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An Examination the Use of Waste Glass Powder as Cement Partial Replacement in Concrete

[1]*Anmol, [2]Er. Harish Sharma, [3]Er. Susheel Kumar, [4]Er. Madhu Bala, [5]Er. Jeevanjot Singh

[1]P.G Scholar, Department of Civil Engineering, S.B.B.S.U, Khiala, Jalandhar, India
[2,3,4,5]Assistant Professor, Department of Civil Engineering, S.B.B.S.U, Khiala, Jalandhar, India
*Correspondence Author's E-mail: anmolsaroya707@gmail.com

***Abstract* - In this research article, it is elucidated that the mixing of Waste Glass Powder (WGP) particles with concrete has an impact on its strength and shrinkage, which varies according to particle size. When using Waste Glass Powder (WGP) in concrete, more water is needed. The use of fine Waste Glass Powder (WGP) in the mixture can result in concrete that is equally or more robust compared to typical concrete. The diminishment of the Waste Glass Powder (WGP) is a result of its minuscule constituents. Cement was substituted with Waste Glass Powder (WGP) by the researchers during this study for the concrete mixture. The study tested if Waste Glass Powder (WGP) can make M30 concrete stronger. The strength was measured after 28 days using various percentages of WGP (0%, 15%, 20%, 25%, and 30%). They simplified their explanation by likening it to conventional concrete. We measured how much it could handle pressure and strain without breaking. Cement can be mixed with the leftover ash from burning.**

Keywords: Compressive strength Concrete, Split Tensile Strength, Durability, Waste Glass Powder (WGP), Workability.

I. INTRODUCTION

The process of making concrete for construction involves mixing cement, aggregates, water, and additives. Studies are being conducted by researchers across the globe to analyse the application of waste materials like fly ash, silica fume, rice husk ash, and rubber tires within concrete. Fillers can be used as another term for these waste materials. In everyday life, glass is commonly utilized but has a short lifespan and is often thrown away in landfills. Regardless of the nature of their output, a significant amount of waste is generated by most industries. Each year, worldwide recycling efforts manage to handle and repurpose only a fraction, roughly 5%, of waste materials. There is a decline in cement availability, resulting in higher expenses. The concrete industry has the opportunity to incorporate used glass as a suitable option. Glass is utilized in numerous daily activities, but its durability is limited, resulting in its disposal in landfills. Glass is not environmentally friendly to dispose of in landfills since it does not naturally break down. The utilization of waste glass in construction projects is a favourable choice compared to cement or other materials. The strength of cement is heightened when waste glass powder is employed in place of fine or coarse aggregates. For a significant period, individuals have utilized glass, which is a type of solid material lacking a distinct form. Solid waste was previously disposed of by people through dumping it in low-lying areas. Landfilling waste is an unsustainable approach that should be avoided for future considerations. Plastics, glass, tiles, as well as agricultural waste, all contribute to pollution in the environment.

The utilization of recycling waste is gaining significance in technological advancements towards a more sustainable world.

Utilizing glass again, a material frequently employed in structures and other applications, can prove to be a highly beneficial practice. Conserving energy is facilitated through the rephrasing of glass to produce fresh containers. Over the past few years, the amount of waste glass has been increasing gradually due to the growing use of glass. When used glass is recycled to make cement products, it will cost less to produce cement. Crushed glass, that is properly measured and prepared, can look like gravel or sand. Cement companies should consider using a combination of OPC (Ordinary Portland Cement) and fly ash as a standard to compare workability, cost, strength, etc. while setting goals for the production of PPC (Portland Pozzolana Cement). To maintain sustainability for growth, it is important to use PPC or a combination of OPC and fly ash. Researchers have been studying the characteristics of concrete made with fly ash instead of cement. It is widely known that fly ash has many benefits when it comes to protection against certain harmful reactions and it is also cost-effective.

Glass is an incredibly advantageous material that has numerous applications. Temperature can be increased during the tempering process to improve the strength of, regardless of its clarity or colour. Every industry inevitably produces waste, regardless of their specific activities. Disposing of this waste

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can pose a challenge in earlier times, individuals would bury solid waste in land areas that were at a lower elevation. In the grand scheme, this approach to waste disposal is not sustainable over time. The presence of industrial waste, such as ash and slag, is a pressing concern caused by factories. The environment is suffering from contamination due to plastic, glass, tile, and agriculture waste. Recycling waste is growing significant in order to achieve sustainability. Glass plays a role in various aspects of our daily activities, yet it is often disposed of in landfills instead of being reused. Landfills are environmentally unfriendly due to the fact that glass does not decompose. Consequently, using waste glass powder (WGP) instead of cement or fine/coarse aggregates is a favourable choice.

II. WASTE GLASS POWDER (WGP)

Waste Glass Powder (WGP) is collected from shops in Pondicherry and transformed into a fine powder. Waste Glass Powder (WGP) is a tough substance. Prior to the addition of powdered glass to the concrete, it is necessary to crush it into the suitable dimensions. The crushing of glass powder was carried out in these studies using a machine called a ball/pulverize for approximately 30 to 60 minutes. Through the process of rephrasing, the particles were reduced to a size smaller than 150 µm. The crushed glass was passed through a sieve equipped with 75 µm holes, resulting in its separation and refinement.

