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EXPERIMENTAL INSPECTION OF PARTIAL CEMENT WITH GLASS POWDER AND EGGSHELL POWDER ON CONCRETE RESISTANCE

M GHOUSE PASHA[*1], JOLLIREDDY OMPRAKASH [*2]
*[*1]PG Student, Civil Department, Dr.K.V.Subba Reddy Institute of Technology, Kurnool, Andhra Pradesh, India*
*[*2]Assistant Professor, Civil Department, Dr.K.V.Subba Reddy Institute of Technology, Kurnool, Andhra Pradesh, India*

ABSTRACT
It is necessary to investigate what is impacted by an increase in environmentally friendly waste that might replace cement in the production of concrete, given conventional methods for cement extraction and production and the fight against negative CO2 footprints linked to rising cement costs. As a result, this study starts investigating the usage of glass and eggshell powders as cement substitutes in the manufacturing of concrete and evaluates their characteristics and effects on concrete strength. Additionally, the impact on concrete density was assessed. Glass powder, cement, eggshell ash, water, and coarse and fine units from different sources were utilized. In accordance with standards, the experimental procedure comprised concrete sample pouring, slump testing, pressure, tugging, and bending testing, screening analysis, and specific gravity testing for aggregates. 5%, 10%, 15%, 20%, and 25% glass powder and 5%, 10%, 15%, and 20% eggshell powder were used in place of cement. Three distinct curing regimes were used to cast and heal concrete samples over the course of seven, fourteen, and twenty-eight days. According to test data, concrete becomes less workable as cement replacement rates rise. Egg shells and glass powders were used in this work's trials as partial cement substitutes. The M30 is the particular design blend. Samples were created by substituting 5%, 10%, 15%, 20%, and 25% glass powder for cement. Additional cement can be replaced with mineral admixtures, such as eggshell powder of 5%, 10%, 15%, and 20%, if the optimal proportion of glass powder replacement is maintained. The mechanical characteristics of the glass powder and egg shell powder, including bending strength, compressively divided tension, and other curing times of 7, 14, and 28 days, were measured and compared with conventional concrete.
Keywords: Eggshell Powder, Glass Powder, Cement

I. INTRODUCTION

1.1 General

The biggest and most devastating environmental problem is global warming. Greenhouse gases, especially carbon dioxide (CO2), are the main cause of these events. Finding ways to reduce our carbon footprint is a new science. In this world. A difficult and important task for the development of security in the future. The strength, durability and versatility of concrete have made it a popular building material. Concrete is made up of three main ingredients: cement, water, and aggregate, which can be stone, gravel, or sand. The use and production of concrete has a negative impact on the environment, primarily due to the carbon dioxide emissions associated with cement production. Cement production requires a lot of energy, and the process also releases a lot of carbon dioxide, which contributes to the problem of global warming. In addition, the removal of raw materials such as sand and stone, which are needed to make concrete, will have a negative impact on ecosystems, landscapes, and buildings. To address these issues, scientists are looking for ways to reduce the environmental impact of concrete by developing production methods, including the use of other ingredients such as GGBS, fly ash, slag, and glass powder, egg shell powder &wollastonite powder. In addition, the use of concrete in construction can be beneficial to the environment by extending

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the life of buildings and structures and energy consumption. Due to the need for sustainable construction, the development of the production process and the use of the process are important.
Adding additional cementitious materials (SCM) to concrete is a way to reduce the environmental impact of the cement production process. SCM is a material that can replace ordinary cement when making concrete. This will result in reduced energy required to produce cement and reduced greenhouse gas emissions. Industrial waste materials such as fly ash, slag, limestone, wollastonite, glass powder, GGBS and silica dust are examples of supply chains. This additive reduces cement content while improving workability, strength and durability. Furthermore, the use of SCM will increase the durability of concrete by reducing shrinkage and cracking, increasing resistance to chemical and freeze-thaw cycles and extending the service life of models. The use of SCM in concrete construction has the potential to improve the durability and performance of concrete structures while reducing the environmental impact of construction. The addition of SCM to cement mixtures is called ternary and quaternary binders and is another way to improve the properties of concrete. Many studies have been conducted to investigate the microstructure, strength and durability of quaternary concrete composites by considering the effects of various factors.
This study report examines the performance of concrete using glass trash and eggshell powder as a partial replacement for cement and compares its performance with normal concrete.

