International Journal of Innovative Research in Computer Science & Technology (IJIRCST)
ISSN: 2347-5552, Volume-10, Issue-3, May 2022
https://doi.org/10.55524/ijircst.2022.10.3.17
Article ID IRP1265, Pages 87-100
www.ijircst.org

Utilization of Recycled Glass as Fractional Replacement of Cement and Waste Concrete as an Aggregate in Sustainable Concrete Practice

Zamin Shakeel[1], Sakshi Bhatia[2], and Nasir Ahmad Dar[3]

[1]Research Scholar, Department of Civil Engineering, RIMT University, Mandi, Gobindgarh, Punjab, India
[2]Assistant Professor, Department of Civil Engineering, RIMT University, Mandi, Gobindgarh, Punjab, India
[3]Research scholar, Department of Civil Engineering, Sir Padampat Singhania University, Udaipur, India

ABSTRACT- This paper summarizes the ongoing researches about the effect of recycled glass powder and the recycled aggregates on conventional concrete Practice. Many studies on using the recycled powdered glass and the recycled aggregates in conventional concrete practice that have been carried out earlier were studied, and their effects on the conventional concrete were also analyzed. In this paper we will analyze the individual effects by these each replacements and then I will combine both the materials in concrete and will analyze the result of that concrete. Glass mainly consists of silica. Utilising the powdered glass waste as fractional replacement could be proven an efficient step for the development of sustainable infrastructure systems. When the recycled waste glass is grinded into the powdered form with micro size particles, it exhibits pozzolanic reactions with the hydrates of cement, resulting in the formation of secondary C-S-H products. Similarly the use of recycled concrete as aggregate would also result into the development of sustainable infrastructure systems. Similarly possibility of utilization of recycled concrete as aggregate has been concluded to have positive impact on the fresh concrete production.

KEYWORDS- Waste glass, recycled aggregates, sustainable.

I. INTRODUCTION

The utilization of waste materials in construction industry has diversely and significantly increased from past years. The reason behind such diverse utilization is that these substituent materials don't have any adverse effect on the conventional concrete and at the same time this technique provides an effective way for disposal of these waste products. Waste glass and demolished concrete is also included in such material category. Million tonnes of waste glass and waste concrete are evolved from the society regularly. Disposing these materials as landfills is unsustainable because they are indecomposable in nature. Glass mainly consists of silica. Utilizing the powdered glass waste as fractional replacement could be proven as efficient step for the development of sustainable infrastructure systems. When the recycled waste glass is grinded into the powdered form with micro size particles, it exhibits pozzolanic reactions with the hydrates of cement, resulting in the formation of secondary C-S-H products. Similarly the use of recycled concrete aggregate would also result into the development of sustainable infrastructure systems. In this paper cement will be partially replaced by waste glass powder as a binder, and the natural coarse aggregate will be replaced with the recycled aggregates from the coarse aggregates. The fractional replacement of cement by glass powder will be carried at 0-20%, and the natural aggregates will be fully replaced fractionally by 0-100% with recycled aggregates from demolished concrete [1-7].

II. MATERIALS

A. Cement

In this paper ordinary Portland cement of43grade is use. Fig 1 shows the bag of cement.

Figure 1: Cement bag

B. Fine Aggregate

The fine aggregate used in this paper is natural sand. From the sieve analysis of the sand it falls under the zone II Fig 2 shows the fine aggregates by sieving.

Figure 2: Fine aggregates

C. Coarse Aggregate

The angular crushed aggregates are used. The aggregates are collected from the local crusher plant. In this paper 20mm nominal size aggregates are used and Fig 3 shows the coarse aggregates.

Figure 3: Coarse aggregates Crushed glass

First the waste glass bottles were collected. These bottles were the crushed using Los Angles apparatus showing in Fig 4. The crushed material from this apparatus was pulverized used hand operated stone pulverize.

Figure 4: Crushed glass Powdered glass

The size of the glass powder particles is kept under 200# as shown in Fig 5

Figure 5: Powdered glass

D. Super Plasticizer

FAIRFLCO S (MODIFIED) is a water decreasing agent of greater range and retarding concrete admixture as per the code BS-5075 part-4, ASTM C-494 type 'G' and IS 9103, 1999. FAIRFLO S (MODIFIED) is supplied in brown liquid form, made by modification of Sulphonated Naphthalene slump retaining polymer. This high range water reducing agent can be used in different ways to cast dense, strong and durable concrete. These greater water reducing properties of this product makes it suitable in precast concrete, where early strength is of prime importance. The properties of the super plasticizer are given below.
Color and state: brown colored in liquid form as shown in Fig 6
Presence of chlorine: As per IS-456 NIL,
Air entrainment: Not more than 1%, **pH Value:** 7.5±0.5, **Specific gravity:** 1.1

Figure 6: Super plasticizer

E. Waste Aggregate

The recycled aggregates are collected from the waste concrete. The waste concrete lumps are hammered manually and crushed to the desired size.

III. TESTING OF MATERIALS

A. Specific Gravity of Cement

Specific gravity can be defined as the ratio of weight of given volume of a material to the weight of an equal volume of water. The specific gravity of Ordinary Portland Cement is 3.15 [7-12]. While as per Portland Cement Association the specific gravity of the Portland Pozzolanic cement is about 2.7.The procedures followed during the test is as follows:

- The Flask should be free from the liquid that means it should be fully dry, weigh it and mark its weight as W1
- Now fill the flask wit cement upto the half mark on the flask. put on the stopper of flask .Now weight the flask and mark it as W2.
- Add kerosene to the flask filled with cement; mix it thoroughly to remove the entrapped air, weight the flask again and mark this as W3.
- Now put off the materials from the flask, clean it and refill this flask with kerosene and then weight again as shown in Fig 7. Mark this weight as W4.

Figure 7: Specific gravity test of cement

Table 1: Specific gravity test readings

S. NO	DESCRIPTION	WEIGHT
1	The weight of the empty flask is taken as W_1.	29 gms
2	Weight of flask + cement , W_2	56 gms
3	Weight of flask+ cement + kerosene, W_3	83 gms
4	Weight of flask filled fully with kerosene, W_4	67 gms
5	Specific gravity of kerosene	0.79

Specific gravity = $W_1 - W_2$ / $((W_1 - W_2) - (W_3 - W_4))$X0.79
Specific gravity of cement = 3.1

Fineness of cement

Weight of cement sample taken = 100 gram.
Residue retained above sieve = 4 gram.
Percentage retained = (4/100)*100
Percentage retained = 4% , which is less than 10%.

B. Testing of Fine Aggregate

Specific gravity of fine aggregate & description shown in Table 2.

