plastic usage along with good quality concrete in workability and strength.

Keywords: - **concrete, plastic polypropylene ribbons, replacement, GGBS, industrial waste, pollution, workability**

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I. INTRODUCTION

The urban areas are hotter due to enormous usage of energy and less plantation apart from that the sustainable development is ignored causing the rural areas and semi developed areas to have less temperatures variations, this impact causes the urban heat island effect. In the current scenario the industrial revolution along with enormous demand for materials and rapid industrialization caused haphazard development causing intensive pollution and degradation of natural resources along with depletion with loss to nature. After air and water concrete is the most used material on the globe. The lust for growth and development with no thinking for the ill effects caused the global warming. The rich nations along with the developed and developing nations are adding pollution and green house gases to the globe making it a less greener and least eco friendly planet to live for the entire mankind.

The increase in demand for resources and their extraction through any means has caused many manmade calamities and yet to come to be faced in future. Concrete is wonderful material, no doubt, but its use since the past few centuries in an old or in a modified form has raised concern as it is not be recycled in all forms, but its waste only can be reused either in full or in partials after breaking causing pollution of air and land along with water. Since old times the calcium silicates are used to form the binding materials along with alumina and lime. As the use is limited there is a less concern by then, but now days the enormous use has caused concern for the demand and supply of the natural resources along with the production causing ecological and natural pollution.

Demand for production of cement, concrete and reinforcement materials has caused bad impact on the natural resources and depleted them in many ways. Hence a replacement either in full or partial is expected for these materials as the waste generation through usage and industrialization is tremendous and it is growing hand in hand along the demand for the resources. Generation of aluminum, copper, steel, and other metals produce slag and this is a waste from production lines but it has good potential to be used as aggregate replacer or fine particles replacer after the grinding or sorting purpose is achieved. This has good strength and depicts strength similar to natural aggregates. When this granulated blast furnace slag is grinded to powder it can be used a good binder in place of cement too. This can be done by activating and adding suitable activators along with additives for making good quality concrete. Concrete used in making the substructures and superstructures along with submerged structures must be quick to set and economical to use along with good placing ability. The expresses ways and good grade pavements need standard quantity of concrete with good workmanship and workability. The malls, high rise structures and good quality roads counted among good infra of a nations accounting to its economic might. This economic might must encounter pollution free, sustainable development for its citizens and next generation to have a healthy life with long span. In the last decades there is good research done and implemented too to reduce, reuse and refuse the waste generated in economic and scientific way. In this regard substitute is tried to be found across the lines for concrete, sand, cement and aggregates. Cement being the most used compound and it has seen vast development along this side hence it is been tried by many researchers for either full or partial replacement without being compromised with its quality or strength characteristics. Minimizing criteria is also used for its use along the constructions lines. There are good numbers of materials imbibing the similar properties of cement like the thermal power plants refuse – the fly ash. Nearly 80 percent of energy generation process on the globe now is based on non renewable sources of energy like coal and gas. The coal produces even more natural hazardous waste, the fly ash, which causes land, water, air pollution. Compounds like Metakaolin, blast furnace slag, furnace fumes are good to replace the cement. Compounds like admixtures and air entrants along with void fillers are also used for improving the stamina of the concrete made so. Major concern being the reuse of waste like said above along with plastics causing degradation to nature is the reason for the replacement. Plastics like polypropylene are stubborn to recycling and automatic degradation due to prolonged life and chemical inertness along with resistance to natural forces. These can be a bit reduces with the sunlight but it takes too much time for this process. Rubber tires are another source of pollution and their recycling can cause grave land pollution along with soil dormant behaviour, making them barren and the presence of benzene along the recycling can cause cancer. Thus careful recycling is expected for efficient usage of recycled materials like crumbed and shredded rubber along with powered form. Plastic in many forms can be used like that of polystyrene, vinyl, or polyethylene. The availability of good research has lead to availability of chemicals like accelerators, rapid hardeners and conditions controllers for concrete.

In the present study concrete is made using GGBS as powder for replacing cement along with an activator sodium silicate which works in the alkaline medium for better characters and strength display. The addition of plastic ribbons cut through daily use plastic grade plates and packaging materials and glasses can be effectively used. The ribbons are cut through a sharp knife or a scissors and uniformly mixed at the samples. These ribbons are being used for better reinforcement elements and help to mold the concrete effectively. The problem of recycling plastics can be managed to some extent using this method and plastic polypropylene sheets, packing materials and glasses can be effectively used else they will chock the drain systems. The alkali materials used is activator pertains to American society of testing and materials standard C494 class C. this will help to develop strength and good workmanship. The workability of such concrete is good as it will help to fast removal of applied formwork.