1.2. Why use waste glass powder?

Glass powder (GLP) such as FA and GGBS are also used as materials; it partially replaces cement, which is partially reacted when wet; the name "glass" includes many types of chemicals, including binary alkali silicate glass, borosilicate glass and ternary soda-lime silicate glass. Partially replacing cement with ground glass waste improves the microstructure and stability of cementitious materials. When cullet waste is partially used instead of cement, it is more dense (less porous) and has a better structure; this prevents hygroscopicity, thus extending the service life of cementitious materials. When there are concerns about problems with cement hydrates and reactive aggregates, partial replacement of cement with ground glass waste can be beneficial to the stability of cementitious materials. Coloured glass waste is crushed to a size close to the cement particles and used to replace about 20% of the cement in concrete, which increases the water resistance, durability and mechanical strength of the concrete. This makes the product stable and strengthens the pore system in the concrete. Replacing cement with semi-crushed glass can save a lot of space, energy and money. Extensive research has been done to solve the alkali-silica problem (ASR). Unfortunately, replacing cement in concrete with pozzolanic elements such as waste glass does not only increase strength and economy, but also durability.

1.3. Important research and tools

Recent research demonstrates that concrete constructed from glass aggregate proves the higher durability and good thermal qualities of glass aggregate. The use of glass waste in concrete results in a high C_3S, low C_3A, C_4A_4, C_3S/C_2S composition, thereby enhancing efficiency and offering stronger resistance to sulfate assaults. Glass powder includes SiO_2, which helps strengthen the strength and durability of concrete when it combines with the alkalis in the cement to generate a cementitious product (pozzolanic reaction). Glass particles less than 90 μm react to generate cementitious compounds. The cost of concrete will reduce when waste glass is transformed into concrete, utilizing waste goods instead of natural ingredients is one of the greatest methods to stabilize commercial concrete. A considerable amount of glass garbage is produced worldwide. 0.7% of all municipal garbage generated in India is glass. The environmental effect of the stone, its material and application are essential. Some impacts are unfavorable; others are beneficial. The rest depends on the stones chosen. The major element of concrete is cement, which has its own environmental impact and has a considerable impact on concrete.
The cement industry is one of the main sources of carbon dioxide (CO_2), accounting for 6% of worldwide anthropogenic emissions, 50% from chemical operations and 40% from oil burning. The architectural group prefers to use trash or recycle. Concrete goods are also expanding due to the importance of sustainable building. Glass is an inert substance that may be used and reused many

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times without affecting its chemical characteristics. The concrete industry is now experimenting on utilizing waste glass to replace some of the cement. After the glass waste is crushed into extremely fine powder, it shows pozzolanic qualities due to the presence of SiO2, hence 0%, 5%, 10%, 15%, 20%& 25% etc. It can substitute cement in some concentrations. Glass is an amorphous material with a high silica concentration, thus when the particle size is smaller than 75 microns it can be pozzolanic and used as a replacement for cement.

Figure 1: Production of Glass powder

Egg shells are agricultural throw objects made from breeding from chicks, bakeries and fast-food restaurants, which can damage the surroundings, resulting in ecological problems/contamination that require proper treatment. With the constantly high task of converting waste into prosperity, the efficiency of adapting eggshells to advantageous applications is a concept worthy of gain. It is systematically recognized that egg shells are mainly composed of calcium compounds. In the current work, the waste egg shells were collected and the sun was poured down by bakeries and fast-food restaurants. The stored eggshells were powdered in a flour mill. Ground egg shells were sieved in the size of a sieve of 90 micrometers and packed to use them in cement replacement.