Table 2: Specific gravity of sand test readings

S. No.	DESCRIPTION	WEIGHT
1	The weight of the empty pycnometre is taken as W_1.	450 gms
2	Weight of pycnometre + sand , W_2	1050 gms
3	Weight of pycnometre + sand + water, W_3	1863 gms
4	Weight of pycnometre filled fully with water, W_4	1492 gms

Specific gravity = (W1-W2)/((W1-W2) - (W3-W4))
Specific gravity = 2.61

Sieve analysis of fine aggregates as shown in Table 3
Weight of sample = 500 gms

Table 3: Sieve analysis readings for sand

Sieve size	Retained weight (gms)	Percentage retained	Cumulative percentage	Percentage passing
10 mm	00	00	00	100
4.5 mm	6	1.2	1.2	98.8
2.36 mm	48	9.6	10.8	89.2
1.18 mm	42	8.4	19.2	80.8
600 mic	112	22.4	41.6	58.4
300 mic.	175	35	76.6	23.4
150 mic	98	19.6	96.2	3.8
pan	19	3.8	100	0

C. *Testing of Coarse Aggregates*

Specific gravity of coarse aggregate shows in Fig 8 & description show in Table 4.

Table 4: Specific gravity test readings

S.NO	DESCRIPTION	WEIGHT
1	The basket and the sample are weighed while suspended in water, W1.	2518 gms
2	W The empty basket is then returned to the tank of water jolted 25 times and weighed in water= **W2**	645 gms
3	The surface dried aggregate is then weighed = **W3**	3018.5 gms
4	Weight of oven dried aggregates= W4	2990 gms

Specific gravity= (W1-W2) / ((W1-W2) – (W3-W4))

Specific gravity = 2.64

Figure 8: Specific gravity of coarse Aggregate

Concrete Mix proportions for Trail Mix as shown in Table 5.

Table.5: Proportions for Concrete Mix

Cement	439 kg/ m^3
Water	197.6 kg/ m^3
Super plastisizer	4.39 kg/ m^3
Fine aggregates	741 kg/ m^3
Coarse aggregate	978 kg/ m^3
W/c ratio	0.45

For casting trial-1, weight of ingredients required will be calculated for 3 cubes is shown in Table 6.

Table 6: Casting of concrete in lab, to check its properties

Volume of concrete required for 3 cubes = 3 x (0.15^3 x1.2)	.013 m^3
Cement = (439 x 0. 013) kg/m^3	5.14 kg
Super plastisizer = (4.39 x 0.013)	0.04 kg
Water = (197.6 x 0. 013) kg/m^3	2.05 kg
Fine aggregates = (741 x 0.013) kg/m^3	10.86 kg
Coarse aggregate = (978 x 0.013) kg/m^3	13.73kg

Before the above trail was fixed for final proportions, several trials were made and their results are in tabulated forms below in Table 7.

Table 7: Superplastisizer dosage

Trial No.	w/c ratio	Reduction in water content.	Dosage of super plastisizer	Slump achieved
1	0.45	20%	0.8%	20mm
2	0.45	10%	1.5%	30mm
3	0.45	0%	2%	---
4	0.45	0%	1.5%	120mm
5	0.45	0%	1%	100mm

IV. RESULTS AND DISCUSSION

A. Workability of Concrete

The workability of the concrete was checked using the slump cone test apparatus. The slump value for the conventional type of concrete was found to be 100 mm ±10 mm deviations.

B. Compressive Strength Of Concrete

The compressive strength test results for the conventional concrete are as follow in Table 8.

Table 8: Compressive Strength with days

S.No.	**Duration**	**Compressive strength**
1	7 days	17 MPa
2	14 days	22.5 MPa
3	28 days	26.2 Mpa

C. Flexural Strength of Concrete

Flexural strength is one measure of the tensile strength of the concrete [13-14]. It is a measure of an un-reinforced concrete beam to resist failure in bending. For finding the tensile strength of the concrete moulds of 150×150×700 mm were casted and tested on UTM, using central point load system. Sample shown in Figure 9.

Figure 9: Flexural strength test of concrete

Testing of concrete with recycled aggregates. Compressive strength test results for the concrete with 25% of recycled aggregates (WA-25) shown in Fig 10.

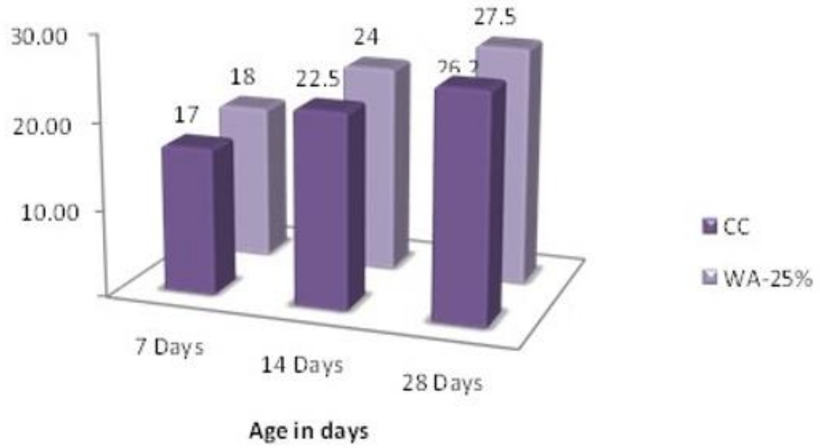

Figure 10: Compressive strength results of WA-25

Compressive strength test results for the concrete with 50% of recycled aggregates (WA-50) as shown in Fig 11.

