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Comparative Study on Partial Replacement of Fine Aggregate by Glass Powder and Foundry Sand

K.Lineesh1, D.Sivakumar2, S.Janaki Sundaram3
1,2,3Department of Civil Engineering
Vel Tech High Tech Dr.Rangarajan and Dr.Sakunthala Engineering College, Chennai, Tamil Nadu, INDIA

***Abstract*—The recycled materials can be used effectively in architectural and civil engineering fields. They can stand close to the concept of green concrete which is in compatible with the environment. Foundry sand from casting industries is a waste material which is dumped extensively and in shops, damaged glass sheets & sheet glass cuttings are go to waste, which are not recycled at present and usually delivered to landfills for disposal. Using Glass powder and waste foundry sand in concrete is an interesting possibility for economy on waste disposal sites and conservation of environment. The constant depletion of sand beds at all major sources of availability is a major concern and thus efforts are taken in order to replace sand in construction activities. In this study, effect of foundry sand and glass powder as fine aggregate replacement on the compressive strength, flexural strength and split tensile strength of concrete with a mix proportion of 1: 1.28: 2.56: 0.45 was compared and investigated at different limited curing periods (7 days and 28 days).The percentage of foundry sand and glass powder used for replacement were (10%, 20%, and 30%) by weight of fine aggregate. Test showed impressive results, showing capability of glass powder for being a component in concrete is very much appreciable than the foundry sand because GP giving higher strength results. Making concrete from waste materials saves energy and conserves resources which lead to a safe sustainable environment.**

***Index Terms*—Fine aggregate, Glass powder, Foundary sand.**

I. INTRODUCTION

Concrete is a widely used material in the world. Based on global usage it is placed at second position after water. River sand is one of the constituents used in the production of conventional concrete has become highly expensive and also scare. In the backdrop of such a bleak atmosphere, there is a large demand for alternative materials from industrial waste. Some alternative materials have already been used as a part of natural sand. For example fly ash, slag, red mud, ponded ashes were used in concrete mixtures as a partial replacement of natural sand [6].

Similarly the waste glass are collected from the shops are used. The collected glasses are crushed to sand size and it could be used an alternate material for natural sand as partial replacement [2]. Foundry sand is high quality silica sand with uniform physical characteristics which is a by-product of ferrous and non-ferrous metal casting industries, where sand has been used as a moulding material because of its thermal conductivity. It can be used as a replacement material for natural sand due to its high silica content [7]. In brief, successful utilization of glass and foundry sandas fine aggregate will turn the waste material into a valuable resource.

T R Naik and Reni Mullukattil Lukose by their research work give the necessary suggestions for use of foundry sand and GP as a aggregate replacement through the Journal of Geotechnical and Geo-environmental Engineering and Journal of Research in Modern Engineering and Emerging Technology [15].

However detailed quantitative data on the various beneficial applications of foundry sand and glass powder have not been well documented in the past.

Fig. 1 Foundry sand

Fig. 2 Glass powder

Objectives

- To evaluate the utility of glass powder and foundry sand as a partial replacement of cement in concrete.
- The main parameters studied are compressive strength, split tensile strength and flexural strength, and their results are studied.
- To understand the effectiveness of glass powder and foundry sand in strength enhancement
- To compare the values obtained in GP and foundry sand as a fine aggregate replacement and results are plotted.

II. MATERIALS AND METHODS

Strength is one among the most important properties of concrete, since the first consideration in structural design is that the structural members must be capable of carrying the imposed loads. The mix of concrete used in this study is M25. Concrete mix with 0% waste material is the control mix and water cement ratio adopted is 0.45 in accordance with the Indian Standards specification IS 10262 - 2009. A design mix proportions of 1: 1.28: 2.56: 0.45 was investigated for the research.

The percentages of replacements are 10%, 20%, and 30% by weight of fine aggregate. Tests were performed for compressive strength, flexural strength and split tensile strength of concrete for all replacement levels of fine aggregate at different curing period (7 days and 28 days). Besides, the physical and chemical properties of the foundry sand and GP are also studied.

A. Cement

Portland Pozzolona cement is used for all concrete mixes. The cement used is fresh and without any lumps.

B. Coarse Aggregate

Locally available coarse aggregates are used in the present work. Testing of coarse aggregate is done as per IS: 383 – 1970. The values obtained are tabulated in Table1.

TABLE 1 PROPERTIES OF COARSE AGGREGATE

Characteristic	Value
Maximum size	20 mm
Specific Gravity	2.61
Total Water Absorption	0.38%
Fineness Modulus	6

C. Fine Aggregate

The sand used for the experimental program is locally procured and conformed to grading zone II as per IS: 383-1970. The sand is first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm. Properties of the fine aggregate used in the experimental work are tabulated in Table 2.

TABLE 2 PROPERTIES FINE AGGREGATE

Characteristics	Value
Type	Medium
Specific Gravity	2.65
Bulk Density	1613 kg/m^3
Fineness Modulus	2.7

D. Foundry sand

The physical and chemical properties of foundry sand used in this project are listed in Table 3 and 4 respectively.

TABLE 3 PHYSICAL PROPERTIES OF FOUNDRY SAND

Characteristics	Values
Specific gravity	2.49
Bulk relative density	2592 Kg/m^3
Absorption	0.43%
Moisture content	0.1 - 9.8
Plastic texture	Non-plastic
Coefficient of permeability	10^{-3} -10^{-6}cm/s

TABLE 4 FOUNDRY SAND CHEMICAL OXIDE COMBINATIONS

Constituent	Value (%)
SiO_2	67.21
Al_2O_3	4.28
Fe_2O_3	7.32
CaO	0.15
MgO	0.23
SO_3	0.89
Na_2O	0.48
K_2O	0.46
P_2O_5	0.00
Mn_2O_3	0.12
SrO	0.19
TiO_2	0.48
Loss On Ignition	16.25
Total	98.06

E. Glass powder

The utilization of glass powder which can be called as manufactured sand has been accepted as a building material in the industrially advanced countries. As a result of sustained research and developmental works undertaken with respect to increasing application of this industrial waste, the level of utilization of glass powder in the industrialized nations has been reached more than 60% of its total production.

The use of manufactured sand in India has not been much popular, when compared to some advanced countries.

The physical and chemical properties of foundry sand used in this project are listed in Table 5 and 6 respectively.

TABLE 5 PHYSICAL PROPERTIES OF GLASS POWDER

Property	Glass powder
Specific gravity	2.4-2.8
Bulk density	2.53
Moisture content (%)	Nil
Fine particles less than 0.075mm (%)	12-15

TABLE 6 CHEMICAL PROPERTIES OF GLASS POWDER

Constituent	Glass powder (%)
Silica (SiO_2)	72.5
Alumina (Al_2O_3)	01.06
Iron Oxide (Fe_2O_3)	0.36
Lime (CaO)	08
Magnesia (MgO)	4.18
Sodium Oxide (Na_2O)	13.1
Potassium Oxide (K_2O)	0.26
Sulphur Trioxide (SO_3)	0.18

F. Water

Water having qualities of potable water was used in the experiment.

G. Moulds

Cubical moulds of size 150mm × 150mm × 150mm were used to prepare the specimens for determining the compressive strength of foundry sand concrete.
Care was taken during casting and vibrator was used for proper compaction. Cylindrical moulds of size 150 mm diameter, 300 mm height and beam moulds of size 500 mm × 100 mm × 100 mm were used to prepare the concrete specimens for the determination of split tensile strength and flexural strength of foundry sand concrete respectively. All the specimens were prepared in accordance with Indian Standard Specifications IS: 516 – 1959. All the moulds were cleaned and oiled properly. They were securely tightened to correct dimensions and prevent leakage of slurry.

III. Results and Discussions

In this thesis work M25 grade is being used. The concrete samples are caste with mix 1:1.28:2.56 as per design, with partial replacement of fine aggregate. The numbers of concrete samples caste are laid down as per IS code. The tests are carried out after 7 & 28 days of casting of concrete.

a) Compressive strength (cube specimen)
b) Tensile strength (cylinder specimen)
c) Flexural strength or Modulus of rupture (beam specimen)

Fig. 3 Casted cubes

Fig. 4 Casted cylinders

Fig. 5 Casted beams

A. Compressive Strength

The compressive strength for different replacement levels of foundry sand and GP contents (0%, 10%, 20%, and 30%) at the end of 28 days results are given in Table 6 and Table 7 respectively.

TABLE 6 COMPRESSIVE STRENGTH OF FOUNDRY SAND AT 28 DAYS

Foundry sand content (%)	Compressive strength at 28 days (N/mm^2)
0	27.89
10	29.52
20	31.45
30	32.16

TABLE 7 COMPRESSIVE STRENGTH OF POWDER AT 28 DAYS

Glass powder content (%)	Compressive strength at 28 days (N/mm^2)
0	27.89
10	32.85
20	30.33
30	31.15

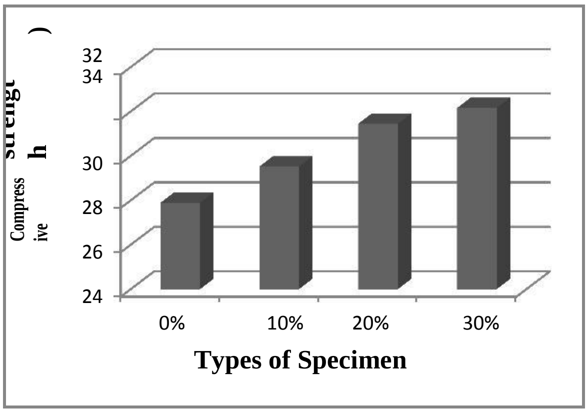

Fig. 6 Compressive strength of foundry sand

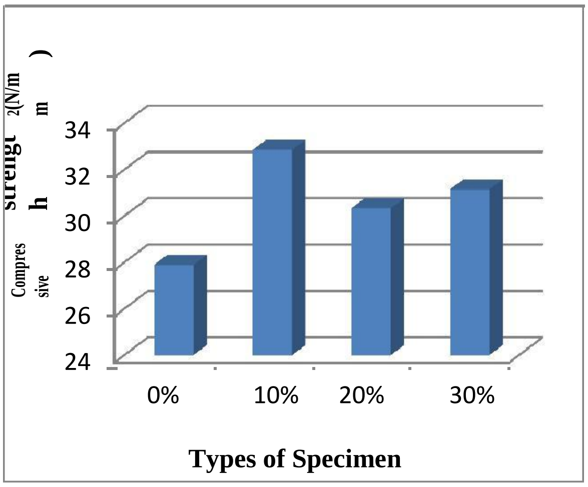

Fig. 7 Compressive strength of glass powder

The compressive strength of concrete increases with increase in the replacement level of both foundry sand and GP (0%, 10% and 30%). But when comparing the two compressive strength, fine aggregate replacement by GP of 10% shows the optimum compressive strength of 32.85 N/mm^2.

B. Split Tensile Strength

The split tensile strength for different replacement levels of foundry sand and GP contents (0%, 10%, 20%, and 30%) at the end of 28 days results are given in Table 8 and Table 9 respectively.

TABLE .8 SPLIT TENSILE STRENGTH OF FOUNDRY SAND AT 28 DAYS

Foundry Sand content (%)	Split Tensile Strength at 28 days(N/mm^2)
0	2.65
10	2.72
20	2.79
30	3.12

TABLE .9 SPLIT TENSILE STRENGTH OF GLASS POWDER AT 28 DAYS

Glass powder content (%)	Split Tensile Strength at 28 days(N/mm^2)
0	2.65
10	3.39
20	2.82
30	3.02

Fig. 8 CTM

Fig. 9 Split tensile testing machine

From the observation of results for 28 days it is evident that the split tensile strength showed an increasing value in the replacement level of both foundry sand and GP (0%, 10% and 30%). But when comparing the two Split tensile strength, fine aggregate replacement by GP of 10% shows the optimum strength of 3.39 N/mm^2.

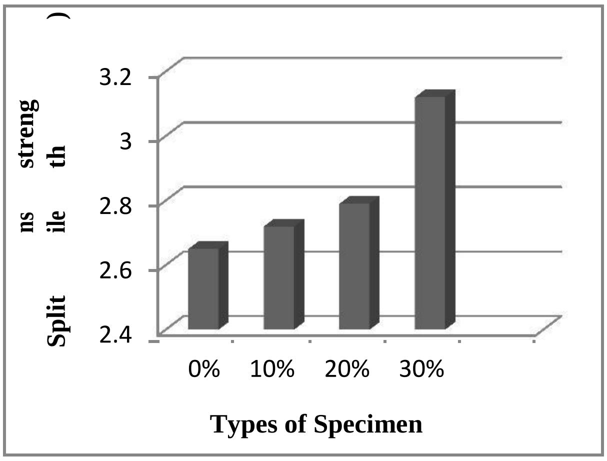

Fig. 10 Split tensile strength of Foundry sand

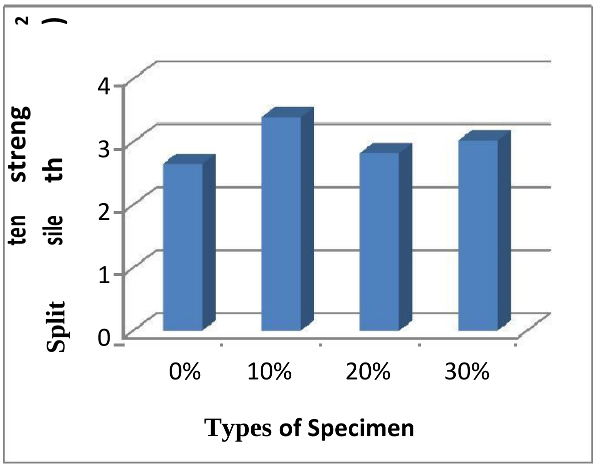

Fig. 11 Split tensile strength of Glass powder

C. Flexural Strength

The Flexural strength for different replacement levels of foundry sand and GP contents (0%, 10%, 20%, and 30%) at the end of 28 days results are given in Table 10 and Table 11 respectively.

TABLE 10 FLEXURAL STRENGTH OF FOUNDRY SAND AT 28 DAYS

Foundry Sand content (%)	Flexural Strength at 28 days (N/mm^2)
0	3.76
10	3.95
20	5.19
30	7.26

TABLE 11 FLEXURAL STRENGTH OF GLASS POWDER AT 28 DAYS

Glass powder content (%)	Flexural strength at 28 days (N/mm^2)
0	3.76
10	7.89
20	5.89
30	5.34

Fig. 12 Flexural strength tests in UTM

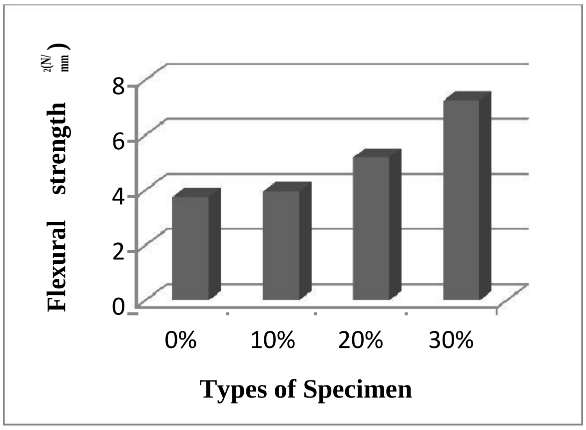

Fig: 13 Flexural strength of Foundry sand

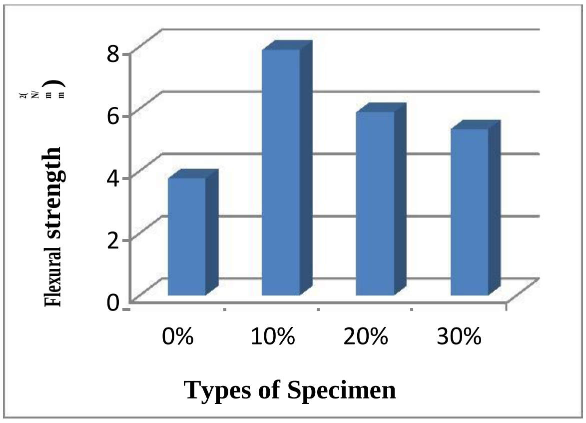

Fig: 14 Flexural strength of Foundry sand

The Flexural strength of concrete increases with increase in the replacement level of both foundry sand and GP (0%, 10% and 30%). But when comparing the two flexural strength, fine aggregate replacement by GP of 10% shows the optimum flexural strength of 7.89 N/mm^2.

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IV. CONCLUSION

The development of concrete with glass powder and waste foundry sand as fine aggregate has been successfully completed and the results were presented and analyzed in the previous chapters. Based on the test results of M25 concrete the following conclusions are drawn:

A. General conclusions

1) It is possible to replace glass powder and foundry sand by scarce sand for concrete.

2) The glass powder concrete is less workable, strong and durable compared to sand concrete.

B. Specific conclusions

1) Compressive strength, split tensile strength and flexural strength of concrete specimens increased, with increase in fine aggregate replacement by foundry sand and glass powder.

2) The increase of 11 % in the 28 days cube compressive strength of glass powder concrete when compared to foundry sand concrete.

3) Increase cylinder tensile strength there is an increase of about 9% in 28 days of glass powder concrete when compared to foundry sand concrete.

4) There is an increase of 10 % in the 28 day flexural strength of glass powder concrete when compared to foundry sand concrete.

5) From the observation it is known that the strength of the concrete replaced by foundry sand shows a gradual increase, whereas the concrete replaced by GP attains the optimum value at the 10% replacement after that it shows a decline values.

6) It can be concluded that fine aggregate replacement by 10% of glass powder is appreciable rather than the foundry sand replacement.

7) Making concrete using waste materials saves energy and conserve primary resources and it is concluded that the more material was reused, the fewer resources were consumed which leads to a safe, sustainable environment.

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