Eggshell powder is a fine powder from eggshells, mainly from calcium carbonate ($Caco_3$), along with small amounts of other minerals such as magnesium, phosphorus, and potassium. This is a natural waste that can be easily converted and included in a variety of uses in a variety of fields, such as agriculture, construction, and health. Phosphorus, potassium, collagen, and other elements that contribute to its strength and potential benefits.

Frequent uses of eggshell powder:

In the structure: Eggshell powder can be used as an additive in cement to improve its strength, sustainability and cost-effectiveness.

Agriculture: Eggshell powder is often used in gardening and agriculture because it is rich in calcium. This helps to promote healthy plant growth. It helps reduce bed acids and improve soil structure.

Health and Nutrition: Calcium Supplements: Eggshell Powder is a natural source of calcium, and some people use it as a supplement to support bone health. Calcium carbonate made from egg shells is thought to be biologically available (slightly absorbed by the body).

Animal Feed: Eggshell powders may be added to animal feeds, particularly for poultry, to provide additional calcium to the egg layer. It can also be used as other cow-based supplements to support bone health.

Advantages of using eggshell powder:

1. Sustainable and environmentally friendly: By recycling eggshells that are otherwise rejected as waste, eggshell powder helps reduce waste and support sustainability.

2. Rich Source of Calcium: High calcium content is advantageous for a variety of applications, especially in terms of health and nutrition.

3. Low Cost: Eggshells are generally available for free or too expensive to make eggshell powder an inexpensive material for a variety of uses.

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How to make egg shell powder:
1.Collect egg shells from used eggs.
2. Clean the egg shell: Wash the shell thoroughly and remove all remaining eggs. Egg shells can be renovated by cooking them in water for a few minutes.
3. Dry the egg shell: Place clean egg shells on a tray or baking sheet and dry at a low temperature (about 200°F or 90°C) for about 15-20 minutes.
4. To grind the powder: As soon as the shells dry, grind the eggshells into fine powder using a mortar and pestle or factory (like a coffee grinder).
5. Storage correctly: Store eggshell powder in an airtight container in a dry place.

Figure 2: Production of Egg shell powder

1.4 Objectives of the Study

1. To reduce the environmental impact and CO_2 emissions associated with conventional cement manufacturing by utilizing eco-friendly waste materials.
2. To study the effect of different percentages of glass powder replacement (5%, 10%, 15%, 20%, and 25%) on the properties of M30 grade concrete.
3. To evaluate the influence of eggshell powder replacement (5%, 10%, 15%, and 20%) in combination with the optimum percentage of glass powder.
4. To assess the mechanical properties of concrete.
5. To identify the optimum replacement percentage of cement using eggshell powder and glass powder without significantly affecting concrete performance.

II. MATERIALS USED

2.1 General

A mixture of cement or binder is added to materials or components to fill the gaps left by assembly and joints to make concrete. This experiment aims to ascertain how the Egg shell powder and Glass powder (ESP-GP) combination affects the mechanical characteristics and longevity of M40 standard concrete. We looked at the strength of concrete that had 5%, 10%, 15%,20% & 25% Glass powder added. Increased cement can be substituted with mineral materials such as ESP (5%, 10%, 15&20%), provided that the glass powder replacement percentage stays constant. The primary components utilized in this investigation are water, fine and coarse aggregate, Egg shell powder-Glass powder, and cement. High-quality materials that meet IS: 383-2016 standards, Conforms to IS: 383-2016 Water [Portable], Coarse Aggregate, ESP- Glass powder**.**

2.2 Cement

Ordinary grade 53 manufactured from a batch of JSW cement, as specified in IS: 12269-1987 (OPC), was used in this work as Portland cement for research. There are no lumps and it is fresh. Cement should be stored carefully to avoid moisture-induced loss of its properties.
1) Cement's Physical Characteristics
Cement particles are where water and cement first interact.
•The hydration increases with the surface area of a given volume of cement.
• The "set time" is the amount of time that passes between adding water to the beginning and end points.
• It is the hardened cement's maximal strength.

