Experimental Study on Partial Replacement of Cement with Bentonite Powder and Fine Aggregate with Glass Powder Along with Scrap Steel in Concrete

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Abstract. This paper aims to deal with the current and future trends of research on the use of manufactured cement in Portland cement concrete. Headways in innovation improve human solaces as well as harm the climate. Hence an attempt has been made in the present investigation to study the influence of additional waste materials like Scrap Steel waste from a workshop at a dosage of 1.5% to 2% of the total weight of concrete as fibers. Replacements of natural cement with 5% 10%, 15% of Bentonite, and fine aggregate of 5% 10%, 15%, with a waste glass powder in the same mix of concrete grade. An experimental investigation was done using an M40 mix and tests were carried out as per recommended procedures by relevant codes. M40 grade of concrete was prepared at 0.4 water cement ratio considering weight batching. The experimental results showed that the workability of the concrete increased with the increase in percent replacement of cement and fine aggregate by Bentonite and glass powder. Similarly the compressive strength of the concrete got increases when the cement is partially replaced with bentonite powder up to 10% and gradually decreases by increasing the percentage of bentonite to 15%. Maximum Compressive strength and Flexural strength is achieved at 10% replacement of bentonite and 15% replacement of glass powder and Split Tensile strength with 2% of Scrap Steel waste in concrete.

Keywords: Bentonite, Glass powder, Steel Scrap, fine aggregate, coarse aggregate, compressive strength, split tensile strength, flexural strength.

1. Introduction

The construction industry has taken impressive steps forward over the last few decades concerning preliminaries in the utilization of some cementitious materials by and large distinguished as pozzolans, for the compounding of different concrete-based items. This poor person just came about a further developing the compressive strength esteem accomplished subsequently yet in addition in characteristics like the capacity to set and solidify submerged. Among these coal fly-debris, impact heater slag, rice frame debris, silica rage, and metakaolin are the most widely recognized ones. Other like gypsum, gypsum fines, Portland concrete, concrete furnace dust, lime dust, stone residue, and calcined earth are additionally being used, because of monetary and natural worries, various strategies for making concrete items are being thought of industry [1]. One technique to accomplish the objective of lessening carbon dioxide emanations and ozone-harming substances is to plan concretes utilizing a lower piece of calcinated material, consequently decreasing carbon dioxide discharges per unit of item. Another methodology is that of including a lower level of concrete as well as gypsum than it is normal with standard concrete or gypsum to guarantee an expanded compressive strength or potentially flexural strength is yet achieved consequently. This one is sturdy, and appropriate for a wide range of utilizations, likewise helping the climate. Furthermore, a need exists for further developed concrete and gypsum items that license the utilization of more affordable totals to lessen the expense of the concrete item [2].

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Concrete is the most broadly utilized man-made development material and its interest is expanding step by step. The utilization of stream sand as fine total prompts double-dealing of regular assets, bringing down of water table sinking of scaffold docks, and disintegration of waterway bed. On the off chance that fine aggregate is supplanted by squandering glass at an unambiguous rate and in an unambiguous size range, it will diminish fine total substance and consequently decrease the evil impacts of stream digging and in this manner make the concrete manufacturing industry supportable. How much waste glass is delivered has continuously

expanded over the new years because of a consistently developing utilization of glass items. Most waste glass has been and is being unloaded into landfill destinations [3].

Figure 1: Bentonite Clay

Figure 2: Crushed Glass

The landfilling of waste glass is unwanted because waste glass is non-biodegradable which makes them naturally less well disposed of. The use of this waste is the need of great importance. There is immense potential for involving waste glass in the substantial development area. At the point when waste glasses are reused in making substantial items, the creation cost of substantial will go down. This move will fill two needs; first, it will be climate amicable; second, it will use squander instead of valuable and moderately costlier regular assets. Ordinarily, glass doesn't hurt the climate in any capacity since it doesn't radiate poisons, however, it can hurt people as well as creatures, on the off chance that not managed cautiously and it is less climate cordial since it is non-biodegradable Glasses and its powder have been utilized as a development material to diminish ecological issues. Glass material items offer more noteworthy strength and better warm protection because of its better warm properties of the glass total. At the point when waste glasses are reused in making substantial items, the creation cost of substantial will go down. Involving squashed glass material for the substitution of normal sand can be legitimate both as healing for garbage removal and diminishing ecological corruption [4].

