

Strength Properties of Concrete with Aggregates from Alternate Sources



Dineshababu S, Rahima Shabeen. S

Abstract: Aggregates used in concrete are fast depleting natural resource and the quarrying of which is causing environmental issues. Hence, the use of aggregate from alternate sources such as from waste discarded glass, from foundry sand discarded after metal casting process and sea shells is investigated. Compressive strength of concrete with glass powder, foundry sand and sea shell is studied individually. Concrete is cast with glass powder and foundry sand as 5%, 10%, 15% and 20% replacement of fine aggregate and with sea shell as 5%, 10%, 15% and 20% replacement of coarse aggregate individually. It is observed that compressive strength of concrete decreases with glass powder, foundry sand, and sea shell. Fine aggregate replaced by 10% glass powder, 10% foundry sand and coarse aggregate replaced by 10% sea shell have the least decrease in strength when compared to control concrete mix.

Keyword: Concrete, compressive strength, glass powder, foundry sand, sea shell.

I. INTRODUCTION

Concrete is the most widely used construction material and is made of cement, aggregates and water. Traditionally, the aggregates used are river sand for fine aggregate and gravel for coarse aggregate. River sand is quarried from river beds and gravel is quarried from large rock masses. Quarrying leads to environmental issues such as of sand from river bed leads to land subsidence, loss of biodiversity and increases vulnerability to flooding. Also, the source of these natural resources is limited. Hence, there is a pertinent need to find alternate material to be used in place of river sand and gravel in concrete. In this paper, the use of materials such as waste glass, untreated foundry sand and sea shell as fine aggregate is explored. Glass powder is obtained from discarded waste glass pieces and crushed into powder. Finely powdered glass could be used as cement because of its pozzolonic character whereas coarsely ground glass could be used as aggregate. Foundry sand is used metal casting industries and is discarded after a number of castings.

The objective of the paper is to determine the compressive strength of concrete with waste glass, untreated foundry sand and sea shell individually as aggregate.

Previous research work by other researchers on glass powder, foundry sand and sea shell is reported. Gurdeep et al (2012)

determine the compressive strength, water absorption and porosity of concrete with fine aggregate partially replaced by waste foundry sand. The authors observed that there is a decrease in compressive strength, water absorption and porosity of the concrete with foundry sand. Whyuni et al (2014) studied the properties of concrete with sea shell ash, rice husk ash and bamboo fiber. Islam et al (2017) studied the properties of concrete and mortar with waste glass particles as replacement for cement. The authors observed a general increase in strength at levels of replacements even without addition of admixtures. Afif et al (2017) observed that the workability of concrete decreases with increase in glass powder. Thiruvengitram et al (2018) observed that durability properties of concrete with used foundry sand were similar to that of control mix. Also, the strength of concrete decreased due to addition of used foundry sand. Gustavo et al (2019) observed that the electrical resistivity of concrete with foundry sand depends on the characteristics of waste foundry sand. Further, the authors observed that the compressive strength of concrete with foundry sand is lesser. Gurumoorthy and Arunachalam (2019) observed that concrete with treated used foundry sand exhibited a better performance than control mix in terms of water absorption, sorptivity and rapid chloride permeability.

II. EXPERIMENTAL STUDY

Foundry sand, glass powder, seashell, ordinary Portland cement of grade 43, river sand and gravel were used for the experimental study.

A. Cement

Ordinary Portland cement of grade 43 was obtained from retail supplier. The physical properties were tested in the laboratory. The properties of cement are shown in Table I.

Table- I: Physical properties of cement

S. No.	Physical Properties	Requirements as per IS codes	Test results
1	Consistency	26-33%	29 %
2	Specific Gravity	3.12 – 3.19	3.15
3	Initial setting time	30 min (min.)	40 mins
	Final setting time	10 h (max)	190 mins

B. River Sand

River sand available locally was used for the study. The physical properties of river sand were found according to IS2386 (Part I). The properties of river sand are shown in Table II.

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Strength Properties of Concrete with Aggregates from Alternate Sources

Table- II: Physical properties of river sand

S. No.	Physical Properties	Requirements as per IS codes	Test results
1	Specific gravity	2.6-2.8	2.62
2	Fineness modulus	2.3-3.1	2.48
3	Compact density	-	1738 kg/m ³
	Loose density	-	1557 kg/m ³

C. Glass Powder

Glass powder required was obtained from Pondicherry, India. The glass powder was obtained was of different size. Fig. 1 shows the glass powder obtained. Physical properties of glass powder were found in the laboratory and are shown in Table III.