Significance of the work:

In the present work GGBS is used for replacing cement content with a few percentages and optimized for its effective usage along the strength parameters. This is further extended with use of plastic polypropylene material ribbons cut through sheets of plastic tray or packing materials or plastic glasses and admixture. These two materials are acting as additives. The effective usage of GGBS, plastic and that too of packing grade material will minimize the problem of pollution once used in a scientific way. The grade of concrete made here is M25 having 2.5 percent admixture being mixed.

II. MATERIALS TAKEN AND LAB PROCEDURE

Cement –purchased from local vender and carefully checked the expiry date and manufacturing date. Condition of the cement as per local temperature and humidity conditions.Aggregates are taken are free from girt, dirt and any oily deposits.Plastic polypropylene materials is of packing grade and for this purpose plastic propylene glasses are taken and cut into thin ribbons of optimal length 45 mm and 1-5 mm thickness .GGBS is purchased online from Asoka chemicals and suppliers, Bhopal via India mart.Water is of potable quality.Fine aggregate are taken as of river sand and passing the 10mm sieve and free from clay, uniformly graded and free from calcium deposition along with any organic materials presence if any.Admixture is purchased from local Hardware shop.Sodium silicate is the chemical for good workability

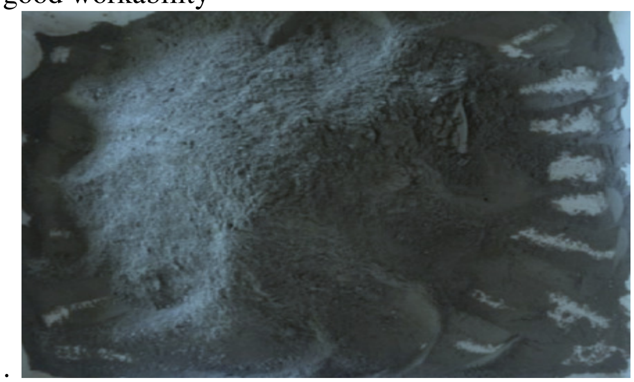
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Figure 1 GGBS

Figure 2 plastic propylene cut ribbons

Table 1 sieve sampling as per IS code for the aggregates

s.no	Sieve size	Weight retained	% weight retained	Cumulate % weight retained	% fine
1	4.75	13.5	1.35	1.35	98.65
2	2.36	40	4.0	5.35	94.65
3	1.18	245.6	24.56	29.91	70.09
4	0.6	206.6	20.66	50.57	49.43
5	0.3	289.5	28.95	79.52	20.48
6	0.15	175	17.5	97.02	2.98
7	Pan	30	3.0	-----	---
8	Sum	1000 grams		263.72	
Fineness modulus = 263.72/100= 2.63					

Table 2 coarse particles analysis

s.no	Sieve size	Weight retained in grams	% weight retained	Cumulative % retained	% finer
1	80	0	0	0	100
2	40	0	0	0	100
3	20	107	3.56	3.56	96.44
4	10	2779	92.63	96.19	3.81
5	4.75	114	3.8	99.99	0.01
6	Pan	0	0	-	-
7	Sum	3000		691	
fineness modulus = (691x100)/3000=2.8					

Water to cement ratio plays an important role in concrete. It being more than 0.75 or equal than particles of water will be more and they exert less pressure being transferred from cement, whereas if the water to cement ratio is less means more cement particles are available for reactivity and load transfer hence they can easily transfer the load among themselves and this lubricating impact can provide good strength to the matrix. Hence more water cement ratio leads to less strength and less water to cement provides more strength. Lower the water to cement ratio better is the transfer of load capacity.

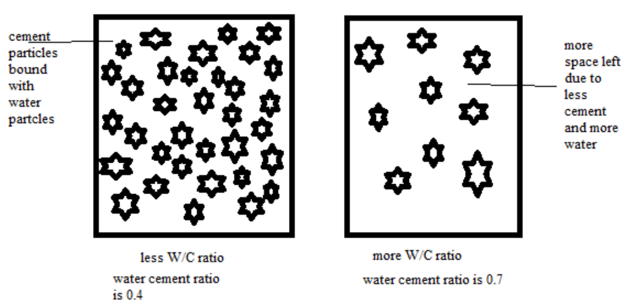


Figure 3 importance of water cement ratio aspect

Key points to be kept while making the design mix.