The fundamental component restricting the substitution of waste glass in concrete is Alkali-Silica Reaction (ASR). The silica in the glass responds with the soluble bases in the concrete and structures a gel-like

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construction (ASR gel). This gel can assimilate water and swell inside the microstructure of the substantial. This expansion causes inner burdens. At the point when these inner anxieties surpass the strength furthest reaches of concrete, then, at that point, extreme breaking and harm can happen. A decrease in the size of glass totals saw no antacid silica response. The vulnerability of glass to soluble bases suggests that coarse glass or glass strands could go through ASR in concrete, perhaps with harmful impacts. Be that as it may, the fine ground glass is a compelling ASR suppressant, forestalling ASR harm to the substantial [5].

2. Literature Review

We have alluded to the information from the worldwide diary of imaginative examination in science, design, and innovation. Following are the writing surveys over Partial substitution of Bentonite and squashed squander glass powder in concrete.

S.Targan's (2012) result showed that the setting season of concretes was by and large sped up when bentonite supplanted a piece of the concrete. Bentonite is a type of metakaolin earth (for example earth that has gone through a heat cycle to be in its powder structure) that comprises an essential mineral called montmorillonite which gives it its properties. Metakaolin mud appears to have the best generally speaking potential as an option pozzolanic material for concrete because of its accessibility in enormous quanta and the moderately modest cost.

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Al Akhras, N M (2016) has researched the impact of metakaolin (MK) substitution of concrete on the sturdiness of cement to sulfate assault and concentrated on the exploratory boundaries were water to fastener proportion (0.5 and 0.6). Mixed concretes containing a higher measure of normal pozzolans show brilliant capacity to decrease the soluble base silica extension and yield practically equivalent solidarity to Portland concrete at 91 years old days. Research has likewise been completed on the utilization of bentonite mud as a substitution for concrete.

Hassan et al. (2013) figured out the reactivity list of mortar 3D shapes containing Jehangira bentonite as a substitution for concrete. He reasoned that 40% substitution of bentonite in the mortar and 25 percent substitution in concrete yielded good outcomes when utilized accordingly (with practically no intensity therapy).

Badshah (2003) figured out the ideal substitution of Jehangir bentonite as pozzolana based on XRD diffraction examination and compressive strength results. He likewise concentrated on the sulfate opposition of cement using Jehangira bentonite. He reasoned that 20% of Bentonite substitution in substantial yields palatable outcomes however any further expansion decreases strength radically. Sulfate obstruction of substantial increments as the pozzolana substitution increments. At 20% of bentonite substitution, the most extreme protection from sulfate obstruction of mortar in a 2% sulfate arrangement is accomplished. The blend including 10% bentonite + 90% sand is the most prudent arrangement that fulfills the cutoff points values required for the mud center of earth fill dams and mud liners of strong waste stockpiling regions.

M.Vijaya Sekhar Reddy (2015) In this paper, the issues of natural and economic concern are tended to by the utilization of waste glass as halfway substitution offline totals in concrete. Fine totals were supplanted by squandering glass powder (GP) as 10%, 20%, and 30% by weight for the M20 blend. The substantial examples were tried for compressive strength at seven and 28 days old enough and the outcomes got were contrasted and those of ordinary cement. The review showed that waste glass can be utilized as a fine total substitution (up to 20%) without significant change in strength.

B.V. Kavyateja (2016) The review gives insights about exploratory assessment on the appropriateness of crushed glass as somewhat substituted for fine all out in strong age. The control mixing extent of 1: 1.5: 3 was assembled by volume with water - the bond extent of 0.5 was used. The compressive characteristics of relieved strong 3D states of sizes 150mm x 150mm x 150mm were evaluated at 3 days, 7 days, 28 days, 56 days, and 90 days. To get the experimental outcomes the functionality is expanded, compressive strength is expanded up to 20% substitution level and at 30%, 40% substitution level it goes to diminishing, and Splittensile strength is somewhat diminishing when contrasted with ordinary cement.