Fig. 1 Graded glass powder

Table- III: Physical properties of glass powder

S. No.	Physical Properties	Requirements as per IS codes	Test results
1	Specific gravity	2.6-2.8	2.62
2	Fineness modulus	2.3-3.1	2.42

D. Untreated Foundry Sand

The used foundry sand required for the study was obtained from an industry in Ambattur, Chennai, India. The used foundry sand was not treated further to remove the oil and other additives added during foundry process. The untreated used foundry sand was tested in the laboratory for its physical properties and are shown in Table IV.



Fig. 2 Untreated foundry sand

Table- IV: Physical properties of foundry sand

S. No.	Physical Properties	Requirements as per IS codes	Test results
1	Specific gravity	2.6-2.8	2.55
2	Fineness modulus	2.3-3.1	2.14

E. Gravel

Natural gravel available locally was used as coarse aggregate. The physical properties of gravel are given in Table V.

Table- V: Physical properties of gravel

S. No.	Physical Properties	Requirements as per IS codes	Test results
1	Specific gravity	2.6-2.8	2.72
2	Fineness modulus	<40%	13%

F. Sea Shell

The sea shells obtained from the sea shore were not further treated and used as such in the concrete. The specific gravity and impact value were found from tests in the laboratory and are shown in Table VI

Table- VI: Physical properties of sea shell

S. No.	Physical Properties	Requirements as per IS codes	Test results
1	Specific gravity	2.6-2.8	2.77
2	Fineness modulus	<40%	17%

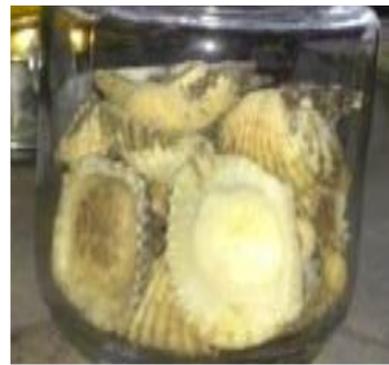


Fig. 3 Sea shells

G. Mix Proportion

The mix proportion for M35 grade of concrete was determined according to IS 10262- 2009.

The percentage replacement of river sand by glass powder was kept as 5%, 10%, 15% and 20%. The percentage replacement of river sand by foundry sand was 5%, 10%, 15%, 20%. The percentage replacement of gravel by sea shell was 5%, 10%, 15%, 20%. The details of the mix proportion are given in Table VII, Table VIII, Table IX and Table X.

Table- VII: Concrete mix proportion for concrete mix

Mix	Cement	River sand	Gravel
CC	450 kg/m ³	687.2 kg/m ³	1106.48 kg/m ³

H. Test on Fresh Concrete

The workability of concrete in fresh state was measured by slump cone test.

Table- VIII: Concrete mix proportion of concrete with glass powder

Mix	Cement (kg/m ³)	River sand (kg/m ³)	Glass Powder (kg/m ³)	Gravel (kg/m ³)
GP5	450	652.84	34.36	1106.48
GP10	450	618.48	68.72	1106.48
GP15	450	584.12	103.08	1106.48
GP20	450	549.76	137.44	1106.48

Table- IX: Concrete mix proportion of concrete with untreated foundry sand

Mix	Cement (kg/m ³)	River sand (kg/m ³)	Foundry sand (kg/m ³)	Gravel (kg/m ³)
GP5	450	652.84	34.36	1106.48
GP10	450	618.48	68.72	1106.48
GP15	450	584.12	103.08	1106.48
GP20	450	549.76	137.44	1106.48

Table- X: Concrete mix proportion of concrete with sea shell

Mix	Cement (kg/m ³)	River sand (kg/m ³)	Gravel (kg/m ³)	Sea shell (kg/m ³)
GP5	450	687.2	1051.156	55.324
GP10	450	687.2	995.832	110.648
GP15	450	687.2	940.508	165.972
GP20	450	687.2	885.184	221.296

I. Compressive Strength Test

Compressive strength of concrete was conducted on a cube of size 150 mm x 150 mm x 150 mm. The cubes were cast as per mix proportion and the compressive strength was tested after a curing period of 28 days.

