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Strength Studies On Slag Sand Concrete Blended With Rice Husk Ash And Glass Powder

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ABSTRACT

Concrete consists of a range of components, including coarse aggregate, fine aggregate, cement, and water. These elements are blended in various ratios to attain particular strength characteristics. However, the rapid increase in the global population and the requirement for accommodating this growth are resulting in an escalating demand for traditional construction materials. Nevertheless, the scarcity and rising costs of these materials underscore the necessity to explore alternative materials for construction. We can achieve this by incorporating various admixtures into the concrete mixture. Cement, which is a fundamental component, plays a crucial role in the concrete manufacturing process. In this paper, we present an experimental investigation focusing on the strength and workability characteristics of M30 grade concrete made with slag sand. This study involves the partial replacement of cement with rice husk ash and the addition of glass powder. Rice Husk Ash (RHA) is among the waste products generated as a by-product of rice paddy milling industries. Locally sourced glass waste was collected and processed into glass powder of suitable size. The contemporary use of glass powder as a substitute for cement aims to enhance concrete strength. The primary objective is to promote the utilization of these materials as cost-effective construction resources for low-cost buildings. In this work, cement was partially replaced with fly ash at consistent percentages of 0 ,10, 20, and 30%. Additionally, glass powder is introduced at percentages of 0, 10, and 20%. Various concrete mixtures were then produced, tested, and compared with traditional concrete. The results demonstrated an improvement in the mechanical properties with the incorporation of rice husk ash and glass powder. This project offers economic advantages, as the replacement of rice husk ash is cost-effective, and it results in the production of superior concrete.

KEYWORDS: Concrete, Rice husk ash, Slag sand, Glass powder, Compressive strength, Flexural strength, Split tensile strength.

1) INTRODUCTION

Concrete stands as one of the most extensively utilized construction materials worldwide, renowned for its adaptability, longevity, and cost-effectiveness. In India, an annual consumption of roughly 7.3 million cubic meters of ready-mixed concrete underscores its importance. Its applications span a wide range, encompassing usage in highways, streets, bridges, high-rise buildings, dams, and more. However, it is paramount to address the environmental concerns associated with conventional concrete production. The emission of greenhouse gases, particularly CO2, is a major driver of global warming, contributing to approximately 65% of this phenomenon. The global cement industry, a vital component of concrete manufacturing, accounts for approximately 7% of total greenhouse gas emissions, amplifying environmental challenges. To alleviate this environmental impact, alternative binders are being introduced to revolutionize concrete production. This approach not only reduces the carbon footprint but also promotes sustainability within the construction industry.

The rapid extraction of sand from riverbeds poses a range of issues, including increased riverbed depths, loss of vegetation along riverbanks, disturbances to aquatic ecosystems, and negative impacts on agriculture due to declining water table levels. Consequently, construction industries in developing nations are placing significant emphasis on the requirement for alternative materials to mitigate the pressure on the natural sand market.

We can address this challenge through two methods: (a) substituting concrete with an alternative material, which is currently very challenging or even impossible in terms of workability, durability, and strength, and (b) partially or entirely replacing specific raw materials. The second alternative option is feasible. Nowadays, numerous innovations in the field of concrete technology are underway, with various researchers actively exploring this domain. Our efforts to address this issue involve the substitution of different by products. We have published multiple papers proposing various materials that can serve as substitutes for essential raw materials like cement, fine aggregates, and coarse aggregates.

Sand is an important material in the preparation of mortar and concrete, playing a significant role in the construction of concrete mixtures. The predominant consumption of natural sand is typically associated with the primary use of cement and mortar. Due to the demand for cost-effective and readily available alternatives in the construction sector, natural sand has become increasingly expensive in recent times. As a means of partially or completely replacing natural sand in concrete and mortar mixtures, various appropriate materials, including crushed stone dust, quarry dust, glass powder, and recycled concrete, have been employed over the past two decades. This approach aims to maintain ecological equilibrium. Given the information stated above, utilizing slag sand as a viable alternative to natural sand is a worthwhile endeavour.

Glass Powder is a by-product generated through the reduction of high purity quartz using coal, coke, and wood chips in an electric arc furnace during the production of silicon metal or ferrosilicon alloys. In recent times, Glass Powder has gained substantial usage due to its capacity to enhance concrete properties. The contemporary utilization of Glass Powder as a replacement for cement aims to enhance the strength and durability of concrete.

Rice husk is a prominent agricultural by-product derived from the outer husk of rice grains following the milling process. It accounts for approximately 20% of the

500 million tons of paddy rice produced globally. Rice husk ash, in the past, had no practical application and was typically disposed of in water streams, resulting in pollution and spring contamination. It wasn't until its potential as a valuable mineral admixture for concrete was discovered. In general, mineral admixtures tend to positively impact the strength and durability of concrete. Additionally, rice husk ash has the potential to influence the physical characteristics of fresh concrete (prior to setting) by enhancing workability, essential for the mixing and forming process, while maintaining a consistent water-to- binder ratio.