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Kumar Animesh (2017) Concrete is the combination of different materials coarse total, fine total, concrete, and water, every one of them is blended to different extents to accomplish explicit strength. Concrete being the main material assumes a significant part in the assembling of cement. Squander glass as fine total and coconut shell as coarse total can be utilized. The Proportion of the mineral and combination is applied in testing blocks for their functionality, pressure strength, and flexural strength. This paper momentarily examines the impacts of the expansion of glass powder and coconut shell on the properties of mortar substantial blend of M25 at 28 days four substantial blend in with fiber doses of 0%, 5%, 10%, and 20% of the weight substantial blend. The consequence of glass powder and coconut shell concrete for 7 days, 28days, restoring of cement. The testing of cement as per Indian standards is particular to distinguish the impact of functionality and mechanical strength properties because of portions of glass powder and coconut shell.

Kamal Ranout (2018) Figured out the compressive strength, flexural strength, and rigidity of cement by involving waste glass as a fine total and checking the interior design of cement by SEM test and XRD test. Squander glass is the better plan to use in concrete as fine total as India produces 22 million metric tons of waste glass each year and reuses just 45% of it. Fine total supplanted by glass with 3%, 6%, 9%, 12%, 15% in M40 blend. In this exploration likewise, Alccofine 1203 was used to give extra solidarity to concrete. Alccofine expansion to glass as added substance assists with further developing the strength properties of glass concrete because of its miniature size. Strength increments as substitution of 5%, 7%, to 9% because of the precise state of glass atoms.

3. Objective of Current Study

- To study the workability of concrete using cement with Bentonite and crushed waste glass powder as a partial replacement for fine aggregate.
- To study the compressive strength of concrete using cement with Bentonite and fine aggregate with waste glass powder as partial replacements of 5% 10% &15%.
- To study the Split Tensile strength of concrete using cement with Bentonite and fine aggregate with waste glass powder as a partial replacement 5% 10% &15% and Glass powder a dosage of 1.5% and 2%.
- To study the Flexural strength of concrete using cement with Bentonite and fine aggregate with waste glass powder as a partial replacement. 5% 10% & 15%.

4. Methodology

4.*1 Materials and Methods*

The following materials have been used in this investigation.

- Cement
- Fine Aggregate
- Coarse Aggregate
- Waste Glass Powder
- Bentonite

Concrete the Ordinary Portland concrete 53 Grade is utilized, Fine Aggregate Ordinary waterway sand is utilized as fine total. The sand is sieved in a 2.36mm sifter as the sand going through this strainer is used as a fine total. Coarse Aggregate The customary coarse total is sieved in a 20mm sifter and the total going through the 20mm strainer is utilized as coarse total. Squander Glass Powder The waste glass utilized in this task is squashed waste glass which is gathered from the piece. After gathering, every one of the undesirable materials, similar to names is eliminated. Then, at that point, it is washed and squashed into the required sizes.

The cement used is an Ordinary Portland Cement (OPC) of 53 grades. The tests were conducted on cement, Fine aggregate & Coarse Aggregate in Table 1;

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Table 1. Physical Properties of Cement & Aggregates

S.NO	PROPERTY	TEST RESULT
1	Normal consistency	32.5%
2	Fineness	<10%
3	Specific gravity	3.35
4	Initial setting time	35 min
5	Final setting time	300 min
6	Soundness	<10 mm
7	The specific gravity of fine aggregate	2.65
9	Water absorption of fine aggregate	1.0%
10	Water absorption of coarse aggregate	0.5%
11	Flakiness Index	8%
12	Elongation Index	23.44%

The Physical and Chemical Properties of Bentonite are given in the Tables 2 and 3.