The process of heating a blend of silica, soda ash, and CaCO3 until it transforms into a liquid result in the creation of glass, which is transparent. It becomes rigid as it cools, without undergoing crystallization. When used glass is recycled to make cement products, it will cost less to produce cement. (Shown in fig1).

Figure 1: Waste Glass Powder

Properties of Waste Glass Powder

Building materials are made using glass waste, which is also known as cullet. It is generally used as a substance that shows no response with other materials. Practical knowledge has demonstrated that cement solutions can be affected by the interaction between smooth, fine glass powder and the resulting reaction. Everyone is aware that glass has an undefined structure and contains significant amounts of surplus energy. The glass that we have tested has about 14% of a substance called Na2O and another substance called K2O. In the glass, the metal ions are not strongly bonded together like the Si-O bonds in the Si-O-+Na or Si-O-+K fragments. In a water solution, the Na+ and K+ ions move easily from the glass into the solution. They combine with other substances in the solution to form sodium hydroxide and potassium hydroxide. This is a way that glass and water can interact with each other. Because the surface of glass grains is very big, similar to the surface of cement grains, the exchange of ions is very active. Titration tests reveal that the alkalinity of cement solution, when no glass additives are present, is approximately 6 millilitres of 0. 1 normal hydrochloric acid. When you mix glass powder with water, it becomes slightly alkaline. The level of alkalinity can range from 0. 15 for colourless glass to 0. 55 for green glass when tested with a certain chemical called 0. 1N.

Applications of Waste Glass Powder (WGP)

1) Rapid cooling of liquid material causes it to solidify into glass instead of forming crystals, due to insufficient time for crystallization to occur.
2) Glass that is predominantly composed of silica is the prevailing form and is extensively utilized in the construction of windows, containers, and decorative items.
3) Glass is a substance that does not have any impact on living organisms, showing no interaction with them.

III. OBJECTIVES

The utilization of waste glass powder in place of cement enhances the strength of the material, surpassing the use of it as a replacement for either fine or coarse aggregates. Humans have been utilizing glass, a type of solid material, for an extensive period of time. In the past, people would dump their garbage in low areas of land. Throwing away garbage in landfill sites is not a good idea for the future. Industrial waste materials such as fly ash, silica fume, blast furnace slag, and more. Plastics, glass, tiles, and agricultural waste are causing pollution in the environment. Recycling of waste is becoming an important part of technology to help with sustainability.

Objectives for Research

1) Decide the confinements on quality and utility brought on by the cement response for different Waste Glass Powder (WGP), and concentrations.

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2) Recognize the limitations on utility and quality caused by the cement response.
3) To assess the reasonability of utilizing common Waste Glass Powder (WGP) to increase the composition of concrete.

IV. MATERIAL AND METHODOLOGY

Cement

When water is added, cement becomes gooey like glue. Once it dries, it becomes hard and solid. Cement is a sticky material. Cement is a tough and sticky stuff that helps things to stick together fast. Water, big rocks, and small rocks were mixed together to make cement. In construction, different kinds of cement are used depending on the specific needs of the job or unique design problems. Despite the existence of various kinds of man-made cements, Portland cement is the most frequently used type and is considered as the standard for comparing other modern cements. The making of Portland cement is a simple process that only needs common materials. The material called mortar, which is used to build walls, is made up of cement and finely ground material. In construction, a mixture of cement, sand, and gravel is used, which is called concrete. Concrete is used more than almost any other material in the world. Apart from concrete and water, there is nothing else that people depend on as much. Calcium oxide is typically made from limestone, which is a type of calcium carbonate. However, it can also be found in other substances such as chalk, shells, and mud. This sentence means that people like to use soil or silt because they are already broken up into tiny pieces. Shown in fig 2

Figure 2: Cement

In order to extract silica, they make use of iron-bearing alumina-silicates, which are a particular kind of rock. The term "cement" is commonly used to describe things that naturally possess a sticky characteristic. The production of Portland cement is a straightforward process that only necessitates readily available ingredients. The process of making calcium silicates entails the effective combination of different components. Achieving the production of high-grade cement necessitates the utilization of materials with a consistent chemical composition and utmost purity.

Aggregate

Proper functionality of concrete relies on the inclusion of ingredients beyond just water and Portland cement. Aggregates can be classified as materials like sand, gravel, or crushed stones. Concrete's reliance on them as an essential ingredient is attributed to their inability to react with other substances utilized in concrete. To create a strong concrete mixture, it's important to ensure that the rocks and sand you use are free from dirt and debris. These things cannot contain dirt or harmful substances because that might cause the concrete to weaken or deteriorate. Concrete is made up of two different kinds of materials: fine and coarse. They both form the majority of the concrete. Many tiny grains found in rocks can pass through a filter that is 3/8 of an inch in size. These tiny grains are typically made of sand or crushed rock that is found in nature. Anything that is greater than zero. A big thing that measures 19 inches is called coarse aggregate. They are often as big as a pencil or a small rubber ball. Rocks that break easily into two pieces are not very strong or last a long time. It is necessary to remove any undesired materials, such as debris, dirt, soil, or organic substances, from the sand and gravel. Most of the large rocks used in concrete are known as gravel. Aggregates make concrete stronger and last longer.

