International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 09 | September - 2022 Impact Factor: 7.185 ISSN: 2582-3930

PERFORMANCE OF SELF COMPACTING CONCRETE USING RECYCLED COARSE AGGREGATE AND WASTE GLASS POWDER AT ELEVATED TEMPERATURE

Parvathy Sanjeev[1], Chithira Krishnakumar[2]

[1]*M. Tech student, Structural Engineering, universal Engineering college, Thrissur, Kerala*
[2] *Assistant professor, Civil Department, universal Engineering college, Thrissur,* Kerala

---***---

Abstract

Incorporating waste and recycled materials in concrete pro vides not only a longterm benefit, but also increased resista nce to
special circumstances that concrete structures face, such as fire. The crushed concrete aggregate has been used as a replacement to natural aggregate in SCC. Waste glass powder utilization as partial replacement of cement was studied. Fly ash can be used as a source to replace the existing building materials which is cost effective. If some of the waste materials can be suitable for concrete making it can reduce the cost of construction. The current study investigated the performance of incorporating recycled coarse aggregate (RCA) and two unprocessed waste powder materials on the residual mechanical properties of self-compacting concrete (SCC) after elevated temperature exposure. SCC mixtures have been created by adding the cement mass with up to 25% waste fly ash (WFA) and replacing cement mass as 10%,20%,30% by waste glass powder, as well as replacing the coarse natural aggregate (NA) with up to 50% RCA. Using RCA up to 50% enhanced the residual mechanical properties of SCC after exposure to the elevated temperature. Replacing cement by 10% waste glass powder gives satisfactory results at high temperature.

Key Words: Self Compacting Concrete, Recycled Concrete Aggregate ,Waste Glass Powder, Waste Fly Ash.

1.INTRODUCTION

The availability of skilled labour in the construction sector decreased throughout the 1980s. The desire for concrete that could address issues with poor craftsmanship was sparked by this circumstance. As a result, self-compacting concrete was created (SCC). Self-compacting concrete has been finished and given the name "High-Performance Concrete." Later, the term "Self-Compacting High-Performance Concrete" was proposed. Despite having superior fire resistance than the majority of construction materials, concrete loses strength and may even crack when exposed to high temperatures. For self-compacting concrete, the benefits of RCA at high temperatures might be more important Concrete's binding agent may be cement alone or combined with other cement-replacing materials (CRMs), such as pulverised fly ash, silica fume, slag, or limestone, among others. The impact of using waste glass powder in place of cement in concrete has been the subject of numerous investigations. Milled glass with particles smaller than 75 microns has the pozzolanic qualities to function as a supplementary cementitious material (SCM) and can be sufficiently compared to other proven SCMs like fly ash and silica fumes.

2. MATERIALS

2.1 Cement

Use of Ordinary Portland Cement (OPC) of Grade 53 according to IS specifications is made in this investigation.

Table-1: Properties of OPC 53 grade cement

Properties	Test results	Technical reference
Specific gravity	3.12	IS4031(PART 11): 1988
Consistency (%)	30	IS4031(PART 4): 1988
Fineness of cement (%)	4.7	IS4031(PART 2): 1996
Initial setting time (minutes)	78	IS4031(PART 5): 1988

2.2 Fine Aggregate

With the exception of grading requirements, fine aggregates should meet the requirements of ASTM C33. Variations in fine aggregate quality will have a significant impact on overall quality of SCC. M-Sand is less than 4.75mm in size. M-sand is used in this study as fine aggregate. Table 2 gives properties of fine aggregates.

Table-3: Properties of Fine Aggregate

Properties	**Test results**
Specific gravity	2.52
Fineness modulus	3.84
Free surface moisture	Nil

2.3 Coarse Aggregate

Coarse aggregates particle sizes ranges between 10 and 40 mm in size. The coarse aggregate used for SCC is round in shape, well graded, and smaller in maximum size than that used for conventional concrete because round smaller aggregate provides flowability, deformability, and segregation. The experimental study's coarse aggregate was 12.5mm in size and conformed to IS 383:1970. Table 4 lists the characteristics of coarse aggregate.