1. Initial proximity of the cement grains always depends upon the water cement ratio.
2. Final proximity of the cement grains always depends on the compaction effect.
3. Degree of hydration always depends on the curing.

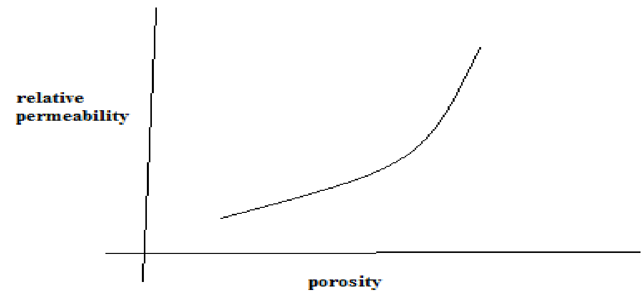


Figure 4 relative permeability- porosity relationships

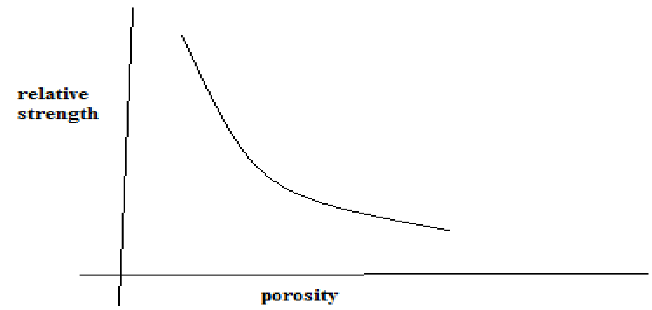


Figure 5 relative strength - porosity relationship

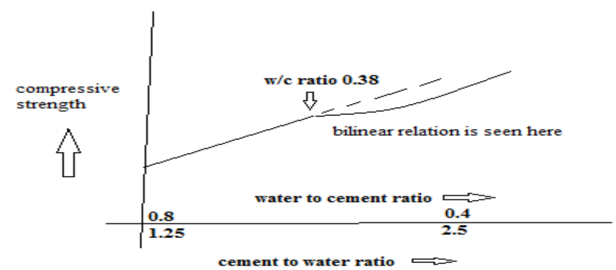


Figure 6 compressive strength and cement water ratio relationship

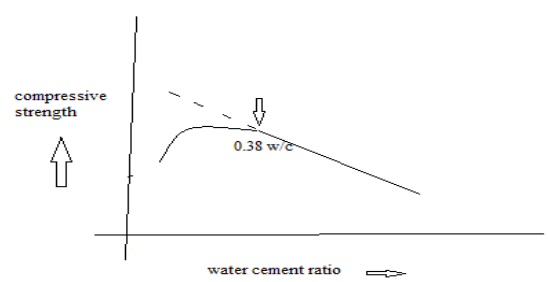


Figure 7 compressive strength and water cement ratio relationship

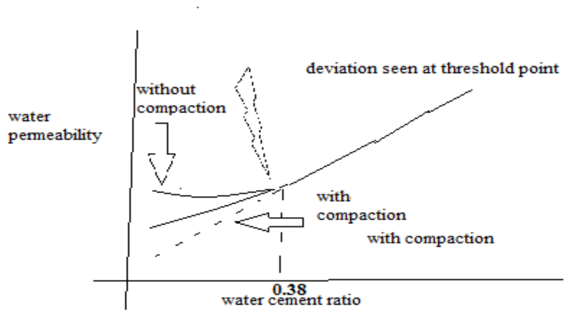


Figure 7 water permeability and water cement ratio relationship

Process and design consideration taken

1. Compressive stamina expected at age of 28 days is 25 MPa
2. 20 mm size aggregates are taken and are rough, hard and tough along with proper angularity
3. Expected workability is 0.9.
4. Concrete is exposed to mild conditions in the lab
5. Good quality batching with controlled condition
6. Minimum quantity of cement to be taken is 310 kg/m^3 and max is $540 kg/m^3$.
7. Water to cement ratio to be taken is at (0.45)
8. Expected workability during slump cone is 25 to 50 millimeter.
9. Super plasticizer is used as admixing agent.