Table 2. Physical Properties of Bentonite

S.NO	PROPERTY	TEST RESULT
1	Color	Light Yellowish
2	Nature	Pozzolanic Material
3	Size	Passed in 90 microns sieve
4	Free Swell	60% by volume

Table 3. Chemical properties of Bentonite [2]

S.No	Chemicals	Test Results
1	Al_2O_3	21.1
2	SiO_2	49.6
3	Fe_2O_3	3.2
4	TiO_2	0.4
5	Na_2O	0.4
6	Cao	0.6
7	MgO	3.5
8	K_2O	2.0

Table 4. Chemical properties of Waste Glass Powder

S.No	Components	Percentage (%)
1	Silica	70.5
2	Alumina	2.0
3	Iron Oxide	1.4
4	Magnesium Oxide	10.5
5	Sodium Oxide	14.2
6	Potassium Oxide	0.5

Mix Proportion of M-40 Grade Concrete with Workability- 100 mm

Table 5. Mix Proportion of M-40 Grade

	Mix	Cement	Fine Aggregate	Coarse Aggregate	W/C
Ratio	**M40**	1	1.81	2.59	0.34

5. Results and Discussion

The following tests were conducted on the concrete cubes, Cylinders & Prisms and are shown in Tabular representations of the results are also follows. Replacements of natural cement with 5% 10%, 15% of Bentonite, and fine aggregate of 5% 10%, 15%, with a waste glass powder in the same mix of concrete grade M-40. Additionally, waste materials Scrap steel waste from workshops at a dosage of 1.5% to 2% of the total weight of concrete as fibers are also added to improve its tensile strength.

5.1 Workability of Concrete

The slump test indicates the behavior of a compacted concrete cone under the action of gravitational forces. The workability is the ability of the concrete to flow free from mixing to the place where it is to be placed finally. The workability increases with the increase of the glass powder but with increase of the Crushed spent fire bricks the workability gets decreased.

Table 6 Slump Value for Fresh Concrete

S.No	Description	%	Slump Value (mm)
1	Conventional Concrete	0	40
2	Replacing cement with Bentonite Powder (B.P) & Fine Aggregate with Glass Powder (G.P)	5% (B.P) + 5% (G.P)	44
3		5% (B.P) + 10% (G.P)	51
4		5% (B.P) + 15% (G.P)	54
5		10% (B.P) + 5% (G.P)	59
6		10% (B.P) + 10% (G.P)	62
7		10% (B.P) + 15% (G.P)	64
8		15% (B.P) + 5% (G.P)	60
9		15% (B.P) + 10% (G.P)	58
10		15% (B.P) + 15% (G.P)	55

5.2 Compressive Strength

The compressive strength of blended concrete at the age of 7 days 14 days and 28 days are presented in Graph 1 Replacing cement with Bentonite Powder (B.P) & Fine Aggregate with Glass Powder (G.P)

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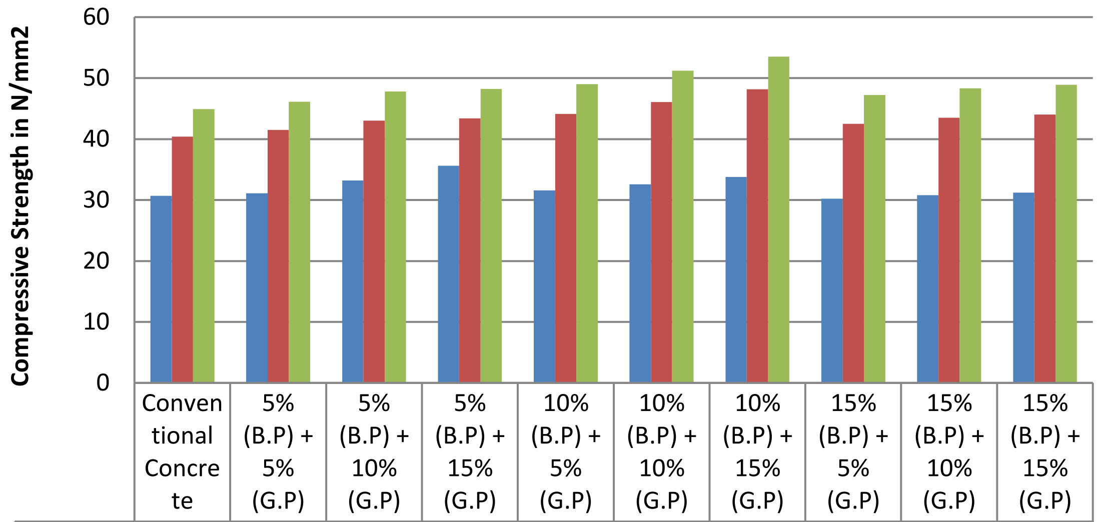