Their role is to enhance its resilience and safeguard it against deterioration and the process of aging. Their strong form can affect the solid material in many different ways. When you combine things, they could break apart and become less useful because they transform into smaller pieces. Brittle rocks can break into two separate pieces. These things cannot contain dirt or harmful substances because that might cause the concrete to weaken or deteriorate. Concrete is made up of two different kinds of materials: fine and coarse. They both form the majority of the concrete. Rocks that break easily into two pieces are not very strong or last a long time. It is necessary to remove any undesired materials, such as debris, dirt, soil, or organic substances, from the sand and gravel. (Shown in Fig 3).

Figure 3: Aggregates

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Waste Glass Powder (WGP)

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Glass is a type of material that doesn't have a definite shape and has a lot of silica in it. It can be used instead of some of the cement in building materials when the glass powder is really tiny, less than 75µm in size. Glass is made by combining three main ingredients. (Shown in fig 4).

Figure 4: Waste Glass Powder

Mix Design

The concrete mix design was done by utilizing IS 10262 for M-25 review/Grade of concrete. Table 1 Mix design of concrete.

S.No.	Material	Mix Design
1.	Type of Aggregate	Crushed angular Aggregate
2.	Admixture	Waste Glass Powder
3.	Aggregates Size	20mm
4.	Water Cement Ratio	0.50
5.	Workability	65mm (Slump)
6.	Grade	M30
7.	Cement Grade	OPC53

Water Cement Ratio: 0.5

V. RESULTS AND DISCUSSION

1) General

This section concisely explains the findings of the laboratory tests conducted on the sample. We experimented with different materials such as cement, sand, tiny pebbles, and a leftover substance known as Sugarcane Bagasse Ash. Another experiment conducted by us involved wet and dry concrete.

2) Slump Test Examination

Table 2: The slump value of all mixtures

S.No.	MIX	Percentage	Slump Value
1.	WGP	0%	92mm
		15%	63mm
		20%	50mm
		25%	46mm
		30%	24mm

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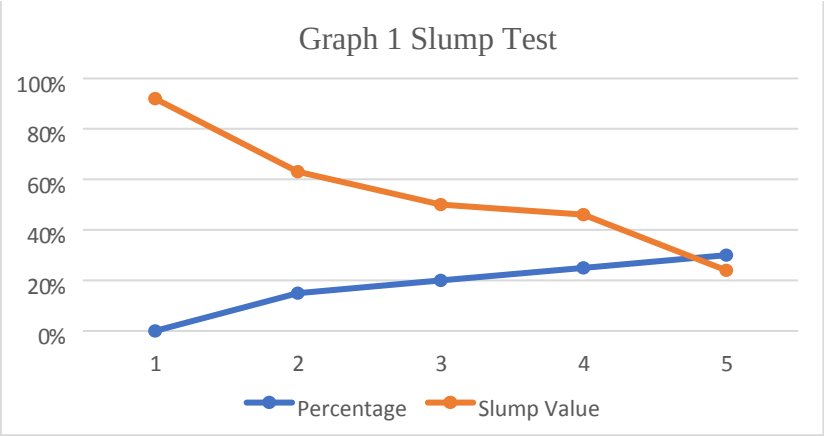

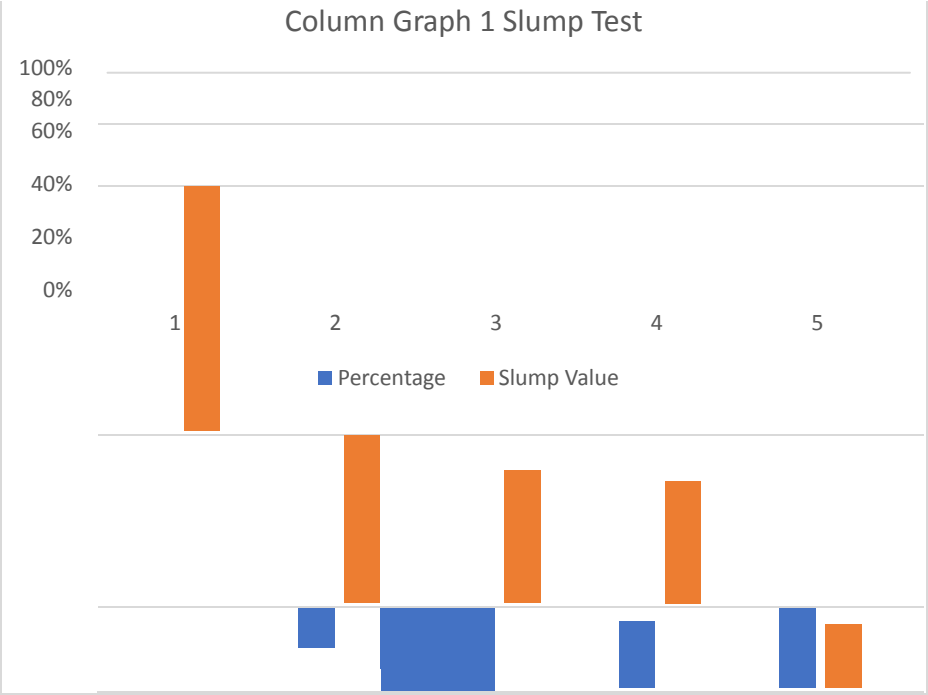

3) Compaction factor test investigation

Table 3: Determine the compaction factor test.