Numerous research studies have explored the performance of concrete when blended with rice husk ash. Nevertheless, there is a scarcity of comprehensive data regarding the impact of rice husk ash on the characteristics of blended concrete. This study aims to examine how the partial substitution of cement with various proportions of rice husk ash influences concrete, specifically its compressive strength, split and flexural strength, and workability. The ultimate goal is to develop structures with the most desirable properties.

2) LITERATURE REVIEW

1) **Saraswathy et al. (2007)** studied the impact of rice husk ash (RHA) on the porosity and water absorption of concrete was investigated, with RHA replacing up to 30% of the cement. The findings revealed that as the RHA content increased, the porosity values decreased. The fine particles of RHA contributed to the denser packing of particles in the matrix, resulting in a reduced volume of larger pores. Additionally, the coefficient of water absorption in RHA concrete was significantly lower in comparison to the control concrete.
2) **Kartini et al. (2008)** documented the improvement in the mechanical properties of Rice Husk Ash (RHA) concrete when a superplasticizer was used. In the absence of a superplasticizer, RHA concrete exhibited lower compressive strength compared to the control concrete. This was due to the requirement for a higher water content to achieve similar workability.
3) **Idir R et al. (2009)** observed a notable decline in the demand for recycled glass in recent years. The high cost

associated with glass recycling has made storing it more cost-effective than recycling. As a result, various alternative options exist for repurposing waste glass. To address the sustainable management of glass storage, one promising approach would be to incorporate this type of glass into concrete, presenting a potential and motivating solution.

4) **Kannan et al. (2012)** conducted an examination to assess the impact of rice husk ash, metakaolin, and their combinations as substitutes for blending components in cement. Their investigation involved the analysis of various properties of blended cement mortar, including compressive strength and saturated water absorption. The findings indicated that the improvement in compressive strength was 20.9% when rice husk ash was used as a 15% replacement, 17.42% when metakaolin was substituted at 25%, and 24.61% when rice husk ash was replaced at 30% in combination with metakaolin at a 1:1 ratio. Regarding water absorption, it was 25% at 25% replacement of rice husk ash, 37.5% at 25% replacement of metakaolin, and 39.58% at 40% replacement of rice husk ash in combination with metakaolin at a 1:1 ratio.
5) **Mudasir Hussain Pandit et al. (2014)** was conducted a study in which they explored the use of fly ash, micro silica, and recycled concrete aggregates. Their objective was to completely replace cement with fly ash while incrementally increasing the addition of micro silica from 5% to 15%. Additionally, they replaced coarse aggregate with recycled concrete aggregate, increasing the replacement from 5% to 15%, all within the context of an M25 grade concrete mix. The results of the study revealed that the introduction of fly ash led to permeability issues. However, increasing the replacement of concrete aggregates helped mitigate this issue, and the optimal percentage for replacement was determined to be 10%, taking into account various safety considerations.
6) **Rakesh Sakale et al. (2015)** conducted a study examining the impact of replacing fine aggregate with waste glass powder in increments of 10%, 20%, 30%, and 40% by volume of cement. The study assessed how this replacement affected compressive strength, split tensile strength, workability, and flexural strength of the concrete. The findings revealed that the compressive,

flexural, and split tensile strengths of the concrete demonstrated an initial increase as the proportion of glass powder increased, with the strengths peaking at approximately 20%, and then exhibiting a decrease.

7) **Mohseni et al**. **(2017)** conducted an experimental study to investigate the effects of using metakaolin and rice husk ash as partial replacements for cement, along with the addition of polypropylene, on the water absorption and mechanical properties of mortar. Various cement mortar mixtures were created with different replacement ratios of metakaolin, ranging from 5% to 15%, and rice husk ash, varying from 10% to 30% by weight of the cement. The content of polypropylene fibers was maintained at 0.3%. The results of the study indicated that the combination of 10% metakaolin, 10% rice husk ash, and 0.3% polypropylene fibers exhibited improved durability and mechanical properties.
8) **Bheel et al. (2020)** An observable trend in the study was a reduction in workability as the utilization of RHA increased in concrete. Where workability decreased as the proportion of RHA in the mix increased. This aligns with the conclusions drawn in a related experimental study by Bheel et al. in 2020, which noted that workability was minimized as the quantities of fly ash and RHA in the mixture were augmented.

3) OBJECTIVES OF STUDY

- To conduct a thorough investigation into the strength and workability properties of M30 grade concrete made with slag sand, incorporating both glass powder and rice husk ash.
- To identify the ideal combinations and ratios of rice husk ash, slag sand, and glass powder.
- To achieve improved compressive strength, tensile strength, and flexural strength, all while evaluating the impact of these additional materials on the workability and feasibility of concrete placement.
- To investigate the cementitious characteristics of rice husk ash and its potential application as an affordable construction material by partially substituting ordinary Portland cement in concrete. This approach offers a practical solution for the disposal of rice husk ash, converting it into a valuable agricultural resource. Notably, this initiative has the potential to enhance rural economies and generate employment opportunities.