	Conventional Concrete	5% (B.P) + 5% (G.P)	5% (B.P) + 10% (G.P)	5% (B.P) + 15% (G.P)	10% (B.P) + 5% (G.P)	10% (B.P) + 10% (G.P)	10% (B.P) + 15% (G.P)	15% (B.P) + 5% (G.P)	15% (B.P) + 10% (G.P)	15% (B.P) + 15% (G.P)
7 days	30.7	31.1	33.2	35.6	31.6	32.6	33.8	30.2	30.8	31.2
14 days	40.41	41.49	43.02	43.38	44.1	46.08	48.15	42.48	43.47	44.01
28 days	44.9	46.1	47.8	48.2	49	51.2	53.5	47.2	48.3	48.9

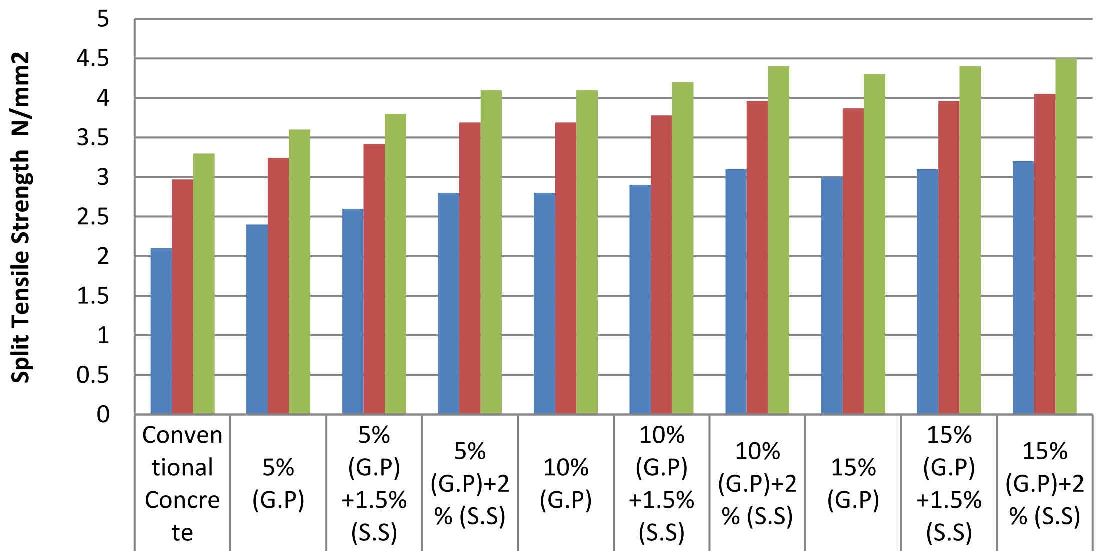
Graph 1: Compressive Strength of Blended Concrete

The Compressive strength is determined at 7, 14, and 28 days of casting. The variation of compressive strength at the age of 7th and 28th days with the optimum percentage of Replacing cement with Bentonite Powder (B.P) & Fine Aggregate with Glass Powder (G.P) were given in Graph 1 From the test results, it was observed that the maximum compressive strength was obtained for mix 10% (B.P) + 15% (G.P) is 53.5 N/mm^2 and it is observed that the compressive strength decreased from 53.5 N/mm^2 to 48.9 N/mm^2 with an increase in the percentage of Bentonite powder 15%.

5.3 Split Tensile Strength

5.3.1 5% of Bentonite Powder

Split Tensile Strength of concrete cylinders 150mm in diameter and 300mm long were tested as per the procedure explained in IS 5816. Replacing cement with 5% of Bentonite Powder along with adding 5%, 10% & 15% Glass Powder replacing fine aggregates, and adding Scrap Steel (S.S) waste of 1.5% & 2%



	Conventional Concrete	5% (G.P)	5% (G.P) +1.5% (S.S)	5% (G.P)+2% (S.S)	10% (G.P)	10% (G.P) +1.5% (S.S)	10% (G.P)+2% (S.S)	15% (G.P)	15% (G.P) +1.5% (S.S)	15% (G.P)+2% (S.S)
7 days	2.1	2.4	2.6	2.8	2.8	2.9	3.1	3	3.1	3.2
14 days	2.97	3.24	3.42	3.69	3.69	3.78	3.96	3.87	3.96	4.05
28 days	3.3	3.6	3.8	4.1	4.1	4.2	4.4	4.3	4.4	4.5