S.No.	MIX	Percentage	Compaction factor
1.	WGP	0%	0.89
		15%	0.86
		20%	0.82
		25%	0.80
		30%	0.77

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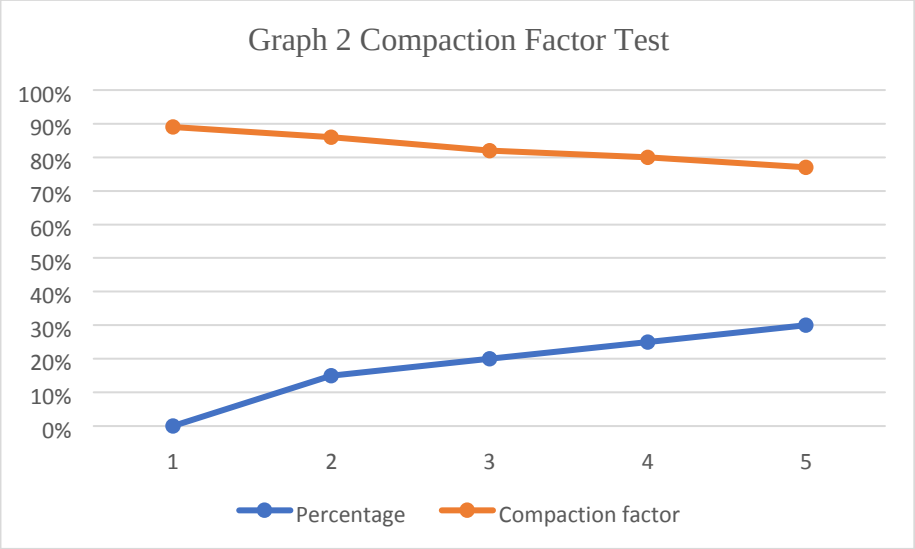

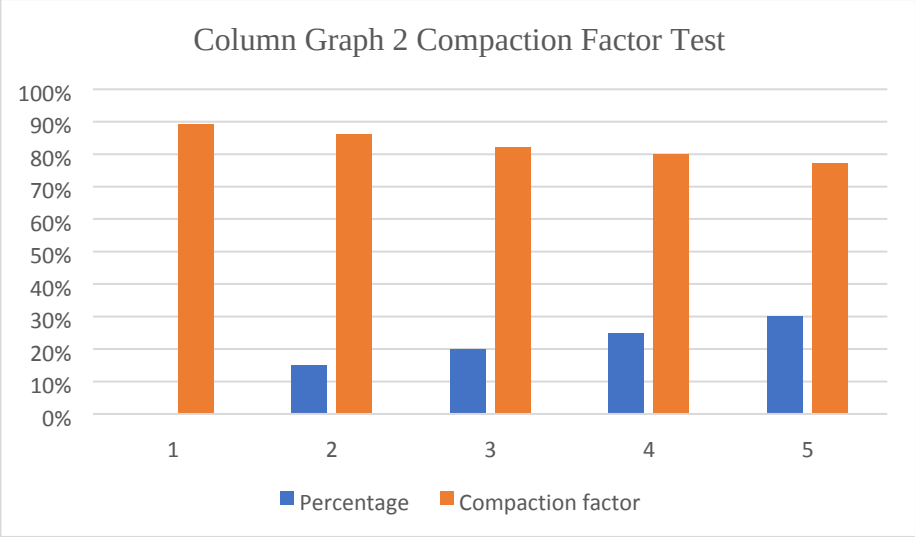

Table 2: The concrete value compaction factor under supervision is 0.89. When the proportion of concrete overlaid with WGP is raised from 15% to 30%, the value of the compaction factor falls from 0.89 to 0.77.

4) Aging and Compressive Strength

The M30 Grade concrete has strength of 34.40 N/mm2 after 28 days.

Table no 4 below shows the compressive strength.