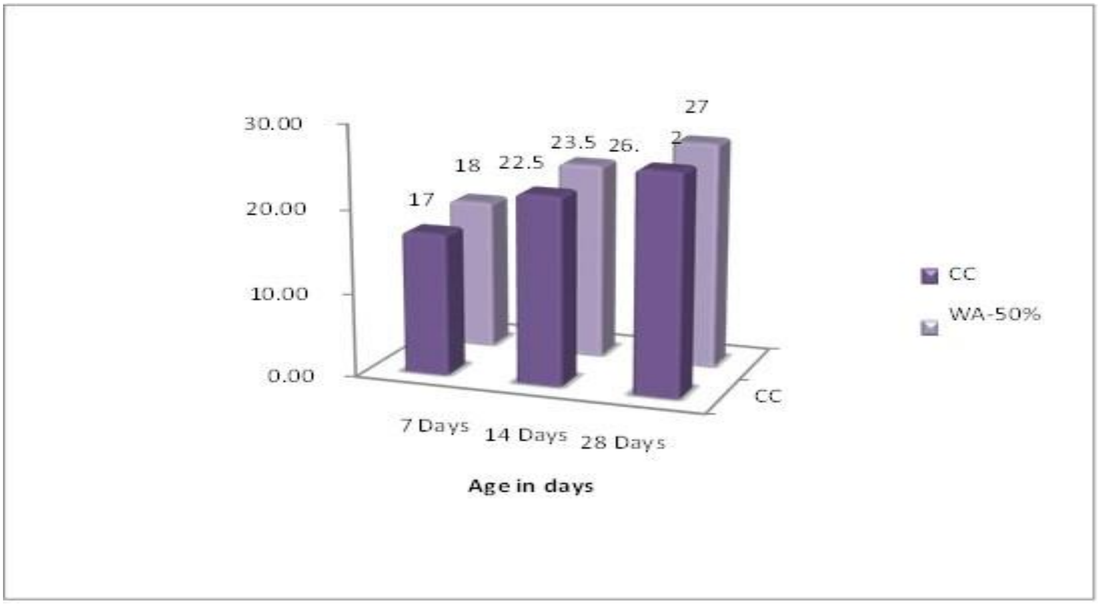

Figure 11: Compressive Strength results of WA-50

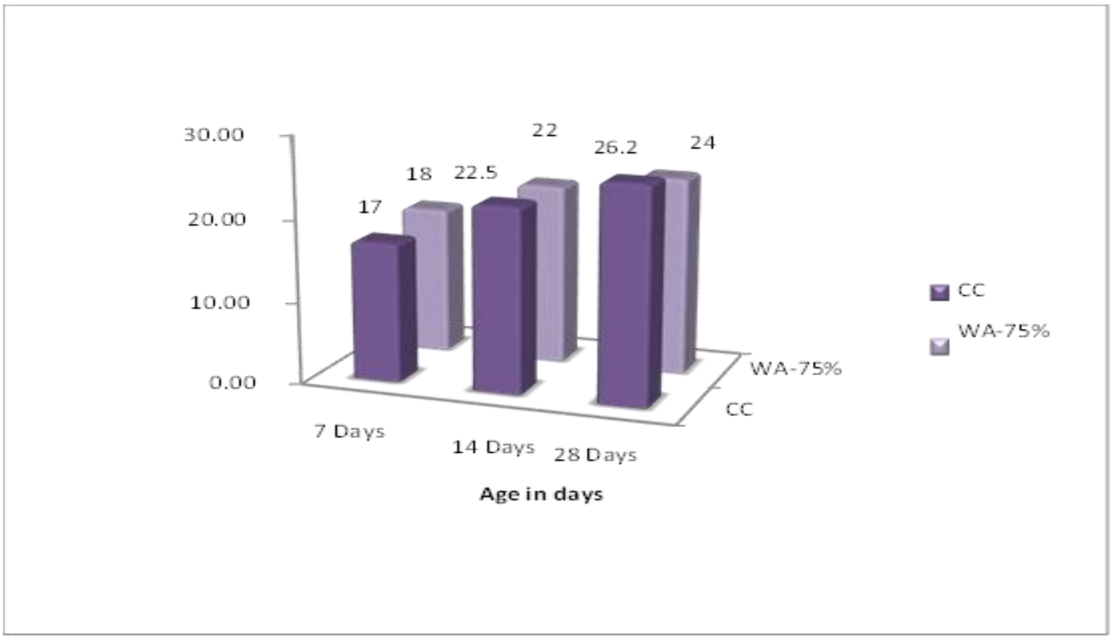

Figure 12: Compressive Strength results of WA-75

Compressive strength test results for the concrete with 100% of recycled aggregates (WA-100) as shown in Fig 13.

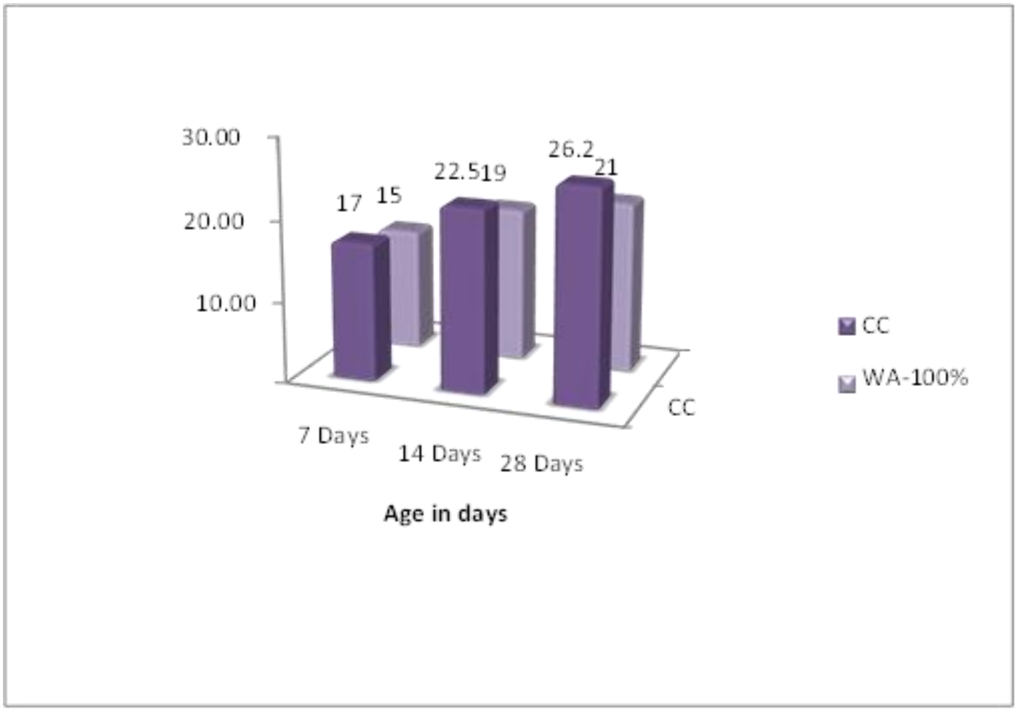

Figure 13: Compressive Strength results of WA-100

28 days compressive strength test results for the concrete with waste aggregates shown in Fig 14.