Graph 2: 5% of Bentonite Powder Split Tensile Strength

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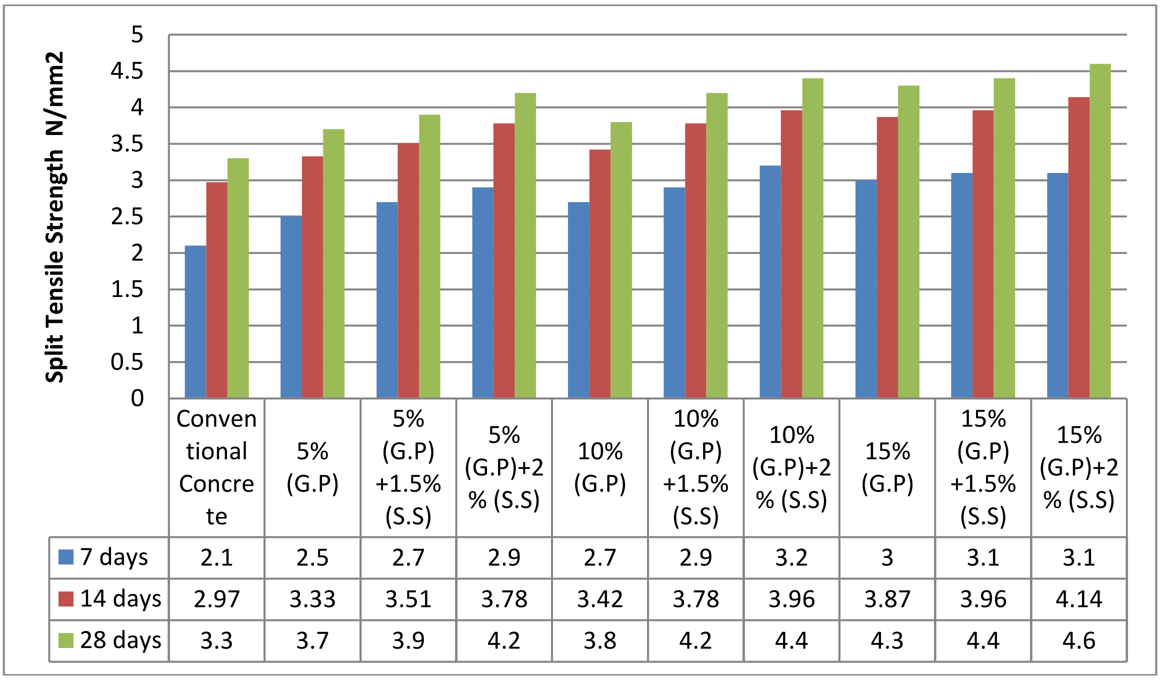
The values of split tensile strength of cylindrical specimens subjected to ambient curing conditions. The variation of split tensile strength at the age of 28th days with the optimum percentage of GGBS and metakaolin was given in Graph 2 It was observed that the maximum split tensile strength was obtained for a mix of 5% of Bentonite Powder with 15% (G.P) + 2% (S.S) is 4.5 N/mm^2.

5.3.2 10% of Bentonite Powder

Split Tensile Strength of concrete cylinders 150mm in diameter and 300mm long were tested as per the procedure explained in IS 5816. Replacing cement with 10% of Bentonite Powder along with adding 5%, 10% & 15% Glass Powder replacing fine aggregates, and adding Scrap Steel (S.S) waste of 1.5% & 2%