5) Compressive strength of control concrete in N/mm^2

Table no 4 shows the compressive strength

Grade of Concrete	7days	28days
M30	21.6	30.4

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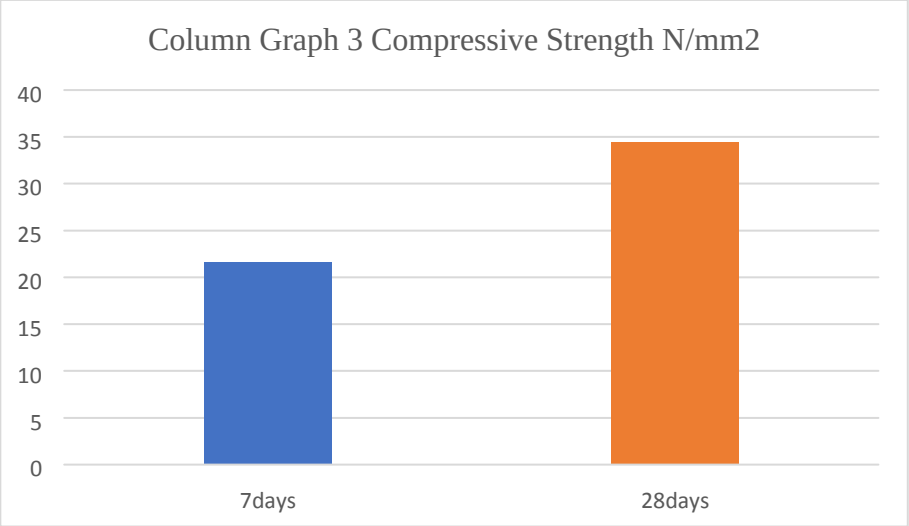
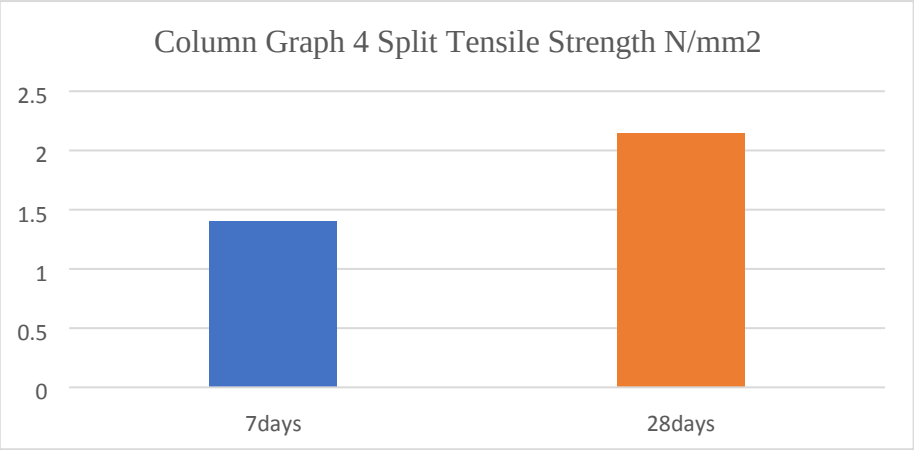


6) Impact of Age on Control Concrete's Split Tensile Strength

Category M30 After 28 days, the control concrete has a flexural rigidity of 2.15 N/mm2. The graph of compressive strength versus cement replacement percentage introduces the special table strength statistics. Tensile strength of fracture in control concrete in Newton-Meters (N/mm2).

Table No.5 Shows the Split Tensile Strength in 7days and 28 days

Grade of Concrete	7days	28days
M30	1.40	2.15



7) Impact of Concrete with Various WGP Contents on Compressive Strength

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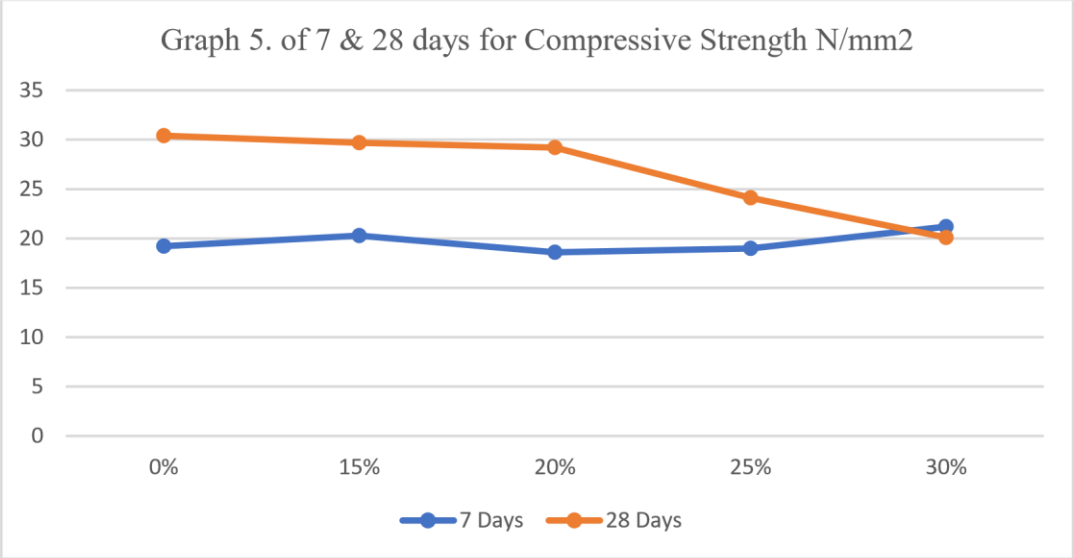
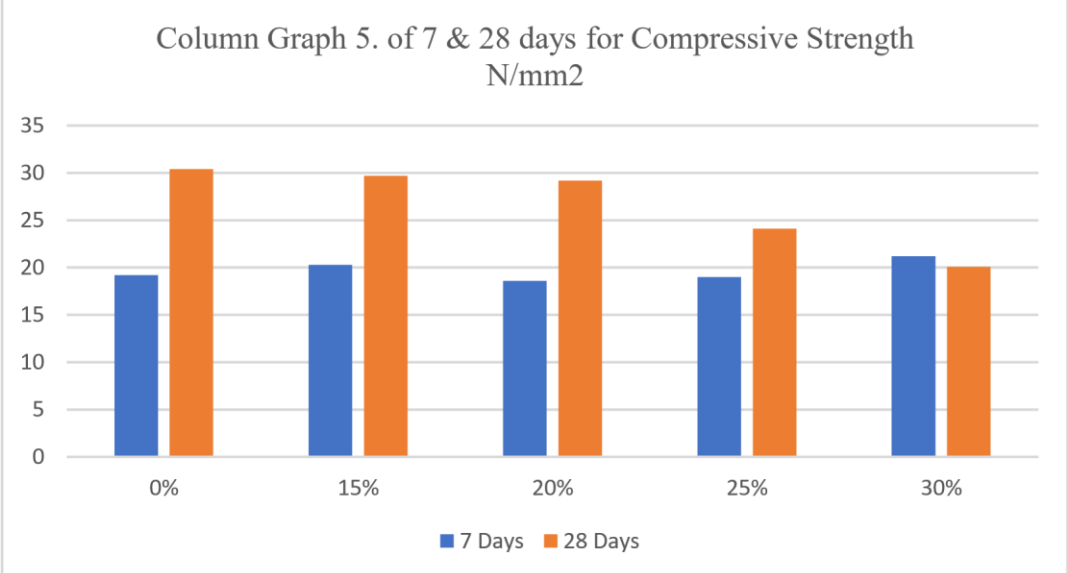
Table 6 Compressive strength of WGP Concrete