III. RESULTS AND DISCUSSION

A. Compression Test

The compression test results of concrete with partial replacement by glass powder and foundry sand is shown in Fig.4. The strength of concrete with 20% replacement of river sand by glass powder decreases the strength by 48%, the compressive strength value decreases from 37.5 MPa to 19.42 MPa. The strength of concrete at replacement levels of glass powder 5% to 15% is between about 27MPa to 30MPa. Though as a whole, the compressive strength of concrete decreases with replacement of river sand by glass powder. This may be attributed to the smooth surface of the glass particles and the resulting decreased bond strength. However, a 5% to 15% replacement level of river sand by glass powder can be feasible and application of such concrete in non-load bearing applications can be explored. The other studies are not within the scope of this paper. The strength of concrete with 5% replacement of river sand by untreated foundry sand decreases the strength by 24%, the compressive strength value decreases from 37.5 MPa to 28.4 MPa. The strength of concrete at replacement levels of glass powder 5% to 20% is between about 28MPa to 30MPa. The

compressive strength of concrete decreases when river sand is replaced partially by foundry sand. However, there is not much variation in strength when replacement level is increased from 5% to 20%. Hence, further levels of replacement of foundry sand can be explored.

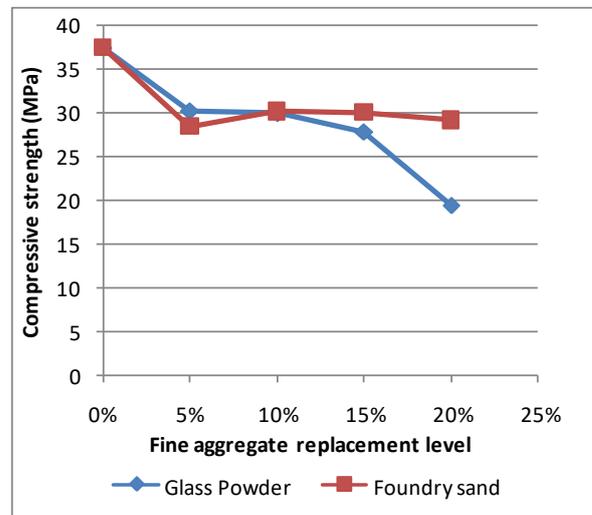


Fig. 4 Compressive strength of concrete

Fig. 5 shows the comparison of compressive strengths between concrete made with glass powder and concrete made with foundry sand. It is observed that concrete with foundry sand has higher compressive strength than concrete with glass powder at replacement levels 10% to 20%. At 20% replacement level, the strength of concrete with foundry sand is greater than concrete with glass powder by 33%.

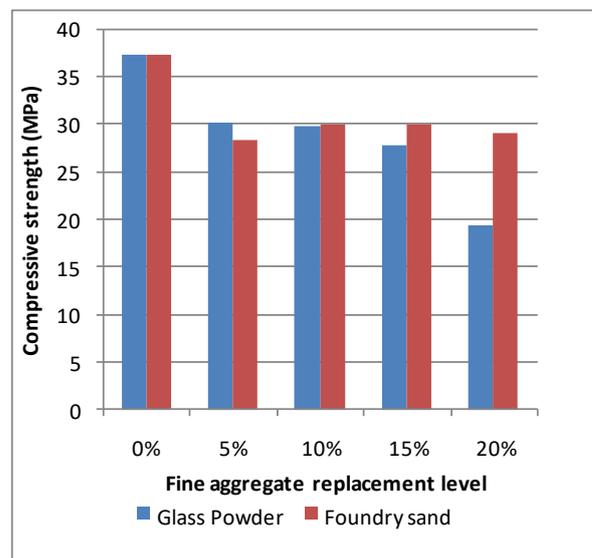


Fig. 5 Comparison of compressive strength of concrete with glass powder and foundry sand

Fig. 6 shows the compressive strength of concrete partially replaced with sea shell. It is observed that the strength of concrete with sea shell all replacement levels is lesser than that of concrete without sea shell. The strength of concrete decreases by 33% when gravel is replaced 20% by sea shell.