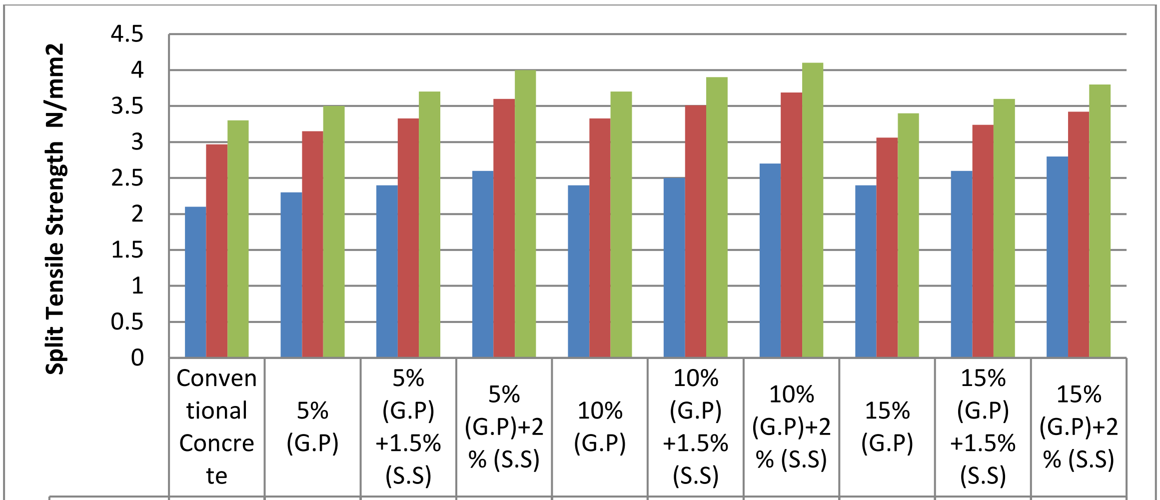


Graph 3: 10% of Bentonite Powder Split Tensile Strength

The values of split tensile strength of cylindrical specimens subjected to ambient curing conditions. The variation of split tensile strength at the age of 28th days with the optimum percentage of GGBS and metakaolin was given in Graph 3. It was observed that the maximum split tensile strength was obtained for a mix of 10% of Bentonite Powder with 15% (G.P) + 2% (S.S) is 4.6 N/mm^2.

5.3.3 15% of Bentonite Powder

Split Tensile Strength of concrete cylinders 150mm in diameter and 300mm long were tested as per the procedure explained in IS 5816. Replacing cement with 15% of Bentonite Powder along with adding 5%, 10% & 15% Glass Powder replacing fine aggregates, and adding Scrap Steel (S.S) waste of 1.5% & 2%



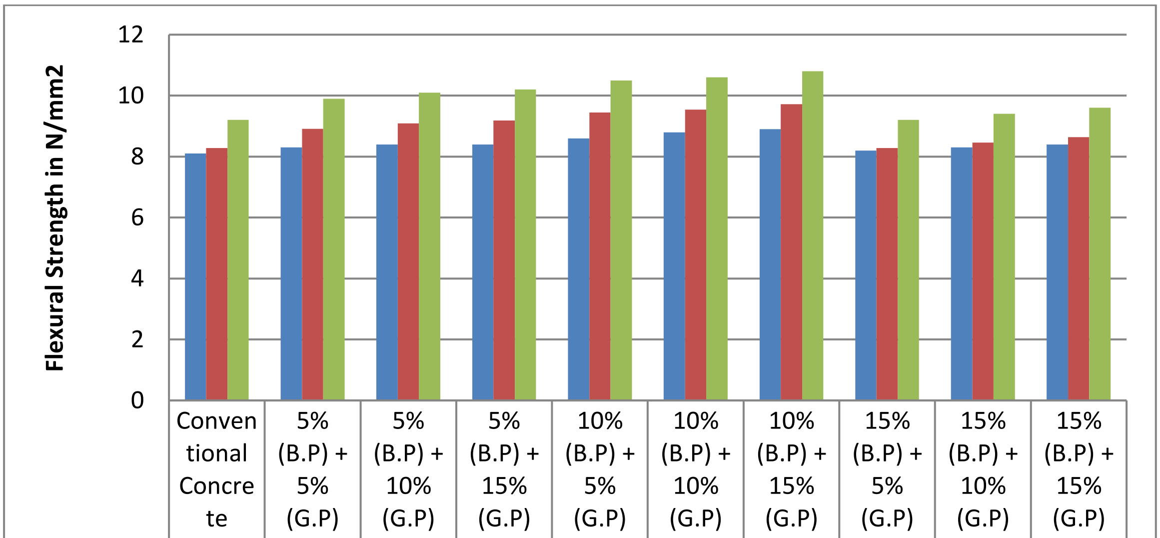
	Conventional Concrete	5% (G.P)	5% (G.P) +1.5% (S.S)	5% (G.P)+2% (S.S)	10% (G.P)	10% (G.P) +1.5% (S.S)	10% (G.P)+2% (S.S)	15% (G.P)	15% (G.P) +1.5% (S.S)	15% (G.P)+2% (S.S)
7 days	2.1	2.3	2.4	2.6	2.4	2.5	2.7	2.4	2.6	2.8
14 days	2.97	3.15	3.33	3.6	3.33	3.51	3.69	3.06	3.24	3.42
28 days	3.3	3.5	3.7	4	3.7	3.9	4.1	3.4	3.6	3.8