MIX	%of cement Replacement	Cube Compressive Strength N/mm2	
		7 Days	28 Days
WGP	0%	19.2	30.4
	15%	20.3	29.7
	20%	18.6	29.2
	25%	19	24.1
	30%	21.2	20.1





8) Impact on Concrete with Different WGP Contents on Split Tensile Strength

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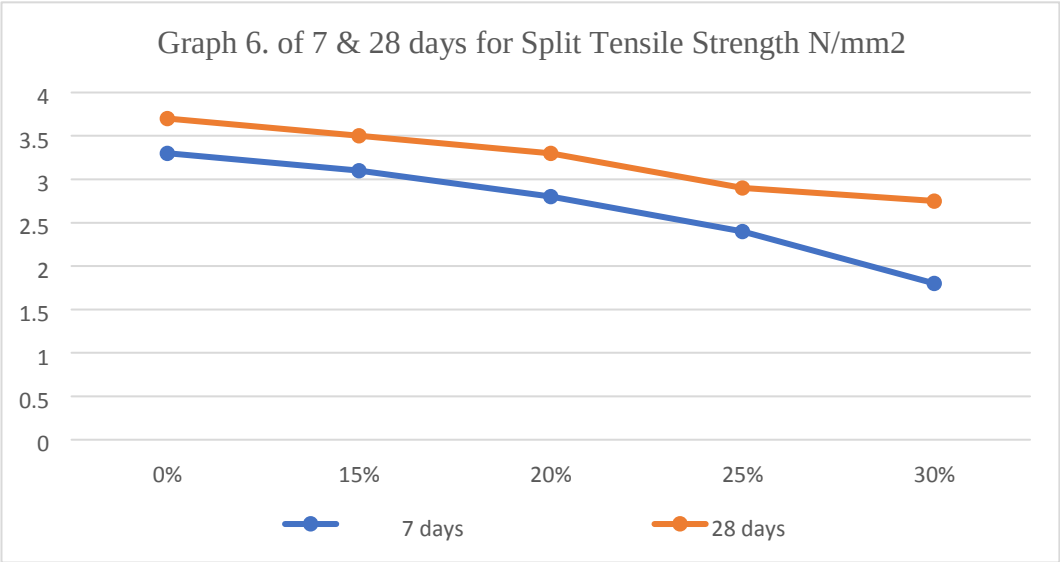
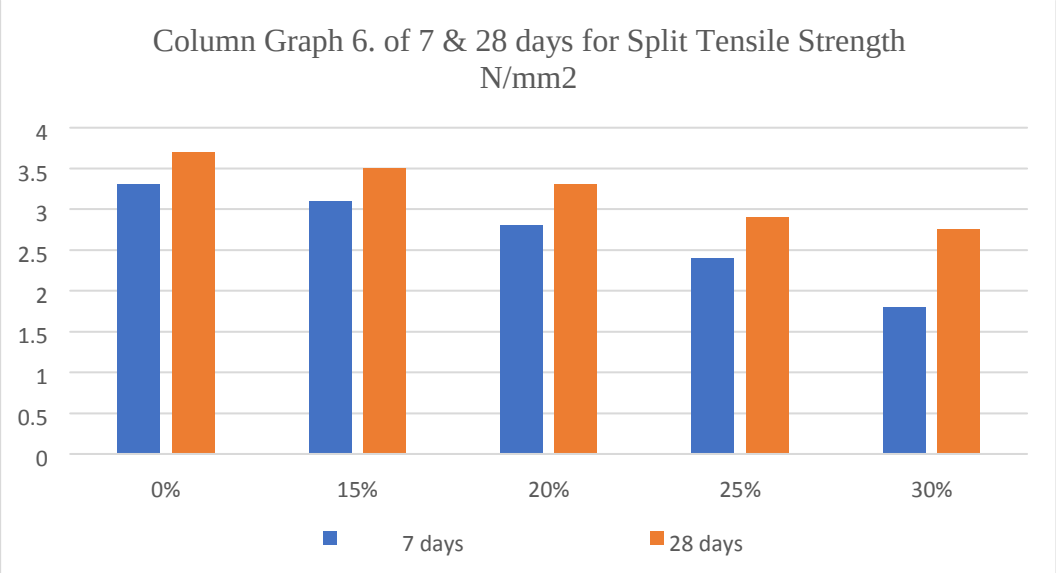
Table 7 Spilt Tensile Strength of (WGP) Concrete