Strength Properties of Concrete with Aggregates from Alternate Sources

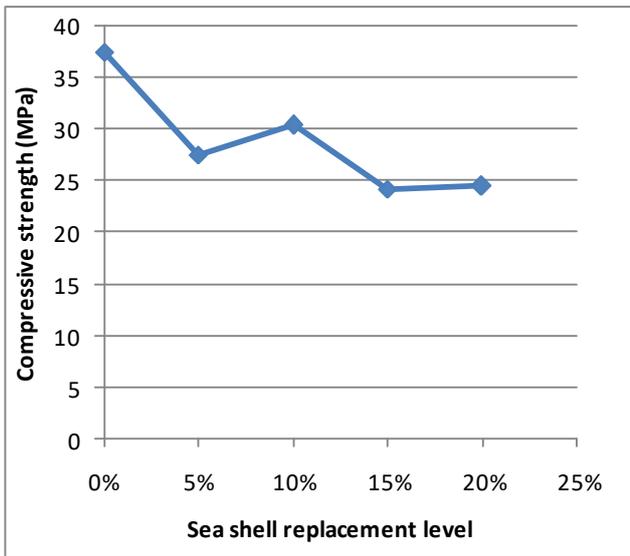


Fig. 6 Compressive strength of concrete with sea shell

B. Slump Cone Test

The slump cone test results are shown in Fig. 7. It is observed that the slump of concrete with glass powder increases with the increase in replacement level. This may be attributed to the smooth surface of glass and the lesser friction. There is a negative correlation between slump value and percentage of replacement of foundry sand.

The slump of concrete with sea shell decreases with increase in replacement percentage. The curved surface of shells is observed to hinder workability of concrete.

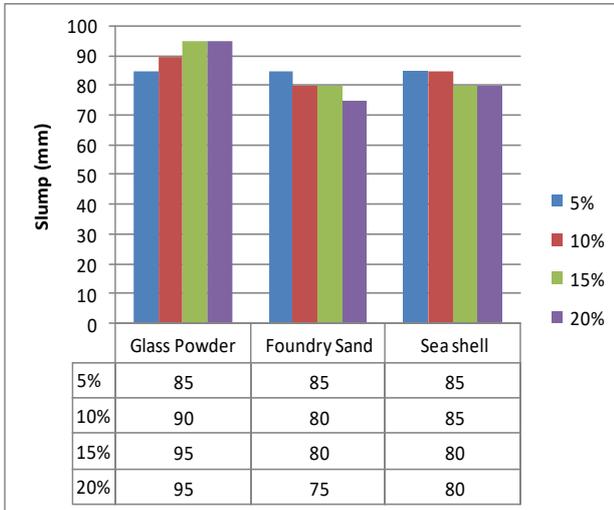


Fig. 7 Slump test values for concrete

IV. CONCLUSION

Concrete with varying replacement levels of glass powder, foundry sand and sea shell were tested under compression. Based on the limited test results, the following conclusions are made.

1. There is negative correlation between compressive strength and replacement percentage of glass powder whereas there is a positive correlation between workability and replacement percentage of glass fiber
2. Presence of foundry sand decreases the compressive strength of concrete and also decreases workability.
3. Sea shell as partial replacement to coarse aggregate

decreases the compressive strength.

4. All the alternative source of aggregate considered in the study result in decrease in compressive strength. Hence, future studies could focus on investigating the other properties like durability, insulation ability, thermal conductivity and energy absorption to bring out the advantages of these alternate sources of aggregates.

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REFERENCES

1. Gurdeep Kaur, Rafat Siddique, Anita Rajor, "Properties of concrete containing fungal treated waste foundry sand", *Construction and Building Materials*, 2012, Vol. 29, pp. 82-87.
2. Wahyuni A. S, Fepy Supriani, Elhusna, Agustín Gunawan, "The Performance of Concrete with Rice Husk Ash, Sea Shell Ash and Bamboo Fibre Addition", *Procedia Engineering*, 2014, Vol.95, pp. 473-478.
3. Islam G.M. Sadiqul, M. H. Rahman, Nayem Kazi, "Waste glass powder as partial replacement of cement for sustainable concrete practice" *International Journal of Sustainable Built Environment*, 2017, Vol. 6(1), pp. 37-44
4. Afif Rahma, Nabil El Naber, Sherzad Issa Ismail, Sanjay Kumar Shukla, "Effect of glass powder on the compression strength and the workability of concrete" *Journal Cogent Engineering*, 2017, Vol. 4, pp. 1-12.
5. Thiruvengadam Manoharan, Dhamothiran Lakshmanan, Kaliyannan Mylsamy, Pandian Sivakumar, Anirbid Sircar, "Engineering properties of concrete with partial utilization of used foundry sand", *Waste Management*, 2018, Vol. 71, pp. 454-460.
6. Gustavo J. L. Coppioa, Maryangela Geimbade Lima, Julia W. Lencioni, Luciana S. Cividanes, Paulo P. O. L. Dyer, Silvelene A. Silvad, "Surface electrical resistivity and compressive strength of concrete with the use of waste foundry sand as aggregate", *Construction and Building Materials*, 2019, Vol. 212, pp. 514-521.
7. Gurumoorthy N, Arunachalam K, "Durability Studies on Concrete Containing Treated Used Foundry Sand", *Construction and Building Materials*, 2019, Vol. 201, pp. 651-661.

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