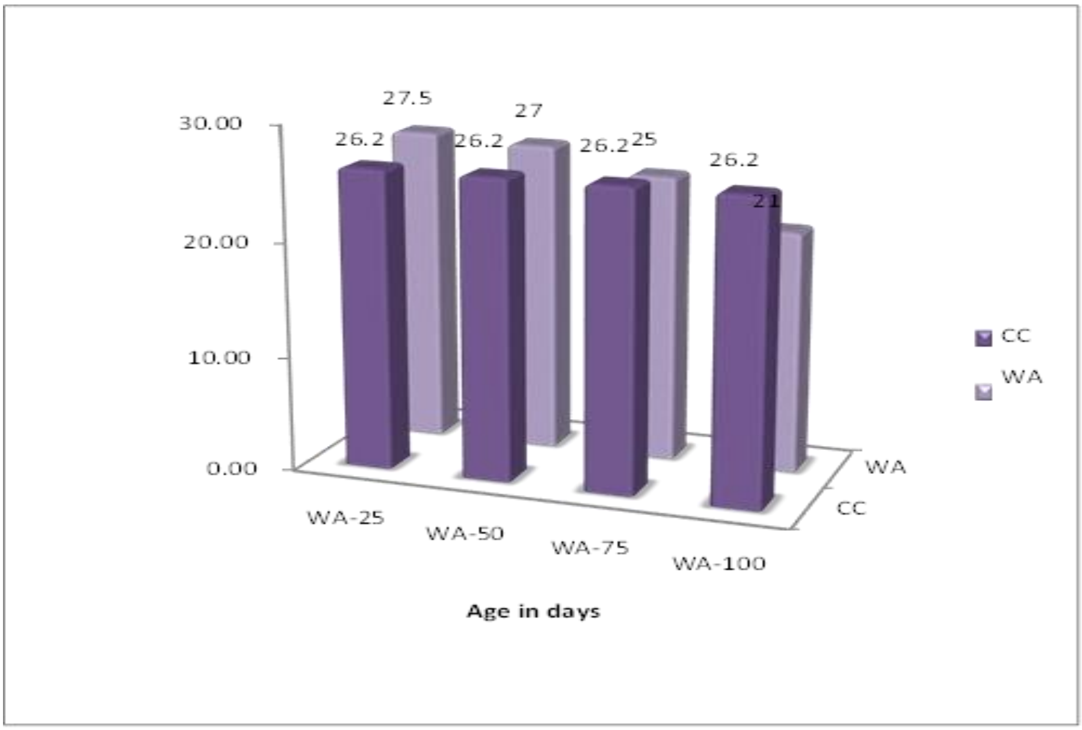

Figure 14: Compressive Strength results of WA after 28 days

Flexure (tensile) strength test results for the concrete with waste aggregates in Fig 15.

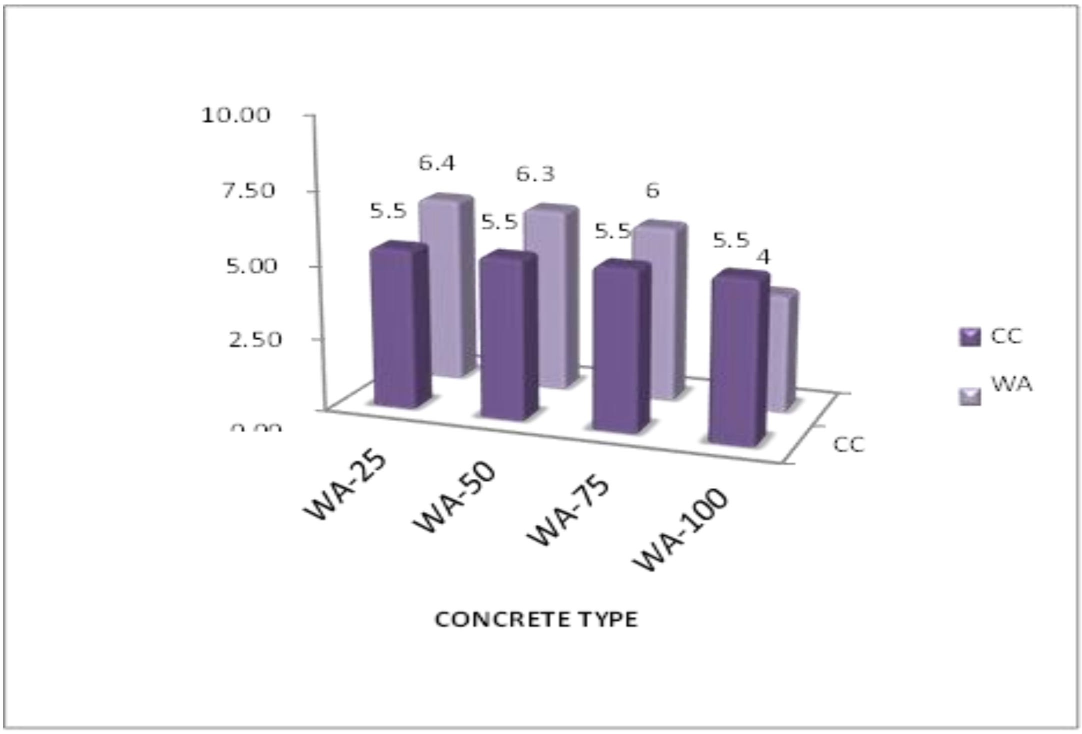

Figure 15: Flexure (tensile) Strength results of WA after 28 days

Slump cone test results for the concrete with of waste aggregates shown in Fig 16.

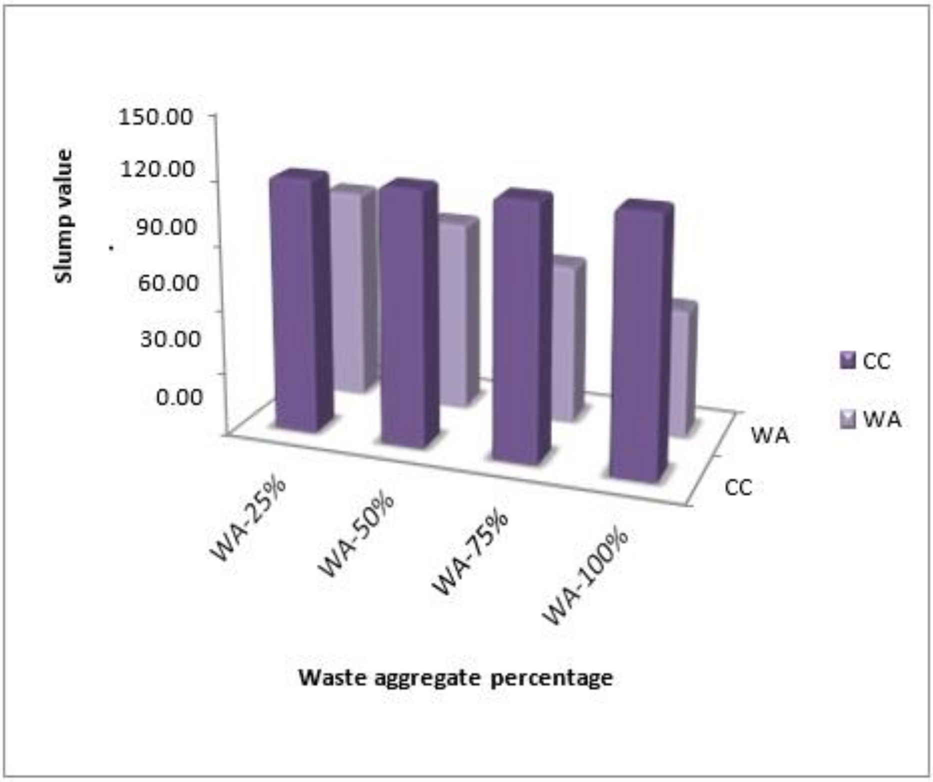

Figure 16: Slump cone test results of WA

Testing Of Concrete With Waste Glass

Compressive strength test results for the concrete with 15% of waste glass (GP-15) shown in Fig.17.