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• The physical characteristics of cement paste determine its ability to maintain its volume after setting.

2) Cement's chemical composition?

The primary raw materials used in the production of cement are iron oxide, silica, alumina, and lime. In the furnace, these oxides react at very high temperatures.

Figure 2.1Cement

2.3 Fine Aggregate

It is normally the aggregate that passes through a 4.75 mm IS screen and only coarse particles are allowed in the standards. On the basis of fine aggregate, it will be defined as follows:

1. Natural Sand - Aggregate generated by the natural disintegration of rocks and deposited by streams or glacial constructions
2. Stone sand - fine aggregate generated by breaking hard rocks.
3. Gravel sand — fine aggregate generated by crushing natural gravel.

Fine aggregates are categorized into coarse sand, medium sand and fine sand according to their particle sizes. IS standards split fine aggregates into four groups based on their grade, from grading zone 1 to grading zone 4.

The biggest aggregate in the four grading regions is 20 mm with regular grading. The specific gravity of the coarse aggregate utilized is 2.73. Sieve examination of both coarse and fine aggregates conforms with IS10262 standard. Develop steadily from Zone-1 grade to Zone-4 grade. Depending on the gradation area of the fine aggregate, 90% to 100% passes through the 4.75 mm IS sieve and 0% to 15% passes through the 150 micron IS sieve.

Figure 2.2 Fine Aggregate

2.4 Coarse Aggregate

It is the majority of the residual aggregate. The 4.75mm IS screen is merely made of a finer material than necessary. The following definitions of coarse aggregate vary by location:

1. Unbroken stone or gravel, which results from stone's natural disintegration
2. Crushed Stone or Gravel: Stone or gravel that has been crushed.
3. Semi-crushed stone or gravel is a combination of the first two aggregates mentioned. Depending on its size, coarse aggregate can have diameters ranging from 40 mm to 20 mm, 16 mm, and 12.5 mm. For instance, material that passes through the 20 mm IS sieve is typically referred to as graded aggregate with a nominal size of 20 mm.

Large aggregates are aggregates that typically fit through large sieves. A 20 mm huge aggregate, for instance, is one that typically passes through the 20 mm IS filter and stays above the 10 mm IS sieve.

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Figure 2.3 Coarse Aggregate

2.5 Glass powder

Glass is an amorphous, amorphous substance that is largely transparent and has a broad variety of functional, utilitarian and ornamental purposes. The most familiar and historical glass is "silicate glass" based on silica (the major constituent of sand). In popular use, the word glass mainly refers to this substance found only in glass windows and glass bottles. Among the several silica-based glasses available, normal glass and container glass are formed of a variety called soda-lime glass, which consists of roughly 75% silicon dioxide (SiO_2), sodium oxide (Na_2O), sodium carbonate (Na_2CO_3). Calcium oxide (CaO) is also termed lime and several other minor compounds. Many applications of silicate glass arise from its transparency, making it widely used as window glass. Glass transmits, reflects and reflects light; these attributes may be increased by cutting and polishing to make optical lenses, prisms, thin glass and fiber optics for high-speed optical transmission.

Figure 2.4 Glass Powder

2.6 Egg Shell Powder

Eggshell powder is sometimes used as an additive in cement to improve its properties, including strength and durability. The idea behind incorporating eggshell powder into cement is that it contains calcium carbonate ($CaCO_3$), which can enhance the material's structural qualities. Here's a breakdown of how eggshell powder can be beneficial when added to cement.

Figure 2.5 Egg shell powder

2.7 Water

Water used in construction must have the following properties:

1. There should be no oil, acid, alkali or other organic or inorganic contaminants.

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2. It should not include metal, plant debris or other elements that would harm the stone and should be appropriate for drinking.