MIX	% of cement Replacement	Split Tensile Strength N/mm^2	
		7 days	28 days
WGP	0%	3.30	3.70
	15%	3.10	3.50
	20%	2.80	3.30
	25%	2.40	2.90
	30%	1.80	2.75





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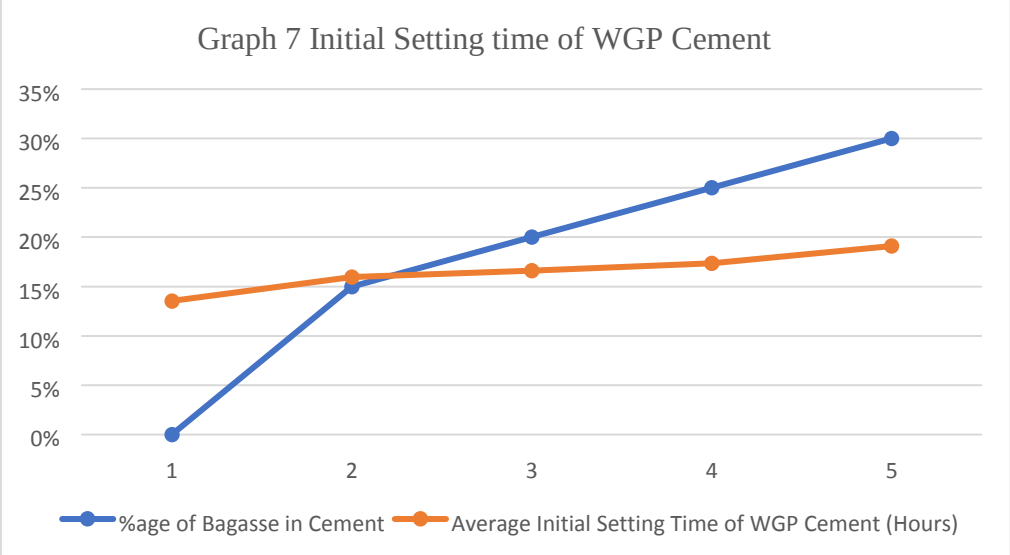
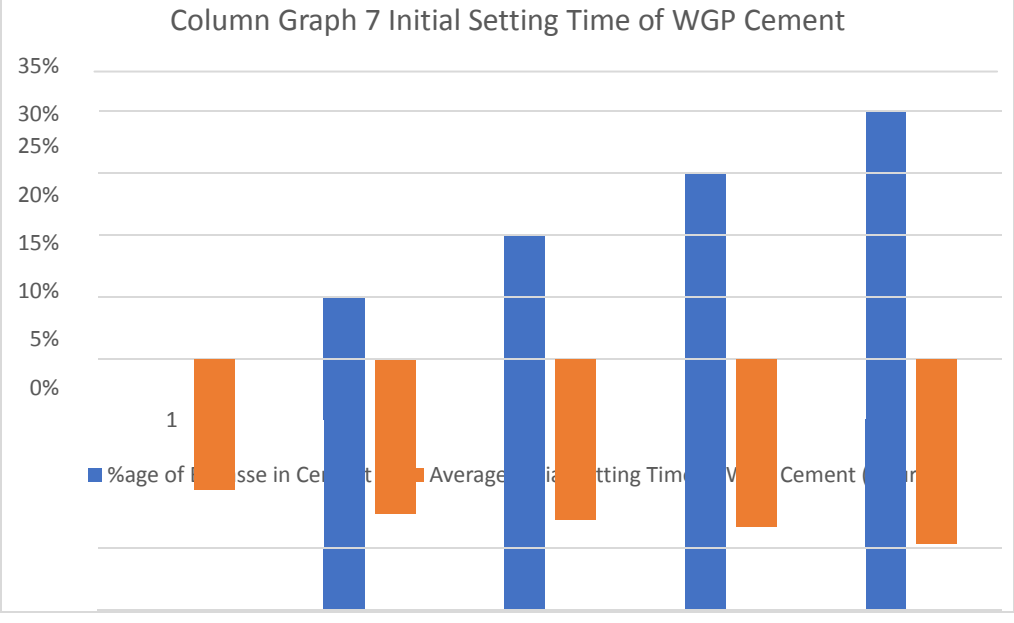
9) Initial Setting Time of Waste Glass Powder Cement

Table No. 8 Initial Setting Time of Waste Glass Powder Cement

S.No.	MIX	%age of Bagasse in Cement	Average Initial Setting Time of WGP Cement (Hours)
1.	WGP	0%	3:15
2.		15%	3:50
3.		20%	3:59
4.		25%	4:10
5.		30%	4:35