Table 3 quantification of materials

Selection Of Water-Cement Ratio: Maximum Water-Cement Ratio	= 0.45
Adopted Water-Cement Ratio	= 0.40
Selection Of Water Content: Maximum Water Content (IS-10262)	= 186 Lit/m^3
Estimated Water Content For 50-75 mm Slump	= 154 Lit
Super Plasticizer used	= 2.4% by wt. of cement
Calculation Of Cement Content:	
Water Cement Ratio	= 0.40
Cement Content Which, is greater than 310 kg/m^3	= 154/0.4 = 385kg/m^3

Mix Proportion:

For experimental analysis, various samples of concrete are casted, which consisted of various ratios of blast furnace slag to replace cement. The concrete mix of M25 grade with water-cement ratio of 0.40 is adopted for the research work. The samples are prepared by replacing cement with blast furnace slag are as follows 0%, 10%, 15%, 20%, 25%, 30%, 35%, and 40% by weight. The sodium silicate is used as the alkali activator with GGBS by 6% weight of GGBS. Admixture is added by 2.4% by weight of binder and polypropylene shredding by 0.4% by weight of binder. The samples are tested for compressive strength and split tensile strength at 7 days and 28 days.

Figure 8 prepared samples in the moulds

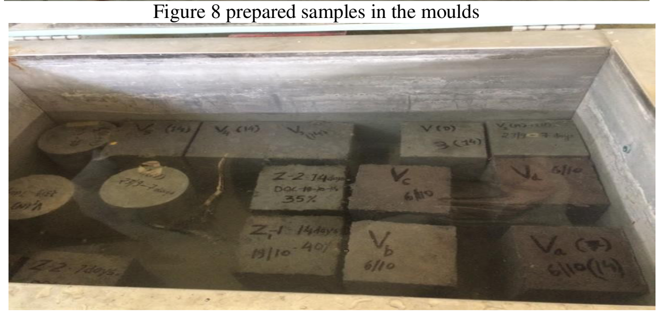


Figure 9 Curing Tank

III RESULT

For testing of compression, tension and workability varying percentage of different samples of cubes and cylinders were casted, each sample consisting of six specimens. Out of these samples three specimens for each sample mix are tested for 7, 14 and 28 days for compressive strength and tensile strength. For determining workability, slump cone test is performed.

Table 4 Compressive Strength with Varying % of Polypropylene Shredding

Mix	Shredding %	**Admixture %**	**28 day N/mm2**
CC	-	2.4	37.52
P1	0.10	2.4	34.95
P2	0.25	2.4	34.63
P3	0.30	2.4	34.07
P4	**0.40**	**2.4**	**33.41***
P5	0.45	2.4	32.04
P6	0.50	2.4	31.20
P7	0.60	2.4	30.77