2.8 Admixture

Conplast WL Xtra is a dark brown liquid with a polymer base for cement dispersion that mixes well with water and disperses uniformly. It lessens the amount of water needed to achieve the necessary workability and minimizes bleeding and segregation. It conforms to IS:2645-2003.Dosage: For 50 kg of cement, 200 ml is the ideal dosage.

Figure 2.6Conplastwlxtra

III. EXPERIMENTAL INVESTIGATION

Normal Consistency of Cement	32%
Setting Time of Standard Cement	Initial -45 min & Final - 510 min
Specific Gravity Of Cement	3.10
Fineness Test of Cement by Sieve Analysis	96%
Soundness of Cement	4 mm
Fineness Modulus of Fine Aggregate	4.07
Fineness Modulus of Coarse Aggregate	3.9
Specific Gravity of Fine aggregate	2.56
Water Absorption Test on Fine Aggregate	1.59%
Bulking of Fine Aggregate	23.71%
Specific Gravity & Water Absorption of Coarse aggregate	2.68 & 1.68%
Specific Gravity of Glass powder & Eggshell powder	2.60 & 1.85
Size(µm) of Glass powder & Eggshell powder	< 150 & < 10 to 100
Colour of Glass powder & Eggshell powder	Greyish-white & white

IV. MIX DESIGN

Grade	M30
Proportion	1: 2: 3.2
W/C ratio	0.40
Cement	370 Kg/m^3
Fine Aggregate	740 Kg/m^3
Coarse Aggregate	1200 Kg/m^3
Water	148 Kg/m^3
Chemical admixture	3.70 Kg/m^3

V. PERFORMANCE TESTING AND RESULTS

5.1 TEST RESULTS ON COMPRESSIVE STRENGTH

Table no 5.1 Test results of Compressive Strength for 7,14 & 28 days for M30

Mix % Replacement	Compressive	Compressive	Compressive

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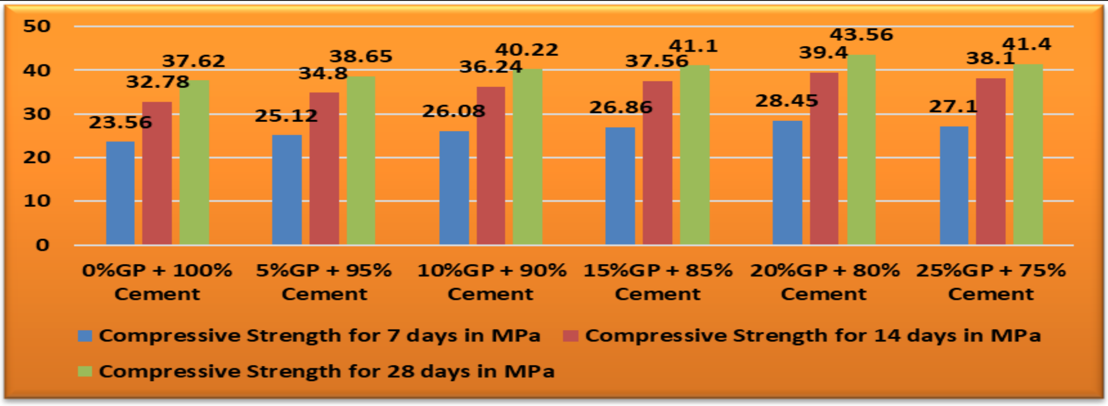
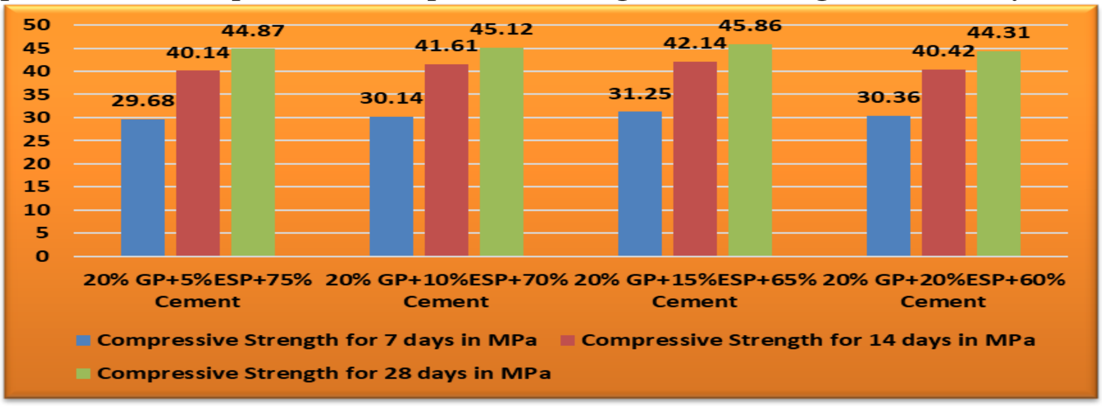
	Strength for 7 days in MPa	Strength for 14 days in MPa	Strength for 28 days in MPa
0%GP + 100% Cement	23.56	32.78	37.62
5%GP + 95% Cement	25.12	34.80	38.65
10%GP + 90% Cement	26.08	36.24	40.22
15%GP + 85% Cement	26.86	37.56	41.10
20%GP + 80% Cement	28.45	39.40	43.56
25%GP + 75% Cement	27.10	38.10	41.40
20% GP+5%ESP+75% Cement	29.68	40.14	44.87
20% GP+10%ESP+70% Cement	30.14	41.61	45.12
20% GP+15%ESP+65% Cement	31.25	42.14	45.86
20% GP+20%ESP+60% Cement	30.36	40.42	44.31