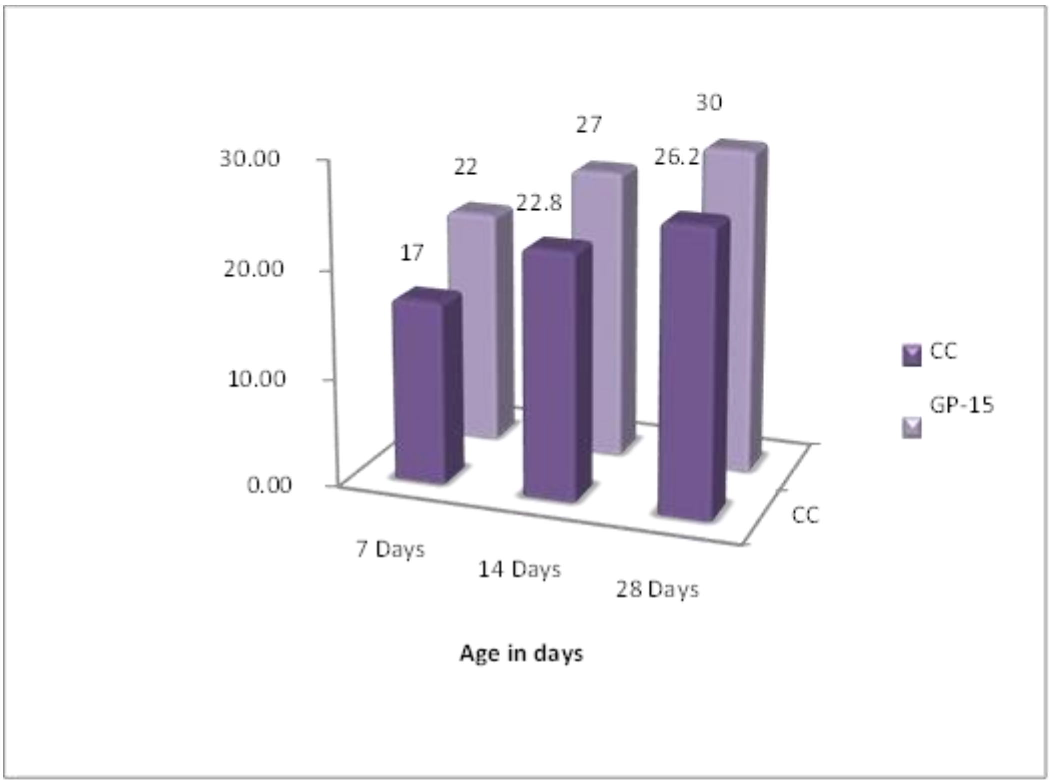

Figure 17: Compressive strength results of GP-15

Compressive strength test results for the concrete with 20% of waste glass (GP-20) shown in Fig.18.

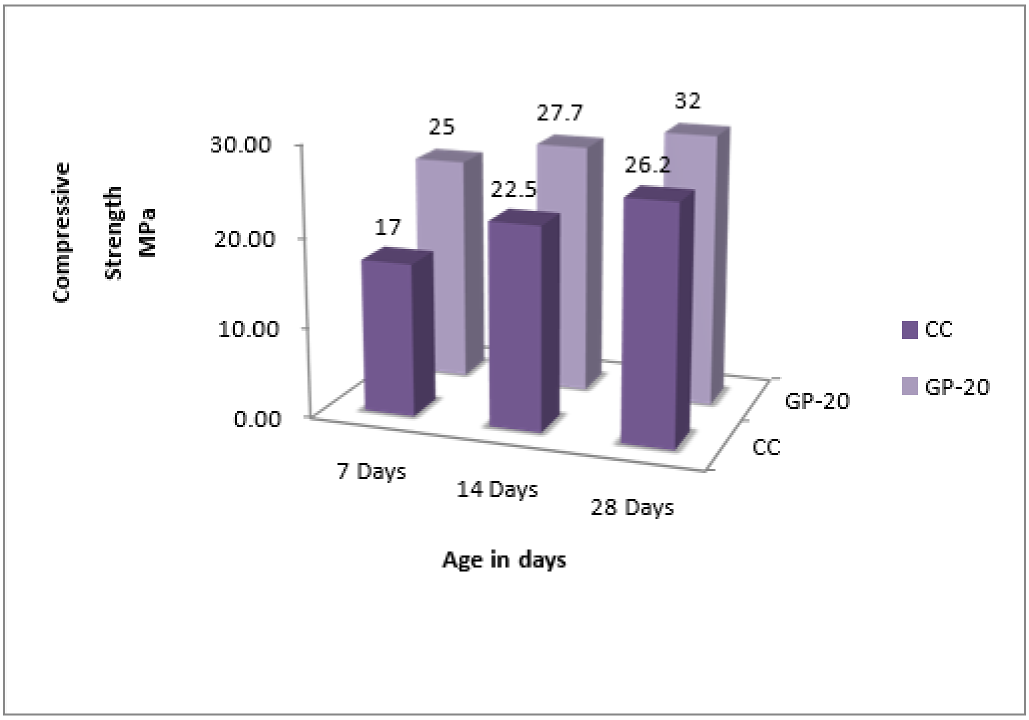

Figure 18: Compressive strength results of GP-20

Compressive strength test results for the concrete with 25% of waste glass (GP-25) shown in Fig. 19.