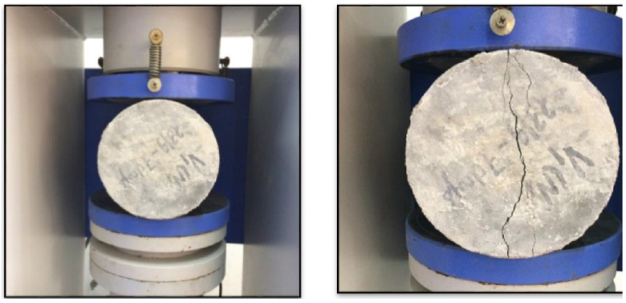


Figure 10 testing of concrete samples

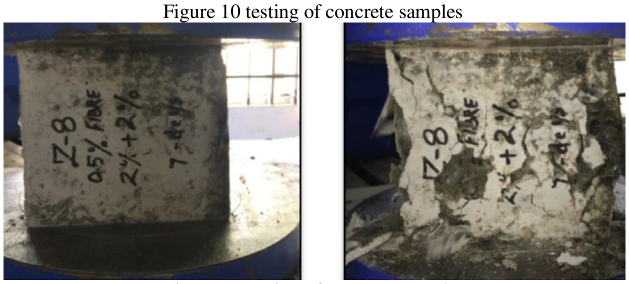
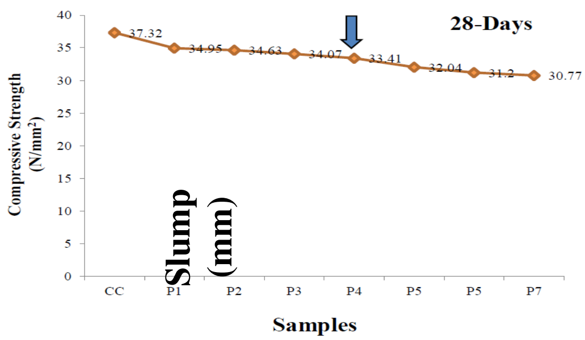
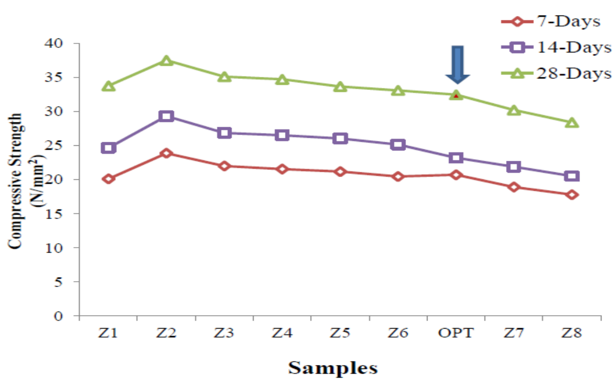


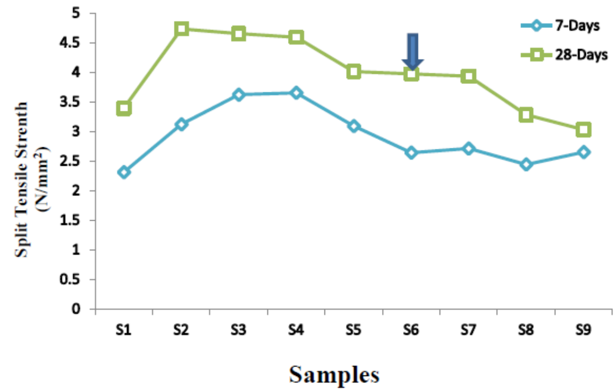
Figure 11 testing of concrete samples



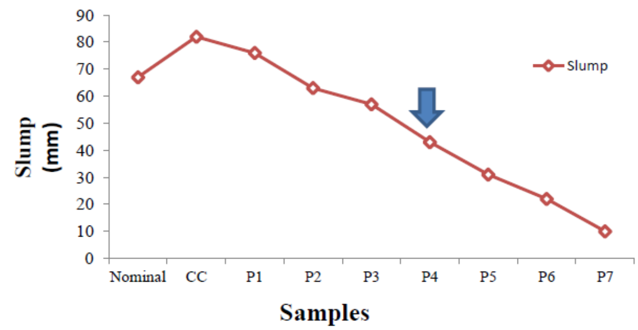
Graph 1 compressive strength with varying shreddings



Graph 2 Compressive Strength of Samples



Graph 3 Split tensile Strength of M25 Concrete



Graph 4 Slump Values with Varying % of Polypropylene Shredding

Mix	GGBFS (%)	Shredding (%)	Admixture (%)	Slump (mm)
Z1	00	00	00	67
Z2	00	00	2.4	82
Z3	10	0.40	2.4	57
Z4	15	0.40	2.4	54
Z5	20	0.40	2.4	49
Z6	25	0.40	2.4	43
OPT	27	0.40	2.4	44
Z7	30	0.40	2.4	39
Z8	35	0.40	2.4	35

figure 12 Slump Values Of Alkali Activated Slag Concrete with Polypropylene Shredding and Admixture

Cost reduction analysis for consumption of cement: The cost analysis is made for the optimum quantities of materials and admixture obtained in last chapter. It is done on the basis of following mix proportions used for M 25 concrete.