Graph No 5.1 Development of Compressive strength after curing 7, 14& 28 days for M30



Graph No 5.2 Relation between optimum Glass powder (20%) +%ESP replacement and Compressive strength

5.2 TEST RESULTS ON SPLIT TENSILE STRENGTH

Table no 5.2 Test results of Split Tensile Strength for 7, 14 & 28 days for M30

Mix % Replacement	Split Tensile Strength for 7 days in MPa	Split Tensile Strength for 14 days in MPa	Split Tensile Strength for 28 days in MPa
0%GP + 100% Cement	2.84	3.35	3.93
5%GP + 95% Cement	2.96	3.57	4.13
10%GP + 90% Cement	3.13	3.71	4.41
15%GP + 85% Cement	3.33	3.87	4.47

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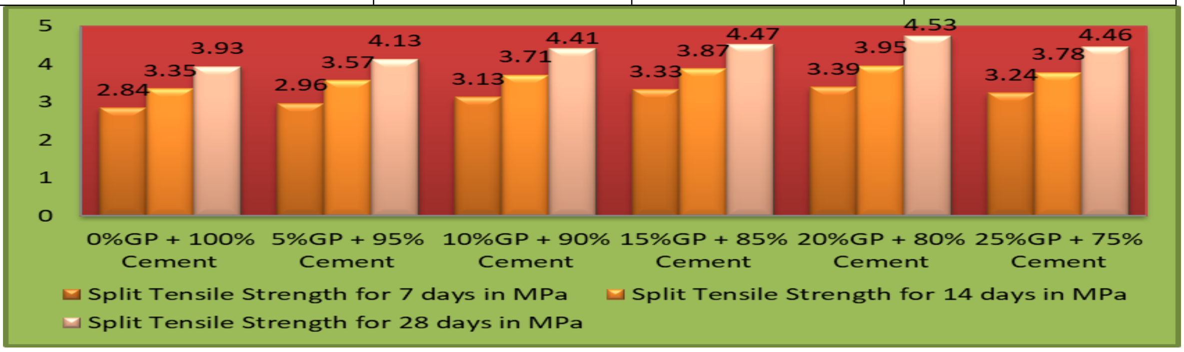
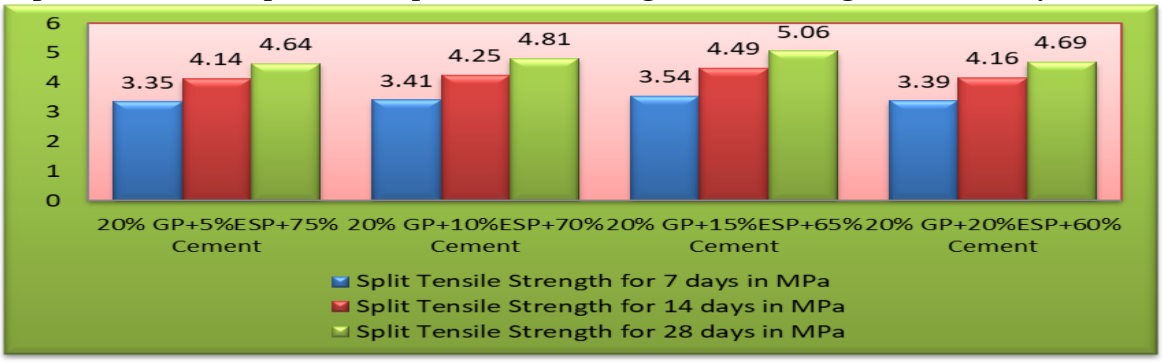
20%GP + 80% Cement	3.39	3.95	4.53
25%GP + 75% Cement	3.24	3.78	4.46
20% GP+5%ESP+75% Cement	3.35	4.14	4.64
20% GP+10%ESP+70% Cement	3.41	4.25	4.81
20% GP+15%ESP+65% Cement	3.54	4.49	5.06
20% GP+20%ESP+60% Cement	3.39	4.16	4.69



Graph No 5.3 Development of Split Tensile strength after curing 7,14 & 28 days for M30



Graph No 5.4 Relation between optimum Glass powder (20%) +%ESP replacement and Split Tensile strength

5.3 TEST RESULTS ON FLEXURAL STRENGTH

Table no 5.3 Test results of Flexural Strength for 7, 14 & 28 days for M30

Mix % Replacement	Flexural Strength for 7 days in MPa	Flexural Strength for 14 days in MPa	Flexural Strength for 28 days in MPa
0%GP + 100% Cement	4.23	5.62	6.67
5%GP + 95% Cement	4.48	5.93	6.86
10%GP + 90% Cement	4.92	6.24	6.98
15%GP + 85% Cement	5.33	6.66	7.22
20%GP + 80% Cement	5.51	6.87	7.57
25%GP + 75% Cement	5.36	6.71	7.23
20% GP+5%ESP+75% Cement	5.58	6.90	7.59
20% GP+10%ESP+70% Cement	5.66	7.12	7.64
20% GP+15%ESP+65% Cement	5.85	7.24	7.83
20% GP+20%ESP+60%	5.62	7.08	7.61