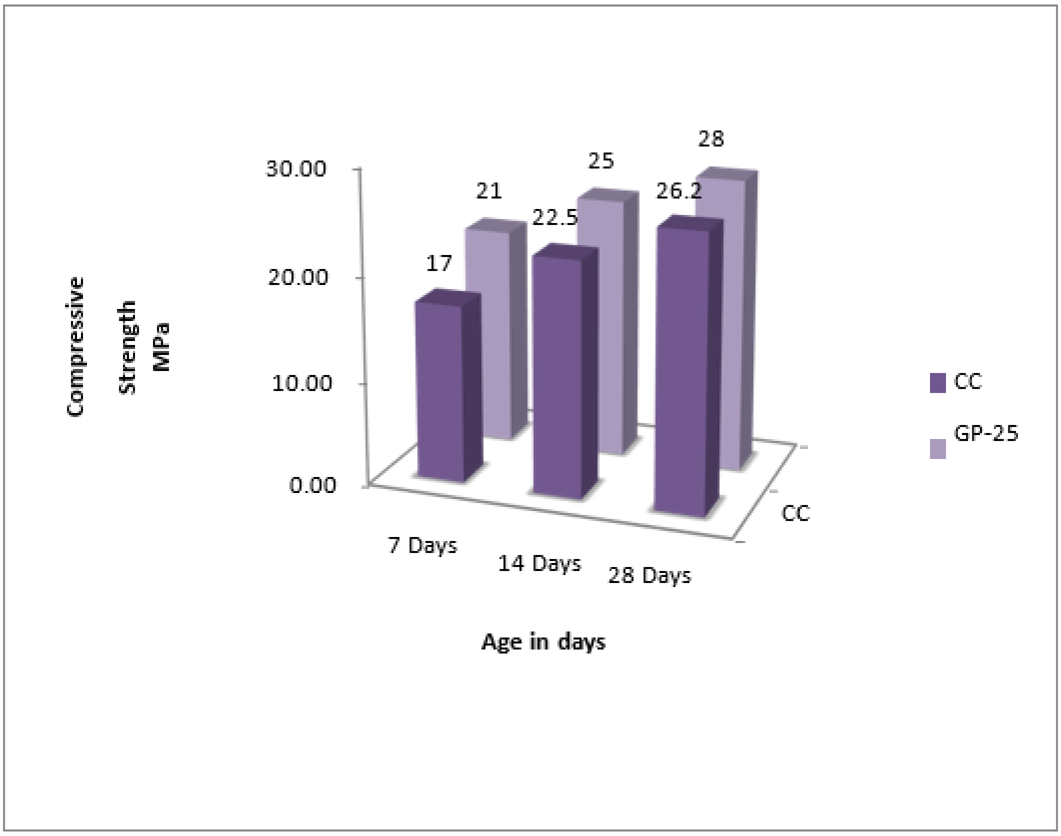

Figure 19: Compressive strength test results of GP-25

Compressive strength test results for the concrete with 30% of waste glass (GP-30) as shown in Fig.20.

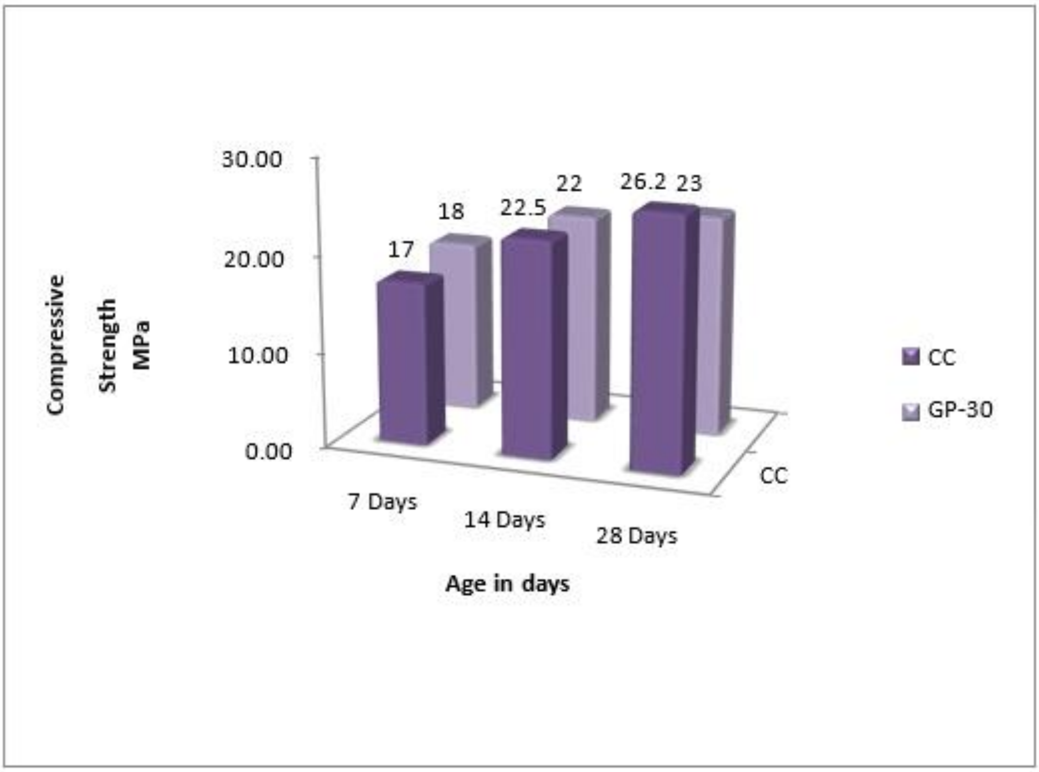

Figure 20: Compressive strength test results of GP-30

Compressive Strength test results comparison for the concrete with wasteglass as shown in Fig.21.

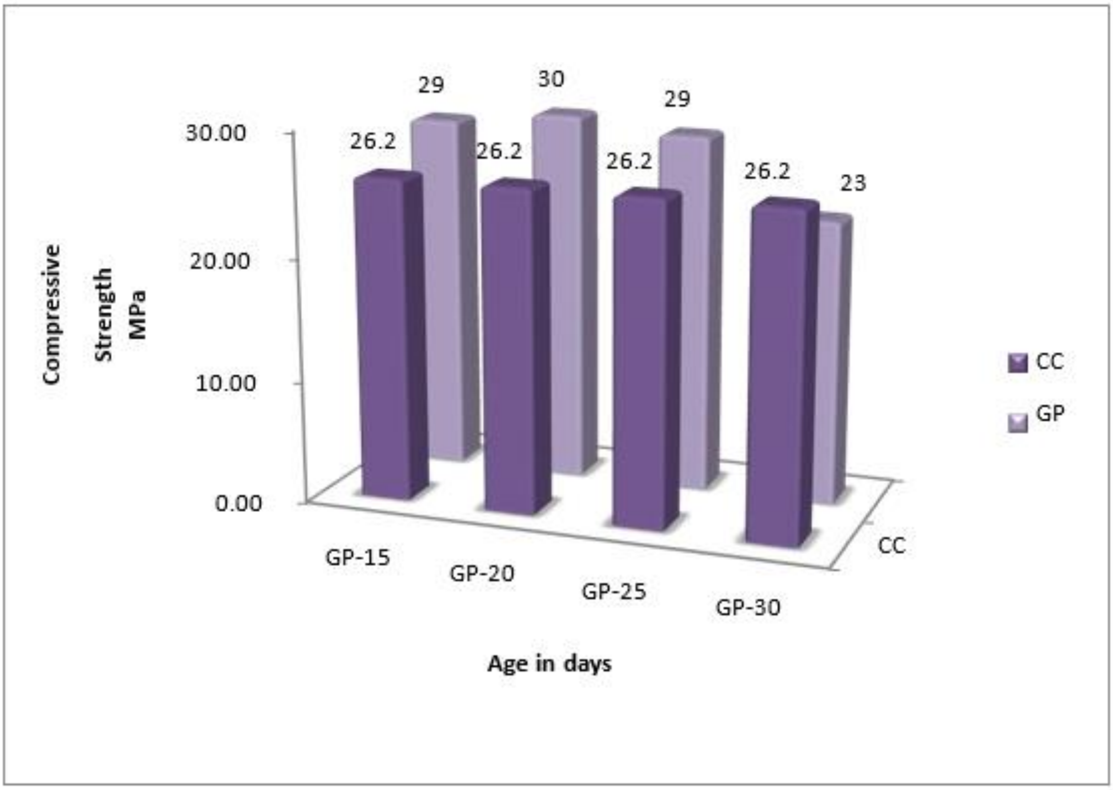

Figure 21: Compressive strength test results comparison for the concrete with waste glass after 28 Days

Flexural (Tensile) strength test results for the concrete with of waste glass as shown in Fig.22.