Table 5 Material for Nominal Concrete

S.No.	Material	Volume
1.	Cement	7.86 Bags
2.	Sand	0.196 cum
3.	Aggregate	0.386 cum
4.	Admixture	7.14 Lts

Table 6 Materials for Replaced Concrete

S.No.	Material	Quantity
1.	Cement	6.29 Bags*
2.	Sand	0.196 cum
3.	Aggregate	0.386 cum
4.	GGBFS	78.6 kg
5.	Polypropylene Shredding	1.57 kg
6.	Sodium Silicate	6.29 kg
7.	Admixture	5.71 Lts
2	**-20% Replaced Cement*	

Table 7 Cost Analyses of Materials for M25 Nominal Mix

S .No.	Description o f Materials	Unit	Quantity	Rate*	Amount
1.	Cement	Bags	7.86	Rs. 360/Bag	Rs. 2830
2.	Sand	Cum	0.196	Rs. 5720/cum	Rs. 1122
3.	Aggregate 10-mm	Cum	0.123	Rs. 1175/cum	Rs. 145
	20-mm	Cum	0.263	Rs. 1250/cum	Rs. 329
4.	Admixture	Litres	7.14	Rs. 65/lt	Rs. 465
5.	PP Fiber	kg	1.57	Rs. 300	Rs. 471
				TOTAL	Rs. 5362

*-market rate as per DSR-2023 (detailed survey report of market)

Table 8 for M25 Modified Concrete:

S.No	Materials	Unit	Quantity	Rate	Amount
1.	Cement	Bags	6.29	Rs. 360/Bag	Rs. 2265
2.	Sand	cum	0.196	Rs. 5720/cum	Rs. 1122
3.	Aggregate	cum	0.386	Rs. 1250/cum	Rs. 483
4.	Admixture	Liters	5.71	Rs. 60/lt	Rs. 343
5.	GGBFS	kg	78.6	Rs. 3/kg	Rs. 239
6.	PP Shredding	kg	1.57	Rs. 11/kg	Rs. 18
7.	Sodium Silicate	kg	6.29	Rs. 35/kg	Rs. 220
Total					Rs. 4690

Cost reduced per m3 of concrete = Rs. 5362 –Rs.4690 = Rs. 672

Percentage cost saving = 12.53 %. Thus saving is significance.

IV CONCLUSIONS

- As the percentage of polypropylene shredding is increasing there is abrupt decrease in the compressive strength. At 0.4% of polypropylene shredding with 2.4% of admixture, compressive strength of concrete is 33.41 N/mm^2, which is near about the target mean strength of nominal M25 grate concrete mix.

- Workability decreases with increase in polypropylene shredding. At 0.4% of polypropylene shredding, the slump of alkali activated slag concrete with 2.4% of admixture is 43mm, making it suitable for road construction.

- Maximum replacement of cement with GGBS in alkali activated slag concrete blended with 0.4% of polypropylene shredding and 2.4% of admixture is 27%.

- There is appreciable enhancement in split tensile strength of concrete with addition of 0.4% polypropylene shredding and replacing cement with GGBS by 20%, along with addition of 2.4% of admixture.

- It is observed that alkali activated slag concrete gains strength at slow pace initially. For getting early strength use of 2.4% of "K2 Plastcure" admixture is justifiable.

- No abrupt failure, however in conventional concrete, brittle failure persists.

- The cost of alkali activated slag concrete is signified by 12.53%

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REFERENCES

[1] Atis C.D. et al., 2009. "Influence of activator on the strength and drying shrinkage of alkali activated slag mortar" *Construction and Building Materials* 23 (2009) 548–555.

[2] Aydın S. & Baradan B., 2013. "The effect of fiber properties on high performance alkali- activated slag / silica fume mortars" , *Elsevier Composites : Part B* 45, pp. 63–69.

[3] Bakharev T., Sanjayan J.G. & Cheng Y., 2000."Effect of admixtures on properties of alkali-activated slag concrete" *Cement and Concrete Research* 30 (2000) 1367-1374.

[4] Behfarnia, K. & Behravan, A., 2014."Application of high performance polypropylene fibers in concrete lining of water tunnels" *JOURNAL OF MATERIALS&DESIGN*, 55, pp.274–279.

[5] Bernal S. et al., 2010. "Performance of an alkali-activated slag concrete reinforced with steel fibers." *Construction and Building Materials*, 24(2), pp.208–214.

[6] Bilim C. et al., 2012. "Alkali activation of mortars containing different replacement levels of ground granulated blast furnace slag",Construction and Building Materials 28 (2012) 708–712 .

[7] Boukendakdji O., Kadri E. & Kenai S., 2012. "Cement & Concrete Composites Effects of granulated blast furnace slag and superplasticizer type on the fresh properties and compressive strength of self-compacting concrete" *Cement and Concrete Composites*, 34(4), pp.583–590.