Table-4: Properties of Coarse Aggregate

Properties	Test results	Technical reference
Specific gravity	2.69	IS2386(PART 3): Clause 2.4.2
Free surface moisture	Nil	IS383(PART 3): 1970
Fineness modulus	4.25	IS383(PART 3): 1970 table 2

2.4 Recycled Coarse Aggregate

The aggregate represents 60 to 75% of concrete volume. Therefore, the complete or partial substitution of conventional aggregate by crushed concrete aggregate presents high economic and ecological advantages as it reduces the deposition of waste in landfills and the extraction of natural aggregates. It is now acknowledged that recycled concrete has less durable mechanical qualities due to the high water absorption coefficient and low density of the recycled concrete aggregates (RCA) as contrasted with concretes made with natural aggregate Recycled concretes seem to show better residual mechanical strength. Recycled coarse aggregate has a lower durability, but mixing it with special materials such as fly ash improves its durability.

Fig- 1 : Recycled Coarse Aggregate

Table 5 Properties of Recycled Coarse Aggregate

Physical Test	NA	RCA
Water absorption (%)	1.01	5.60
Los Angeles wear (%)	26.30	36.11
Density (kg/m^3)	2,640.11	2,612.29

2.5 Waste Glass Powder

Studies have also demonstrated that glass can be employed as a pozzolanic or cementitious component in concrete because of the chemical composition's high silica and calcium content and the glass's amorphous structure. In the primary bonding phase of concrete, the reaction between the glass powder and the $Ca(OH)_2$ in the concrete mix results in C-S-H gels. a gradual decrease in the strength properties of the concrete containing glass material as the temperature increase.

Fig-2: Waste Glass Powder

2.6 Fly Ash

Fly ash is a finely separated by product of pulverised coal combustion that is carried away from the combustion chamber by exhaust gases. It is a fine grey coloured powder having spherical glassy particles that rise with the flue gases. As fly ash contains pozzolanic materials components which reach with lime to form cementitious materials.

3. EXPERIMENTAL PROGRAM

3.1 Specimen Details

27 numbers of cubes and cylinders each were cast for determining the 28 day compressive strength and split tensile strength. The cubes are of 150x150x150mm size. The diameter of cylinder was 150mm and height was 300mm.

3.2 Curing of Specimens

After 24 hours from casting, the specimens were removed from the mould and immediately submerged in clean fresh water i.e, water cured for 28 days in a water tank. The water used for curing was similar with that used for casting. After 28 days, specimens were taken out and kept ready for testing.

3.3 Heating of Specimens

Heating procedure was carried out using an electric oven having a temperature range of 50ºC to 300ºC. At 28 days age of testing, the test specimens were subjected to elevated temperature at 150ºC and 300ºC for a period of 2 hours. Then the heated specimens are cooled. Fig 5.4 shows the image of specimens kept in oven for heating. The compressive and split tensile strength of the concrete samples that were subjected to high temperature were testing. For each group, three specimens were tested and averaged.

Fig. 5.2 Specimens kept in oven for heating

4. RESULTS AND DISCUSSION

4.2 PROPERTIES OF FRESH CONCRETE

4.2.1 Workability

The workability of concrete is measured by slump test in accordance with IS 1199-1959. Trials are carried out to improve the workability by incorporating super plasticizer into the mix. The results show that as the percentage of glass powder increases workability decreased. The decrease in workability in glass powder may be due to balling. The workability of different mixes is shown in Table 6.1 and Fig. 6.1.

Table 6.1 Workability of Concrete Mixes

Mix	G10	G20	G30
Slump(mm)	620	590	490
T50 cm(sec)	7	20	40
L-box	0.9	0.8	0.4

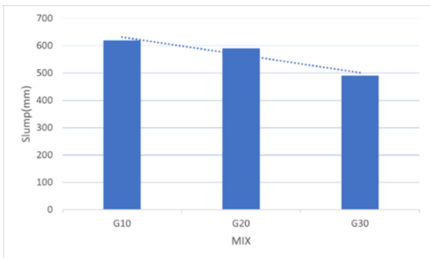

Fig 6.1 Variation in Slump of Concrete Mixes

4.3 PROPERTIES OF HARDENED CONCRETE

4.3.1 Compressive Strength and Split Tensile Strength

The average 28 day compressive strength and split tensile strength for different concrete mix subjected to temperature variation is shown in Table 6.2 and Table 6.3.