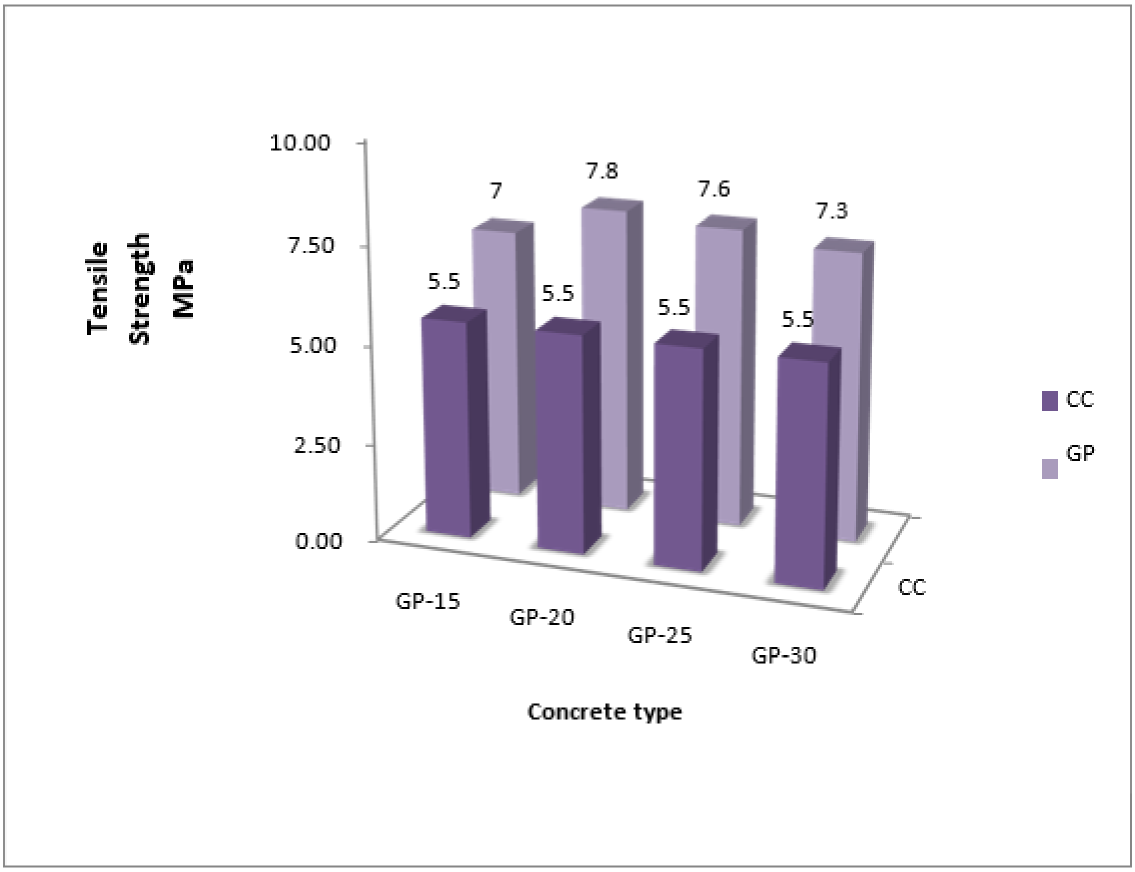

Figure 22: Tensile strength results of concrete with waste glass after 28 days

Slump cone test results for the concrete with of waste glass as shown in Fig. 23.

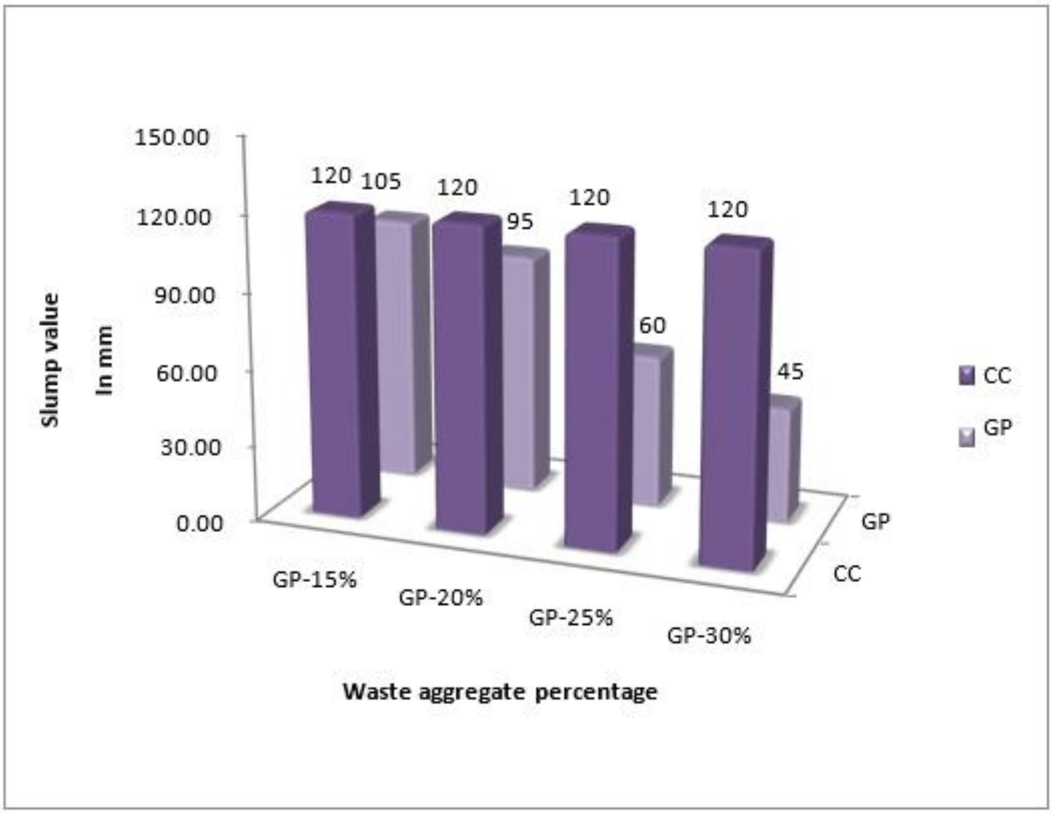

Figure 23: Slump cone test results of GP

Testing Of Concrete Made From Waste Glass And Recycyled Aggregates.