[8] Choi J. et al., 2016."Ultra-high-ductile behavior of a polyethylene fi ber-reinforced alkali- activated slag-based composite" *Cement and Concrete Composites*, 70, pp.153– 158.

[9] Collins F.G. & Sanjayan J.G., 1999. "Workability and mechanical properties of alkali activated slag concrete" , *Cement and Concrete Research* 29, pp.455–458.

[10] Chi-Che Hung and Jiang-Jhy Chang, 2013, " The Influence of Mixture Variables for theAlkali-Activated Slag Concrete On The Properties of Concrete" *Journal of Marine Science and Technology*, Vol. 21, No. 3, pp. 229-237

[11] Hsie M., Tu C. & Song P.S.,2008."Mechanical properties of polypropylene hybrid fiber-reinforced concrete" *Materials Science and Engineering A 494 (2008)* pp.153– 157.

[12] Kakooei S. et al., 2012. "The effects of polypropylene fibers on the properties of reinforced concrete structures" *Construction and Building Materials*, 27(1), pp.73–77.

[13] Lee N.K. & Lee H.K., 2013."Setting and mechanical properties of alkali-activated fly ash / slag concrete manufactured at room temperature" *Construction and BuildingMaterials*,47,pp.1201–1209.

[14] Li G. & Zhao X., 2003. "Properties of concrete incorporating fly ash and ground granulated blast-furnace slag" *Construction and Building Materials*, 25, pp.293–299.

[15] Mazaheripour H. et al., 2011. "The effect of polypropylene fibers on the properties of fresh and hardened lightweight self-compacting concrete" *Construction and Building Materials*, 25(1), pp.351–358.

[16] Nili M. & Afroughsabet V., 2010. "The effects of silica fume and polypropylene fibers on the impact resistance and mechanical properties of concrete" *Construction and Building Materials*, 24(6), pp.927–933.

[17] Pal S.C.,Mukherjee A. & Pathak S.R., 2003."Investigation of hydraulic activity of ground granulated blast furnace slag in concrete". *Cement and Concrete Research,* 33, pp.1481–1486.

[18] Pizoń, J., Miera, P. & Łaźniewska-Piekarczyk, B., 2016. Influence of Hardening Accelerating Admixtures on Properties of Cement with Ground Granulated Blast Furnace Slag. *Procedia Engineering*, 161, pp.1070–1075.

[19] Rakhimova N.R. et al., 2016."Influence of limestone content , fi neness , and composition on the properties and microstructure of alkali-activated slag cement" *Cement and Concrete Composites*, 72, pp.268–274.

[20] Rashad A.M., 2013. "Alkali-activated metakaolin : A short guide for civil Engineer – An overview" *Elsevier Construction and Building Materials*, 41, pp.751–765.

[21] Song P.S., Hwang S. & Sheu B.C., 2005 "Strength properties of nylon- and polypropylene-fiber-reinforced concretes",*Cement and Concrete Research* 35, pp.1546–1550.

[22] Vilaplana, J.L. et al., 2016."Mechanical properties of alkali activated blast furnace slag pastes reinforced with carbon fibers". *Elsevier*, *Construction and Building Materials*, 116, pp.63–71.

[23] Xu Y. et al., 2012."Mechanical properties of expanded polystyrene lightweight aggregate concrete and brick" *Construction and Building Materials*, 27, pp.32–38.

[24] Yao Jun Zhang et al., 2010. "Mechanical performance and hydration mechanism of geopolymer composite reinforced by resin" *Elsevier Materials Science & Engineering A* 527(24–25), pp.6574–6580

[25] IS: 12269-2013, Ordinary portland cement 53 grade specifications.

[26] IS: 4031 (Part 1) 1996, Indian standard method of physical tests for hydraulic cement,Determination of fineness by Dry sieving.

[27] IS: 4031 (Part 11) 1988, Indian standard method of physical tests for hydraulic cement,Determination of Density.

[28] IS: 4031 (Part 4) 1988, Indian standard method of physical tests for hydraulic cement,Determination of Consistency of standard cement paste.

[29] IS: 4031 (Part 5) 1988, Indian standard method of physical tests for hydraulic cement,Determination of Initial and Final setting time.

[30] IS: 383-1970,Indian standard Specification for Coarse and Fine aggregates.

[31] IS: 10262-2009, Indian standard Concrete Mix Proportioning-Guidelines.

[32] IS: 516-1959, Indian standard Methods of Tests for Strength of Concrete.