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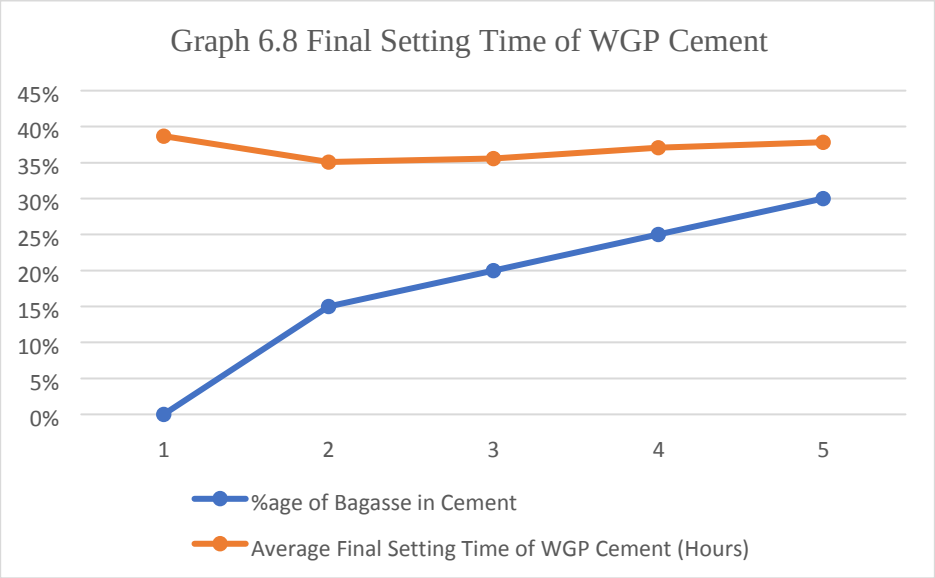
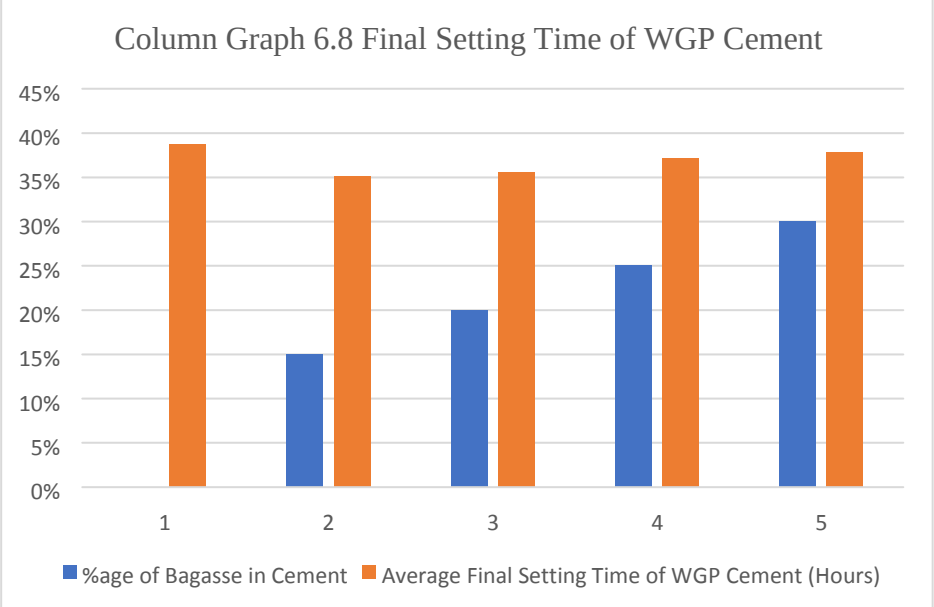
10) Final Setting Time of Waste Glass Powder Cement

Table No 9: Final Setting Time of Waste Glass Powder Cement.

S.No.	MIX	%age of Bagasse in Cement	Average Final Setting Time of WGP Cement (Hours)
1.	WGP	0%	9:17
2.		15%	8:25
3.		20%	8:32
4.		25%	8:54
5.		30%	9:05





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VI. CONCLUSIONS AND RECOMMENDATIONS

By considering the graphs and previous discourse, we can formulate the subsequent determination:

Conclusions

1) Our research focused on the advantages of utilizing Waste Glass Powder (WGP) in the production of M30 grade concrete. We combined cement Waste Glass Powder (WGP) with to make a new material that works well for making concrete.
2) In order to improve the amalgamation of Waste Glass Powder (WGP) and cement, researchers performed a series of tests to examine the consequences.
3) There are various stages involved in the preferred technique. The first step is to determine the specific objective of our concrete. Consequently, we select specific variables that will alter the performance of the concrete.
4) By experimenting with mixtures that consist of these components, we aim to collect information. Utilizing this information, we formulate a plan to strengthen the concrete significantly.
5) The process involved in the functioning of this blend is reminiscent of traditional concrete. The addition of a higher amount of WGP to the cement mix could potentially impair the effectiveness of the concrete.

Recommendations

1) In the context of future projects, it is advised that the findings of this study be taken into account by researchers, stakeholders, and practitioners.
2) According to this study, Waste Glass Powder (WGP) has been identified as a viable substitute for cement in cement mixtures. It possesses a low cost, ensures safety, is easily portable, and contributes positively to the environment.
3) Both cement and glass powder manufacturers, along with the government, need to comprehend the appropriate proportion of waste glass powder to be incorporated into cement.
4) By examining the response of the Waste Glass Powder and cement blend to water and acid, one can determine its strength.

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