Graph 4: 15% of Bentonite Powder Split Tensile Strength

The values of split tensile strength of cylindrical specimens subjected to ambient curing conditions. The variation of split tensile strength at the age of 28th days with the optimum percentage of GGBS and metakaolin was given in Graph 4. It was observed that the maximum split tensile strength was obtained for a mix of 15% of Bentonite Powder with 10% (G.P) + 2% (S.S) is 4.1 N/mm^2. Later split tensile strength decreased from 4.1 N/mm^2 to 3.8 N/mm^2 with an increase in Glass Powder of 15%.

5.4 Flexural Strength

The Flexural strength of blended concrete at the age of 7 days 14 days and 28 days are presented in Graph 5 Replacing cement with Bentonite Powder (B.P) & Fine Aggregate with Glass Powder (G.P)



	Conventional Concrete	5% (B.P) + 5% (G.P)	5% (B.P) + 10% (G.P)	5% (B.P) + 15% (G.P)	10% (B.P) + 5% (G.P)	10% (B.P) + 10% (G.P)	10% (B.P) + 15% (G.P)	15% (B.P) + 5% (G.P)	15% (B.P) + 10% (G.P)	15% (B.P) + 15% (G.P)
7 days	8.1	8.3	8.4	8.4	8.6	8.8	8.9	8.2	8.3	8.4
14 days	8.28	8.91	9.09	9.18	9.45	9.54	9.72	8.28	8.46	8.64
28 days	9.2	9.9	10.1	10.2	10.5	10.6	10.8	9.2	9.4	9.6

Graph 5: Flexural Strength of Blended Concrete

The results of flexural strength of concrete at the age of 7, 14, and 28 days are presented in Graph 5. The variations in flexural strength at the age of 28 days with different percentages of Bentonite Powder (B.P) &

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Glass Powder (G.P) were plotted. From the test results, it was observed that the maximum flexural strength was obtained for a mix of 10% (B.P) + 15% (G.P) is 10.8 N/mm^2 and it is observed that the flexural strength decreased from 10.8 N/mm^2 to 9.6 N/mm^2 with an increase in the percentage of Bentonite powder 15%.

Conclusions:

The following are the conclusions made from my experimental studies for M-40 Grade Concrete, Replacing natural cement with 5% 10%, 15% of Bentonite, and fine aggregate of 5% 10%, 15%. Additionally scrap steel from a workshop at a dosage of 1.5% to 2% added to total volume of concrete

- The workability of concrete increases with replacement of cement with bentonite powder up to 10% and 15% of fines by glass powder.
- The compressive strength of the concrete got increases when the cement is partially replaced with bentonite powder up to 10% and gradually decreases by increasing the percentage of bentonite to 15%.
- The optimum percentage of replacement of cement by bentonite and fine aggregate with waste glass powder is found to be 10% (B.P) + 15% (G.P)
- Maximum Compressive strength of 53.5 N/mm2 is achieved at 10% replacement of bentonite and 15% replacement of glass powder in concrete.
- Maximum Flexural strength of 10.8 N/mm2 is achieved at 10% replacement of bentonite and 15% replacement of glass powder in concrete.
- Maximum Split Tensile strength of 4.6 N/mm2 is achieved at 10% replacement of bentonite and 15% replacement of glass powder with 2% of Scrap Steel waste in concrete.

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