Result for compressive strength of G-A shown in Fig. 24.

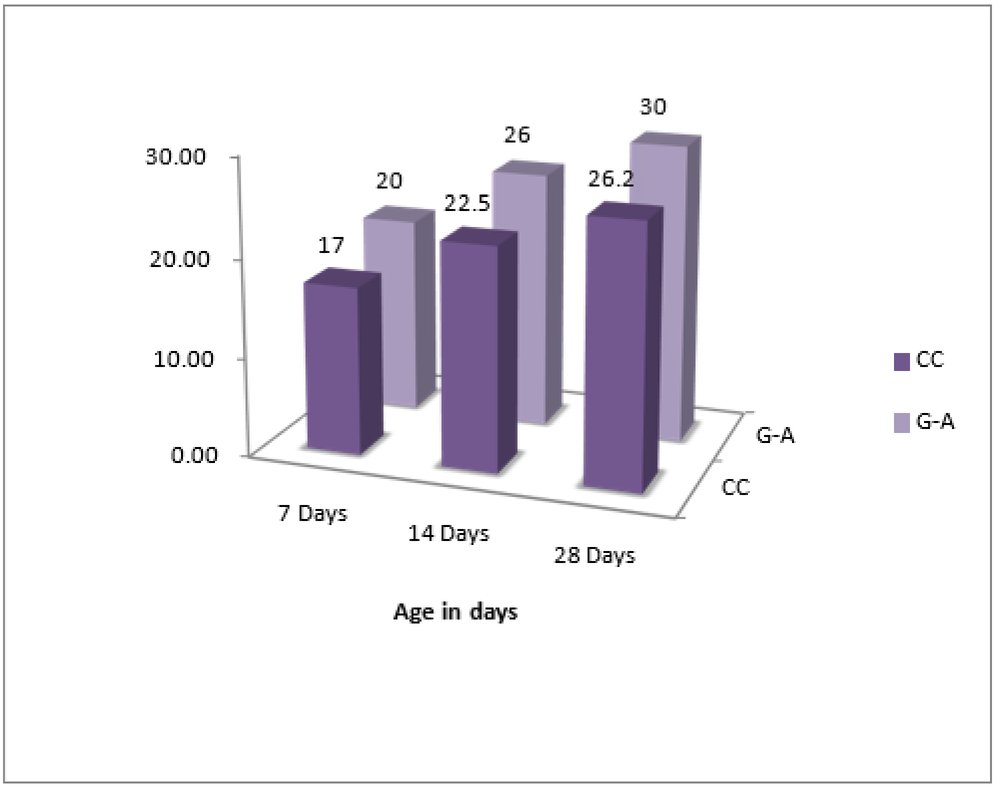

Figure 24: Compressive strength test results of G-A

D. Tensile Strength

The tensile strength of this concrete is 7 MPa.

E. Workability

The workability of this concrete get reduced with respect to the conventional concrete.It was estimated that the 10-15% of the super plasticizer dosage (initially calculated for the conventional concrete) need to be increased to achieve the desired workability.

V. CONCLUSION

The chemical composition of clear and colored glass powders is very similar and the materials could be declared as pozzolanic material as per ASTM standard. The optimum glass content is 20%Concrete compressive strength at 28 days. In general, considering the similar performance with replaced material, glass addition can reduce cost of cement production up to 14%. In addition , production of every six ton glass powder concrete results in the reduction of each ton CO_2 emission from cement production and save the environment significantly by reducing green-house gas and particulate production. Generally the high surface area of milled waste glass changes the kinetics of chemical reaction toward beneficial pozzolanic reaction utilizing the available alkalis before production of a potential ASR gel. However, further research on durability and ASR aspects of glass replaced concrete is required to suggest this material for sustainable concrete practice. Use of recycled aggregates in concrete provides a promising solution to the problem of C&D waste management. Based on a survey of production and utilization of RA in RAC, and the properties of RA and RAC discussed in this paper, it is clear that RAC can be used in lower end applications of concrete. Greater efforts are needed in the direction of creating awareness, and relevant specifications to clearly demarcate areas where RAC can be safely used.

REFERENCES

[1] G.M. Sadiqul Islam, M.H. RahmanNayemKazi: “Waste glass powder as partial replacement of cement for sustainable concrete practice”. International Journal ofSustainable Built Environment Volume 6, Issue 1, June 2017

[2] Ashraf M. Wagih , Hossam Z. El-Karmoty , Magda Ebid , Samir H. Okba: “Recycled construction and demolition concrete waste as aggregate for structural concrete” Housing and Building National Research Centre journal, 2013.

[3] NafisaTamanna, Norsuzailina Mohamed Sultan, Ibrahim Bin Yakub: “Utilization of waste glass in concrete”, IJTER July 2013

[4] Sameer Sheikh, S.S.Bachhav, D.Y. Kshirsagar: “Effective Utilization of Waste Glass in Concrete” IJTER vol. 5, December 2015

[5] GunalaanVasudevan, Seri GanisKanapathypillay: “Performance of Using Waste Glass Powder in Concrete as Replacement of Cement” . American Journal of Engineering Research, vol-2, 2013.

[6] SajedurRahman: “Experimental Investigation of Concrete with Glass Powder as Partial Replacement of Cement” IJTER, May 2015

[7] Ali A. Aliabdo, AbdElmoaty M. AbdElmoaty, Ahmed Y. Aboshama: “Utilization of waste glass powder in the production of cement and concrete” Elsevier , August 2016.

[8] Hongjian Du and Kiang Hwee Tan: “Waste Glass Powder as Cement Replacement in Concrete” Journal of Advanced Concrete Technology Vol. 12, 468-477, November 2014.

[9] Fasih Ahmed Khan, Muhammad Fahad, Khan Shahzada, HarisAlam, Naveed Ali: “Utilization of waste glass powder as a partial replacement of cement in concrete” , International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319-5347, Vol. 04, No. 03, July 2015

[10] ShahidKabir, Ammar Al-Shayeb and Imran M. Khan: “Recycled Construction Debris as Concrete Aggregate for Sustainable Construction Materials”, Elsevier , 2016.

[11] AkashRao, Kumar N. Jha, SudhirMisra: “Use of aggregates from recycled construction and demolition waste in concrete” Elsevier, May 2016.

[12] JozefJunak, AlenaSicakova: “Concrete containing recycled concrete aggregate with modified surface” Elsevier, May 2017.

[13] IS 10262:2009, Concrete Mix Proportioning - Guidelines (First Revision)

[14] IS 383:1970, Specification for Coarse and Fine Aggregates from Natural Sources for Concrete (Second Revision)