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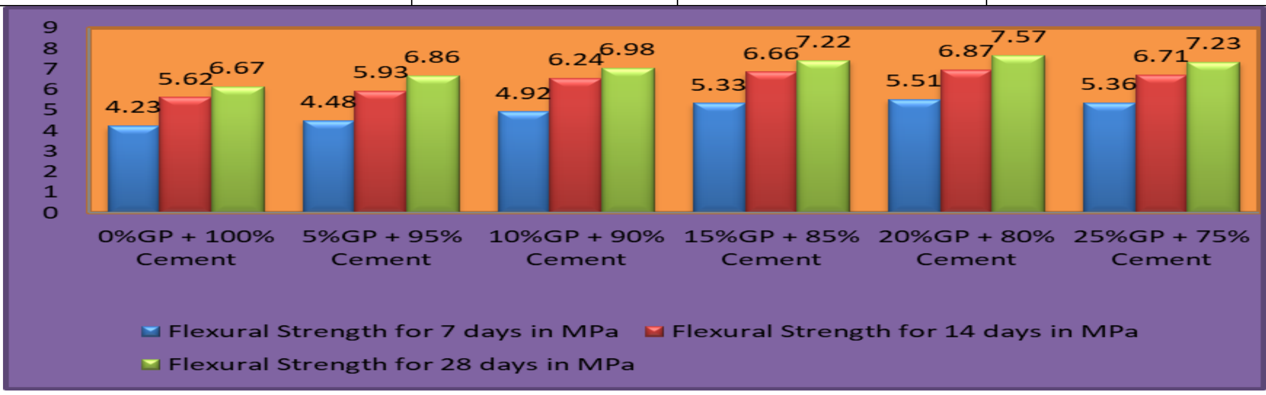
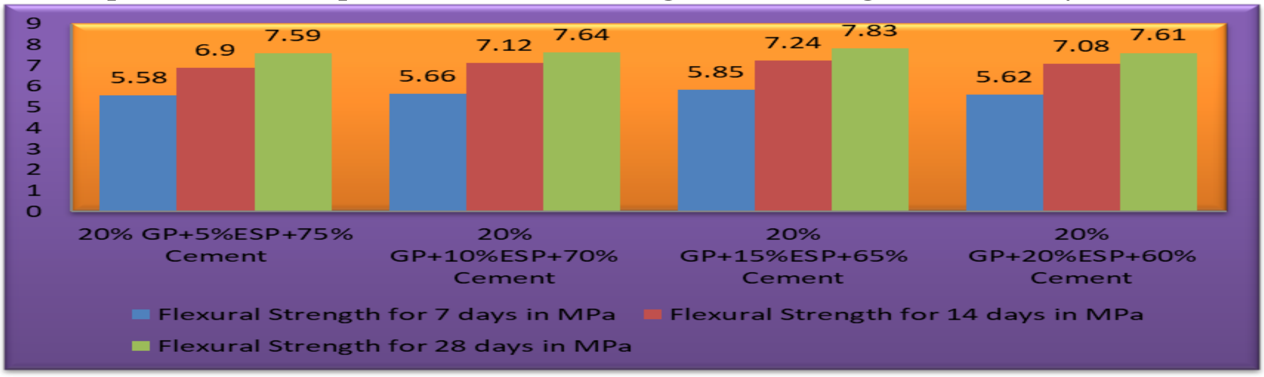
Cement			



Graph No 5.5 Development of Flexural strength after curing 7, 14 & 28 days for M30



Graph No 5.6 Relation between optimum Glass powder (20%)+%ESP replacement and Flexural strength

VI. CONCLUSIONS

Based on the above research, the following analysis was conducted on the synthetic Glass Powder and Eggshell Powder with mineral additives as partial replacement of cement.

1. Its operation is low according to the glass powder ratio in the transition.
2. The results showed that the maximum percentage of glass powder replacing cement was formed when the glass powder content was 20%.
3. The highest concrete properties were obtained with the concrete mixture containing 20% glass powder and 15% ESP compared to other mixtures.
4. The test results showed that the strength of the concrete combined with glass powder and ESP was increased better than that of the glass powder concrete mixture.
5. It is seen that when 20% glass powder is used, the compressive strength increases by 15.78%, the tensile strength increases by 15.26% and the flexural strength increases by 13.49% compared to traditional concrete.
6. Compared to ordinary concrete, using 20% glass powder and 15% ESP can increase the compressive strength by 21.90%, the tensile strength by 28.75% and the flexural strength by 17.39%.

SCOPE OF FUTURE RESEARCH

1. Further research can be done using the difference between glass waste and the recommended amount of glass waste to achieve energy; Compressive, bending strength and splitting tensile strength can be determined.
2. Instead of cement, use glass powder with different water-cement ratios.
3. Other concrete performance tests of other concrete qualities can be performed.
4. Research can be done on replacing coarse aggregates with glass.
5. Add the activator to the waste glass powder concrete mixture and determine the consistency by analyzing the compressive strength of the concrete.
6. Use waste glass powder to determine the durability of the stone.

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