Table 6.2 Variation of Compressive Strength of Concrete Specimens with temperature

Mix	Compressive Strength (N/mm^2)	Reduction in strength (%)			
	Laboratory Temperature	150ºC	300ºC	150ºC	300ºC
G10	35.36	29.32	27.10	17.08	23.35
G20	31.85	18.96	14.36	40.47	54.91
G30	29.77	18.96	17.92	36.31	39.80

Table 6.3 Variation of Split Tensile Strength of Concrete Specimens with Temperature

Mix	Split Tensile Strength (N/mm^2)	Reduction in strength (%)			
	Laboratory Temperature	150ºC	300ºC	150ºC	300ºC
G10	35.36	2.97	2.68	6.01	15.18
G20	31.85	2.83	2.40	1.98	15.19
G30	2.54	2.19	1.55	13.77	38.97

Increase in temperature leads to reduction in the compressive strength. This is due to the reason that the increasing temperature leads to an increase in volume of concrete due to crack intitation, and defect on the bonding between all components of concrete, causing a reduction in the compressive strength. Fig 6.5 shows the image of specimen subjected to elevated temperature.

Fig. 6.4 Specimen after Heating

After high temperature exposure, the tendency of split tensile strength is similar to the result of compressive strength. When the concrete is heated to 150ºC, the free water within the concrete starts to evaporate resulting in an increase in porosity and consequently a decrease in the compressive strength of concrete. When the temperature exceeds 150ºC, the water begins to vaporize, usually causing a buildup of pressure within the concrete.

5. CONCLUSIONS

1. As the percentage of GP increases, workability decreases. This can be improved by increasing water/cement ratio or by the use of some kind of water reducing admixtures.
2. A gradual increase of loss in weight is observed for GP specimens with increases of percentage of glass powder.
3. Recycled coarse aggregate and glass powder can produce self compacting concrete with flyash additions.
4. Strength of recycled concrete decreases due to many reasons such as improper bonding of

aggregate with cement paste and higher water absorption of recycled coarse aggregate.

5. The increase in the temperature leads to reduction in the compressive strength.
6. The experimental result showed that the compressive and split tensile strength of RCA concrete with increasing percentage of GP had a downward trend and could efficiently maintain the strength of concrete after high temperature exposure.

ACKNOWLEDGEMENT

I wish to thank the Management, Principal and Head of Civil Engineering Department of Universal Engineering College, Thrissur, affiliated by Kerala Technological University for their support. This paper is based on the work carried out by me (Parvathy Sanjeev), as part of my PG course, under the guidance of Chithira Krishnakumar (Assistant professor, Civil Department, Universal Engineering *College, Thrissur, Kerala). I express my gratitude towards* her for valuable guidance.

REFERENCES

1. Ana Mafalda Matos, Telma Ramos, Sandra Nunes, c Joana Sousa-Coutinhoa, (2016), "Durability Enhancement Of SCC With Waste Glass Powder", Vol. 19, Part 1, Pp: 67 – 74.
2. Mohammed Abed etal.(2020), "Performance of Self-Compacting High-Performance Concrete Produced with Waste Materials after Exposure to Elevated Temperature "Volume 32, Part 1, Pp: 899-1561.
3. Mixing recycled concrete aggregates – Windshield waste glass aggregates", Volume 209 ,Pp:364-376
4. Herry Suryadi Djayaprabha etal. (2020), "Improving the Mechanical and Durability Performance of No-Cement Self-Compacting Concrete by Fly Ash", Part 1, Pp: 899-1561
5. A. Pineaud etal. (2016)" Mechanical properties of high performance self-compacting concretes at room and high temperature"ELSEVIER, Materials Today ,Vol 112 Pp:747-755.
6. Nourredine Arabi etal.(2019)," Valorization of recycled materials in development of self-compacting concrete: