Experimental Investigation of Concrete When Sand Is Partially Replaced With Waste Glass And Foundry Waste For M30 Grade

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Abstract- *The mixture of cement, natural sand, coarse aggregate and water is called concrete. Fine aggregate is one of the most important components of concrete. The most commonly used fine aggregate is natural river sand.Due to the widespread use of concrete, the global consumption of natural river sand is high. Now, as time goes by, the need of the hour is to remove the burden of the rivers that illegally mine sand on a large scale. The sand mined from the river leads to dry river drying, reduces the habitat of species, and increases migration problems due to lack of water. This problem can be addressed using industry waste and partially replaced with sand to some extent. This can lighten the burden on the rivers, which are currently the main source of sand. In this study an attempt has been made to overcome problem of river sand to an extent by partially replacing it with foundry sand and waste glass.In this project,waste glass powder and foundry waste was used as partial replacement of sand in M30 grade concrete. concrete cubes are casted with 0%(conventional mix),10%,20%,30% and 40% replacement of sand by glass waste and foundry waste for testing of compressive strength and flexural strength. Cubes, cylinders and beams aretestedat7days,14 days and 28 days of curing period for compressive test, split tensile strength, flexural strength.the test results obtained for glass powder and foundry concrete mixers are compared with control mix0%.*

I. INTRODUCTION

Concrete is a commonly used composite building material. This is economical because the concrete components are easily available. Concrete plays an important role in the construction of buildings and other structures since it is used in vast quantities. The proportions of each material would have an impact on the hardened concrete's results. Due to various environmental issues and the need to save energy, a lot of research work has targeted the use of different waste materials. In the past few decades, people have put forward high-quality research work on the use of waste materials, such as: rubber tires in concrete, glass powder and marble powder can replace fine and coarse aggregates, resulting in low-cost production. Environmentally friendly concrete. This waste requires special treatment to replace the fine aggregate in concrete. The manufacturing process, service industries and municipal solid waste will generate a lot of waste. People's increased environmental awareness has greatly increased the concerns related to the disposal of generated waste. The recycling of waste from construction materials results in a major reduction in pollution. the quantities designated for disposal by landfill, which enhances the achievement of recycling rates determined by law, leads to a reduction in the use of non-renewable resources and results in positive results on the environment. In addition, in many places, traditional building materials may be expensive and insufficient to meet the growing worldwide need for housing development. Therefore, the use of waste as a substitute material can help make up for the above shortcomings. The waste should be mixed with inert fractions to produce building materials to improve function, not just to dilute the waste. As developing countries experience rising global demand due to economic expansion, raw materials for natural resources have become more expensive, and the motivation to explore and discover alternatives to by-products, low-cost, and environmentally-friendly uses has become more of a near-term goal than ever before. Recycling, as opposed to original manufacturing, entails processing materials used in new goods to avoid the waste of potentially valuable substances, minimise energy consumption, reduce air and water pollution, and reduce greenhouse gas emissions by reducing the need for traditional waste disposal. Various forms of waste and by-products Both of these wastes will have a distinct effect on cement-based materials' efficiency. The use of these materials in concrete not only saves money, but it also helps to solve disposal issues.

1.1 USE OF INDUSTRIAL WASTES AS FINE AGGREGATE REPLACEMENT

Sand is in high demand as a fine aggregate in concrete production around the world, and many developing countries have recently faced a scarcity of natural sand to meet the demands of infrastructure growth. Researchers and practitioners in the building industry have found several alternative solutions to the stress and demand of river sand. In recent years, a range of new materials in the field of concrete technology have been developed in response to the ongoing demand of construction industries to meet functional, strength, economic, and durability requirements. Many research on the use of industrial and agricultural wastes have been conducted, with fine aggregates being successfully substituted in some of them.

1.6 CONCEPT OF WASTE GLASS POWDER

Waste glass is one of the types of solid waste generated from various domestic, commercial and industrial sectors. Waste glasses are non- degradable wastes which have high potential of being reused and recycled. Waste glass includes containers for storing food items, bottles for storing soft drinks or hard drinks in industries, broken window panes of vehicles, sheet glass cuttings, glass cutting pieces from various building construction sites, waste glasses from various commercial sectors. In context of India, due to unavailability of proper technology, most of the waste glasses are not reused or recycled rather them are transported to sanitary landfills for disposal. Therefore, waste glass has become one of the challenges for pollution control due to its non-degradable nature.

MATERIALS USED IN THE PROJECT:

- Cement
- Aggregates
- Water
- Foundry sand
- Glass waste

3.4 DETERMINING THE PHYSICAL PROPERTIES OF MATERIALS:

3.4.1 Cement For general building, ordinary Portland cement is used. Calcareous materials, such as limestone or chalk, and argillaceous materials, such as shale or clay, are used in the production of Portland cement**.** Cement is made by grinding raw materials, combining them closely in specific proportions based on their purity and composition, and then firing them in a kiln at temperatures ranging from 13000 to 15000 degrees Celsius, where the material sinters and partially fuses to form nodular-shaped clinker. With the addition of about 2 to 3 percent gypsum, the clinker is cooled and ground to a fine powder. A "Portland cement" is the end result of the process. To determine the physical properties of the cement, the following tests are performed according to IS: 4031-1988. The test results are compared to the values listed in IS: 4031-1988.

3.4.1.1 Consistency

The Vicat plunger will penetrate to a point 5-7 mm from the bottom of the mould when the cement paste is of standard consistency; this test is used to determine the amount of water required to manufacture standard consistency cement paste.The percentage of water needed to manufacture cement paste of normal consistency is used to determine the setting time, compressive strength, and soundness. The consistency of cement is determined by its composition, and this test was carried out according to the procedure outlined in IS: 4031-1988. Table 1 shows the consistency value obtained.

3.4.1.2 Initial and final setting time

Lower the needle gently until it makes contact with the surface of the test block, then quickly release it. Allow the test block to complete. At first, the needle will pierce the test block completely. The needle can only penetrate to a depth of 33-35mm from the surface as the paste loses its plasticity overtime. The initial setting time is described as the time between when water is applied to the cement and when the need lepenetrates the test block to a depth of 33-35mm from the surface.

A circular extension may be used to replace the needle on the Vicat apparatus. When the centreneedle of the attachment makes an impact on the surface of the test block while the circular edge of the attachment fails to do so, the cement is considered to be finally set.In other words, the paste has hardened to the point that the centre needle can only pierce the paste for 0.5mm.

PROPERTITES	OPC 53
Fineness of cement	8%
Standard consistency	32%
Specific gravity	3.15
Initial setting time	40 minute
Final setting time	330 minute
Soundness	2mm

Table-3.3 compressive strengths of OPC 53 grade cement

S.No	OPC 53 in N/mm²		
	3 days	7days	28 days
1	29.5	38.8	54.2
2	28.5	37.2	53.8
3	29	37.5	53
average	29	37,83	53.667

3.4.2 Aggregates

Aggregates are a crucial component of concrete. They offer concrete body, minimise shrinkage, and save money. Aggregates make up 70-80% of the amount of concrete. Aggregates can be made naturally or synthetically. Aggregates are divided into two types based on their size: fine aggregate and coarse aggregate.

Fine aggregate (sand)

The fine aggregate is less than 4.75mm in height. Natural or synthetic fine aggregates are available. The grade must be consistent throughout the project. It's crucial to keep an eye on the moisture content and absorption characteristics. Natural sand from the Godavari River, conforming to grading zone-II of table 3 of IS: 10262-2009, was used as the fine aggregate. The results of various fine aggregate tests are presented.

Natural sand or, subject to approval, other inert materials with similar characteristics, or combinations of hard, solid, and durable particles, shall make up the fine aggregate. Urbanization, zoning laws, the costs, and environmental concerns are all limiting concrete use. Fine aggregate is gathered from the surrounding area.

The following tests have been conducted on fine aggregates.

- Specific Gravity
- Bulk density
- Sieve analysis (fineness modulus)

Specific gravity is known as the mass of a substance divided by the mass of the same volume of water at a given temperature. The experiment was carried out in accordance with IS: 2386-1963, and the results were tabulated.

Sieve analysis (fineness modulus): Sieve analysis is the method of splitting a sample of aggregates into fractions of the same particle size in order to determine fineness. The sieve analysis was done with locally available river sand and the results were tabulated.

Bulk density is known as the mass of the substance divided by the volume of the container. The experiment has been completed, and the results have been tabulated.

Result:

Fineness modulus of fine aggregate = (∑cumulative % weight retained)/100 = 222.9/100 = 2.2

The given sand belongs to **ZONE-III and Coarse Sand**

Specific gravity:

Pycnometers are used to calculate the exact gravity of fine aggregate.

The empirical formula for determining the specific gravity of fine aggregate

Specific gravity $= \frac{W2-W1}{(W4-W1)-(W3-W2)} = 2.52$

Bulk density:

For the given sample, the bulk density of the fine aggregate is 1.690kgs/Litre.

S. No	Property	Value
1	Specific gravity	2.447
2	Fineness modulus	3.057
3	Bulk density: Loose Compacted	 18.2kN/m^3 19kN/m^3

Physical properties of foundry sand

MIX DESIGN FOR M30:

3.5 MIX DESIGN

The process of selecting suitable concrete materials and determining their relative amounts with the aim of producing a concrete with the required strength, durability, and workability as economically as possible is known as concrete mix design. Concrete's necessary output in two states, namely, plastic and hardened states, governs the proportioning of ingredients in concrete. It is impossible to properly position and lightweight plastic concrete if it is not workable. As a result, the property of workability becomes critical.

The compressive strength of hardened concrete, which is commonly regarded as an indicator of its other properties, is determined by a variety of factors, including the w/c ratio, cement quality and quantity, water, aggregate, batching, placement, compaction, and curing. Material, factory, and labour costs all go into the price of concrete. The difference in material costs is due to the fact that cement is many times more expensive than aggregates, so the aim is to manufacture as lean a mix as possible.

The cost of concrete is proportional to the cost of materials used to achieve a minimum mean strength, known as characteristic strength, as determined by the structure's designer. This is dependent on the quality control mechanisms in place, but there is no denying that quality control increases the cost of concrete. The labour cost is determined by the mix's workability.

3.5.1 Requirements of concrete mix design

The following are the criteria for selecting and proportioning mix ingredients:

a) From structural considerations, the minimum compressive strength required
b) The necessary workability for complete compaction with the available compacting equipment.
c) Maximum water-to-cementratio to ensure sufficient longevity under the site conditions.
d) Maximum cement content to prevent shrinkage cracking in mass concrete due to temperature cycling

Factors to be considered for mix design

- The classification of the grade (the characteristic strength requirement of concrete).
- The rate at which concrete's compressive strength develops is influenced by the form of cement used.
- Under the limits prescribed by IS: 456-2000, the maximum nominal size of aggregates to be used in concrete can be as high as possible.
- The cement content must be kept as low as possible to avoid shrinkage, cracking, and creep.
- The scale, shape, quantity, and spacing of reinforcement, as well as the transportation, positioning, and compaction technique used, all affect the workability of concrete for adequate placement and compaction.

3.5.2 Design of M30 grade concrete
Stipulations for proportioning

a) Grade designation : M30
b) cement type : OPC 53grade confirming IS: 1226
c) Maximum Cement content : 320 kg/m^3
d) Maximum nominal size of aggregate : 20 mm
e) Maximum water – cement ratio : 0.45
f) Workability : 100 mm (slump)
g) Exposure condition: Severe (for reinforced concrete)
h) Method of concrete placing: Pumping
i) Degree of supervision : Good
j) Type of aggregate : Crushed angular aggregate

Test data for materials
a) Cement used : OPC 53 grade confirming IS: 12269
b) Specific gravity of cement : 3.10
c) Mineral admixture:foundry sand
d) Specific gravity of
1) Coarse aggregate : 2.7
2) Fine aggregate : 2.6
e) Water absorption
1) Coarse aggregate : 0.5%
2) Fine aggregate : 1.0%

f) Free (Surface) moisture

1) Coarse aggregate :NIL

2) Fine aggregate : NIL

g) Sieve analysis

Fine aggregate : Confirming to grading Zone II of Table 4 of IS: 383

Target strength for mix proportioning

$f'_{ck} = f_{ck} + 1.65x\ S$

= 30+1.65x5 =30+1.65x(5) = 38.25 N/mm^2

Where f' ck represents the goal average compressive intensity after 28 days.

f' ck = 28-day compressive strength characteristic

s stands for standard deviation.

Table 1 shows that the standard deviation(s) is 5 N/mm2.

30+1.65x (5) = 38.25 N/mm2 is the target power.

Selection of water-cement ratio

From Table 5 of IS 456, maximum water cement ratio= 0.45

Based on experience, adopt w/c=0.43

0.43< 0.45 hence O.K

Selection of water content

Maximum water = 186 litres (for 25 to 50 mm Slump range) for 20mm aggregate (from Table 2).

For a 100mm slump, the estimated water content is 186 + 6/100186 = 197 litres.

Calculation of cement content

The water-to-cement ratio is 0.45.

Content of cement = (197)/0.45 = 437.77kg/m3

Cement content is calculated using Table 5 of IS 456 as a minimum.

320 kg/m3 for ‘severe' exposure condition

437.77 kg/m³ > 320 kg/m³, hence, O.K

Proportion of volume of coarse aggregate and fine aggregate content

From IS: 10262-2009 Table 3 Volume of coarse aggregate (equivalent to 20mm aggregate) and fine aggregate (equivalent to 20mm aggregate) (Zone II)

When the water-to-cement ratio is 0.50, the result is 0.60.

Coarse aggregate volume for water-cement ratio of 0.45 = 0.55

Volume of fine aggregate = 1-0.55

= 0.451

[1] Mix calculations

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1 m^3

b) Volume of cement = $\frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$

$= \frac{437.77}{3.10} \times \frac{1}{1000} = 0.141 m^3$

c) Volume of water $= \frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1000}$

$= \frac{197}{1} \times \frac{1}{1000}$

$= 0.197\ m^3$

d) Volume of all in aggregate =(a – b + c)

= (1-0.141+0.197)

=0.662 m^3

e)Mass of coarse aggregate = d x volume of CA x Specific gravityCoarse aggregate x 1000

= 0.662 x0.55 x2.7 x 1000

= 983.07 kg

f) Mass of fine aggregate = f x volume of fine aggregate x SpecificGravity of FA x 1000

= 0.662x0.45x2.6x1000= 774.5kg

Mix proportions for trailCement=437.7kg/ m³

Water = 197liters

Fine aggregate= 774.54kg/ m³

Coarse aggregate = 983.07kg/ m³

Water Cement ratio = 0.45

Mix per 1Cum C: FA: CA= 1:1.77:2.24

IV. TESTS ON CONCTRETE

4.1 Fresh Concrete:

The test conducted on fresh concrete is workability of the concrete.

Workability: Workability is defined as the ability of the fresh concrete to fill the mold under proper vibration without reducing the quality. Properties which influence workability are water content, aggregate, cement type, age of concrete and admixtures. Workability increases with increase in water content i.e. more water content results in bleeding and segregation of concrete mix which in turn results in the strength reduction. Chemical admixtures also increase the workability. Concrete mix from undeniable graded aggregate results in harsh mix having low slump which in turn results in low workability.

Slump cone

Compacting factor

Vee- bee test

In this project to determine the workability the slump cone test is conducted. By having the result we can conclude the slump is true slump, shear slump moderate slump.The slump values for different mix proportions are given in the table

Table – 4.1slump values

Mix designations	Slump (mm)
M0	50
MF10	60
MF20	65
MF30	60
MF40	75
MF50	60
MG10	40
MG20	50
MG30	45
MG40	50
MG50	40

Fig 4.1: slump cone

4.2 HARDENED CONCRETE:

The tests performed on the cured concrete are compressive strength, flexural strength, split tensile strength.

Preparation of specimen:

Before placing the concrete in the mould is its interior surface and base plate were lightly oiled to prevent the unevenness of the specimen. The mixed concrete is placed in the oiled mold in layers, each layer of having 5cm thick. Each layer is pampered 30 times with a slandered tampered rod after it is put. The strokes pierced the underlying layer, ridding the bottom layer in its depth.

Curing of test specimen:

As soon as the concreting is completed, the mould is stored in a place free from vibration, for 24 hours. Later the specimen is unmolded and submerged in a fresh water tank for curing.

4.2.1 Compressive strength:

The sample cubes are tested for compressive strength using a compressive measuring system after 28 days of curing. After at least 4 to 5 hours of processing, the test samples are removed from the curing tank. At least three specimens must be checked for each trail.

Fig 4.2 Testing of cubes for compressive strength

The cube is placed under the compressive testing machine in a way that the load should be applied opposite faces of the other than the casted faces. The load is applied on the cube continuously at the rate of 140 kg/cm^2/min. the load is applied till the load break down and no more load can be taken i.e. the red needle returns back. The ultimate load is noted. The compressive strength is determined by dividing the ultimate strength by cube cross sectional area. Similarly the remaining two specimens are also tested. The average of the three specimens of one particular batch of mix gives the compressive strength. The variation of the strength of individual strength should not exceed more than 15%. If exceeded repeat the test.

4.2.2TEST FOR SPLIT TENSILE STRNGTH:

On a split tensile measuring unit, the specimens are tested for tensile strength for 28 days. Specimens should be made for testing for each selected age, ideally from separate batches, and specimens should be extracted from water before 4 to 5 hours of testing.

Fig 4.3: testing of specimens for split tensile strength

Where as in cylinders they are placed under the compressing testing machine in a way that the load is applied along the length of the cylinder. Continuous load at the rate of 140 kg/cm^2/min is applied till the maximum resisting load is attained, i.e. the red needle returns back. The ultimate load is noted. Split tensile strength of the specimen is calculated by diving the two times of the load during the test by dividing the two times the load was applied during the test by the surface area, which was determined using the section's mean measurements. For one particular batch the average of the specimen are to be done. The average of the three specimens of one particular batch of mix gives the compressive strength. The variation of the strength of individual strength should not exceed more than 15%. If exceeded repeat the test.

4.2.3TEST FOR FLEXURAL STRENGTH:

The universal measuring machine is used to determine the concrete's flexural strength. Cleaning the bearing surface of the machine's supporting and loading rollers is recommended. The prism should be mounted under the rollers so that the load is applied to the casted mould's uppermost surface. The prism should be marked at a distance of 13.3cm between each point.

The loading should be applied at a constant rate of 180kg/cm2/mm in a shock-free manner. The load is steadily applied until the specimen fails. It's important to keep track of the failure load. It is important to remember whether the failure occurred in the first or second third. The flexural strength is determined by the portion where the failure occurred.

Fig 4.5: Testing of specimens for flexural strength

V. RESULTS AND DISCUSSIONS

COMPRESSIVE STRENGTH:

The compressive strength values from 7 days, 14 days, and 28 days at different replacement stages, i.e. 0% to 50% replacement of foundry waste and glass waste in fine aggregate, are shown in this graph.

The different mixes are casted using the M 30 mix proportions, and the mix details are shown in the table.

Table – 5.1 Mix proportions for 1 m^3

Mix designations	Cement content	F.A content	C.A content	Foundry waste	Glass waste	Water
M0	437.77	774.54	983.07	0	0	197
MF10	437.77	697.05	983.07	77.45	0	197
MF20	437.77	619.24	983.07	154.91	0	197
MF30	437.77	542.18	983.07	232.36	0	197
MF40	437.77	464.72	983.07	309.82	0	197
MF50	437.77	387.27	983.07	387.27	0	197
MG10	437.77	697.05	983.07	0	77.45	197
MG20	437.77	619.24	983.07	0	154.91	197
MG30	437.77	542.18	983.07	0	232.36	197
MG40	437.77	464.72	983.07	0	309.82	197
MG50	437.77	387.27	983.07	0	387.27	197

Note : M0 is the conventional concrete, MF10 is the 10% of Fine aggregate Replacement with Foundry waste, MF20 is the 20% replacement of Fine aggregate with Foundry waste, MF30 is the 30% of Fine aggregate Replacement with Foundry waste, MF40 is the 40% replacement of Fine aggregate with Foundry waste, MF50 is the 50% of Fine aggregate Replacement with Foundry waste, MG10 is the 10% replacement of Fine aggregate with Glass waste, MG20 is the 20% replacement of Fine aggregate with Glass waste, MG30 is the 30% replacement of Fine aggregate with Glass waste, MG40 is the 40% replacement of Fine aggregate with Glass waste, MG50 is the 50% replacement of Fine aggregate with Glass waste.

Table -5.2 compressive strength Results

MIX DESINATION	Compressive strength N/mm^2		
	7 days	14 days	28 days
M0	15.33	22.5	31.56
MF10	18.2	21.2	28.32
MF20	20.4	19.93	27.68
MF30	23.55	21.13	28.56
MF40	18.22	22.90	32.8
MF50	14.85	19.16	24.56
MG10	14.41	18.89	24.53
MG20	16.34	20.64	26.46
MG30	18.57	22.02	27.87
MG40	20.63	22.52	33.12
MG50	19.32	21.68	28.53

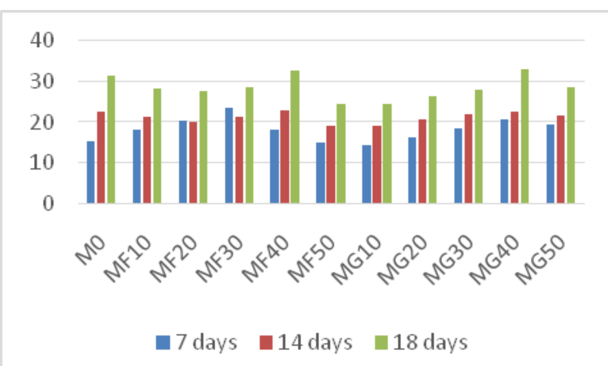

Fig: Compressive strength of conventional concrete verses various proportions of foundry waste and glass waste Mix for 7 days,14 days and 28 days

In figure, shows that the compressive strength of mix MF40 (40% replacement of foundry waste) is 3.92% higher than control mix. Similarly The compressive strength of mix MG40 (40% replacement of glass waste) is 4.94% higher than control mix.

Table -5.3 Split tensile strength results

Mix designation	Split strength N/mm^2		
	7 days	14 days	28 days
M0	2.4	3.12	4.1
MF10	1.415	1.95	2.48
MF20	2.83	2.5	3.20
MF30	2.89	2.51	3.48
MF40	2.92	3.07	4.3
MF50	2.65	2.19	3.04
MG10	2.41	2.43	3.16
MG20	2.62	2.71	3.57
MG30	2.58	3.02	3.83
MG40	2.50	3.00	4.18
MG50	2.32	2.78	3.76

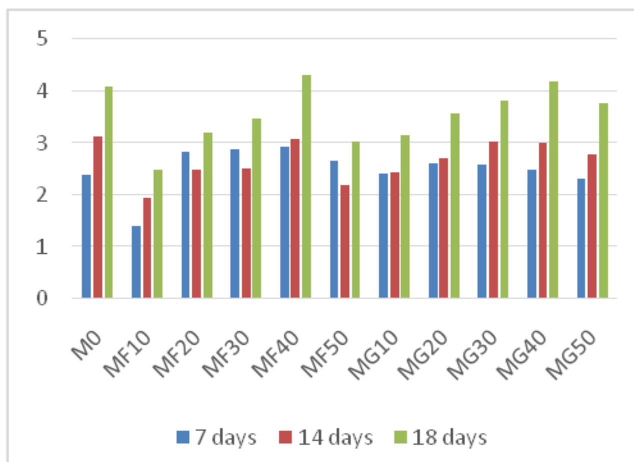

Fig: 5.2 Split tensile strength of conventional concrete verses various proportions of foundry waste and glass waste Mix for 7days 14 days and 28 days

In figure, 5.2 The Split tensile strength of MG40 (40% replacement of glass waste) is 4.87% higher than control mix. Similarly, mix MF40 (40% replacement of foundry waste) is 1.95% higher than control mix.

Table -5.4 Flexural strength results

Mix designation	Flexural strength N/mm²		
	7 days	14 days	28 days
M0	3.98	3.73	4.9
MF10	3.26	3.02	3.87
MF20	3.41	3.13	4.06
MF30	3.57	3.26	4.59
MF40	4.01	3.76	5.3
MF50	3.67	3.21	4.32
MG10	4.91	4.54	6.13
MG20	5.23	5.01	6.35
MG30	5.34	5.19	6.51
MG40	5.54	5.14	6.68
MG50	4.69	4.64	5.87

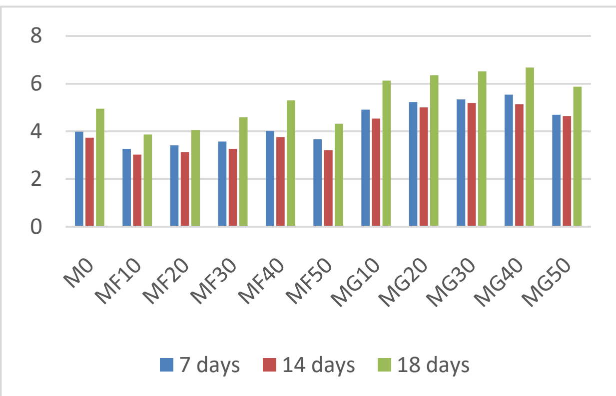

Fig: 5.3 Flexural strength of conventional concrete verses various proportions of foundry waste and glass waste Mix for 7days 14 days and 28 days

In figure, 5.3 Flexural strength of MG40 (40% replacement of glass waste) is 7.07% higher than control mix. Similarly, mix MF40 (40% replacement of foundry waste) is 34.94% higher than control mix. The mixes containing glass waste give higher flexural strength than control mix and foundry waste mixes.

VI. CONCLUSIONS

When we use Foundry Waste sand, glass Waste powder as partial Replacement of sand, Following Conclusions were obtained.

1. The maximum compressive strength, flexural strength and split tensile strength is obtained at 40% replacement of glass waste by comparing with other mixes of glass waste.
2. The maximum compressive strength, flexural strength and split tensile strength is obtained at 40% replacement of Foundry waste by comparing with other mixes of foundry waste.
3. Maximum Compessive Strength obtained at MF40 is 32.8 N/mm^2 and at MG40 is 33.12 N/mm^2 which is greater than control mix.
4. Maximum Split Tensile Strength obtained at MF40 is 4.3 N/mm^2 and at MG40 is 4.18 N/mm^2 which is greater than control mix.
5. Maximum Flexural Strength obtained at MF40 is 5.3 N/mm^2 and at MG40 is 6.68 N/mm^2 which is greater than control mix.
6. the compressive strength of mix MF40 (40% replacement of foundry waste) is 3.92% higher than control mix. Similarly The compressive strength of mix MG40 (40% replacement of glass waste) is 4.94% higher than control mix.
7. The Split tensile strength of MG40 (40% replacement of glass waste) is 4.87% higher than control mix. Similarly, mix MF40 (40% replacement of foundry waste) is 1.95% higher than control mix.
8. Flexural strength of MG40 (40% replacement of glass waste) is 7.07% higher than control mix. Similarly, mix MF40 (40% replacement of foundry waste) is 34.94% higher than control mix.
9. When we compare foundry waste replacement of sand with glass waste replacement of sand, glass waste replacement of sand gives better results.

VII. SCOPE OF FUTURE WORK

The grade of concrete used in our experimental study is M30, may be this foundry sand can also be used as replacing material for fine aggregate in high strength concrete works.

- For light weight and self compacting concrete works foundry sand may also used as replacing material for fine aggregate.
- Not only compressive strength test various tests like split tensile strength, flexural strength, modulus of elasticity etc., may also be conducted.
- Not only mechanical properties durability tests also conducted.

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