- The goal is to shift the status of rice husk from an environmental challenge to a valuable resource for the creation of an exceptionally efficient supplementary cementitious material.

4) EXPERIMENTAL PROGRAMME

4.1. MATERIALS

4.1.1. Ordinary Portland cement

For this experiment, Sri Chakra Ordinary Portland cement (OPC) was employed in the preparation of the mix design. All concrete mixtures in this study were prepared using Ordinary Portland cement of 53 grade, which adhered to the standards specified in IS 12269-1987. The physical attributes of the cement were assessed in accordance with IS 4031-1999, revealing a specific gravity of 3.15 and an initial setting time of 40 minutes.

4.1.2. Rice Husk Ash (RHA)

Rice husk ash was obtained from Hyderabad and employed in the current experimental analysis (see Fig.1). Rice husk ash is highly versatile, offering a multitude of applications due to its diverse properties. It excels as an insulator and plays a role in various industrial processes, including applications in steel foundries, the production of house insulation, and refractory bricks. Additionally, it acts as an active pozzolan and finds numerous applications within the cement and concrete industry. Highly calcined and finely ground rice husk ash (RHA) exhibits remarkable reactivity and significantly enhances the strength and durability of both cement and concrete.

Figure 1 Rice Husk Ash

4.1.3. Slag sand

Slag sand is a product of the steel industry, extracted during the smelting process. It exhibits a specific gravity of 2.89, a water absorption rate of 1.32, and a fineness modulus of 2.32. Slag sand proves to be an excellent option for concrete when employed as a fine aggregate in construction. Its pozzolanic characteristics enhance the durability of concrete, reduce heat generation during hydration, leading to increased compressive strength, and minimize shrinkage, ultimately resulting in cost savings over time. In this study, JSW Slag sand is employed as a replacement for natural sand.

4.1.4. Water

Water plays an important role in concrete since it actively participates in the chemical reactions with cement. Clean potable water free from impurities was used as mixing water for production of concrete mixtures with pH of 7.3, and certain requirements also consider water quality when producing concrete. The attainment of the desired strength and workability of the concrete mixture is contingent upon the appropriate water content. The water employed throughout this research, whether in casting or curing processes, adhered to the standards outlined in IS 456-2000, and it was devoid of any harmful contaminants.

4.1.5. Glass Powder

Glass powder, which consists of finely ground glass particles obtained through grinding or milling glass materials, plays a vital role as an additive in concrete applications. Thanks to its fine particle size and pozzolanic characteristics, glass powder contributes to the improved workability, mechanical properties, and durability of concrete mixtures. Additionally, the utilization of glass powder in concrete presents an eco-friendly approach to address the increasing concern of glass waste management.

4.1.6. Coarse aggregate

Coarse aggregate plays a pivotal role in concrete, providing fundamental properties that influence its strength, durability, and overall performance. Coarse aggregates remained unaltered, with the sole modification being the selection of size. Materials within the range of 4.75mm up to 20mm aggregates were chosen in accordance with the properties specified in IS:383-2016, and their specific gravity was determined to be 2.85.

4.2. MIX DESIGNING

The concrete mix design adhered to the standards of IS 10262-2019, with the aim of achieving M30 grade strength while maintaining a water-to-cement ratio of 0.5. A total of twelve distinct concrete mixes were formulated, featuring variations in the percentages of Rice husk ash and Glass powder, ranging from 0% to 30% and 0% to 20%, respectively. The primary focus of the investigation revolved around conducting a comprehensive evaluation of strength characteristics, encompassing compressive, flexural, and split tensile strength. To ensure the reliability of the test results, six cubes, three cylinders, and three beams were meticulously cast and subjected to examination for their hardened properties.

Table 1 Mix proportions

Cement(kg/m^3)	Coarse Aggregates(kg/m^3)	Fine Aggregates(kg/m^3)	W/C Ratio
425	1150	560	0.5

4.3. TEST PROCEDURES

4.3.1. Compressive strength

Concrete cubes, each measuring 100 x 100 x 100 mm, were fabricated in metallic molds and subsequently subjected to compressive strength testing after 28, and 90 days of wet curing. The testing procedure adhered to the standards outlined in IS 4926:2003(R2017) and BS EN 12390-3:2009, employing a universal testing machine with a constant load rate of 2.5 kN/s.

4.3.2. Split tensile strength

Concrete cylinders, measuring 150 x 300 mm, were fabricated using metal molds and subsequently subjected to splitting tensile strength testing following 28 days of wet curing. The testing was conducted in accordance with IS 5816:1999(R2004) and involved loading the concrete cylinder samples at a constant rate of 3 kN/s.

4.3.3. Flexural strength

Concrete beams, with dimensions of 100 x 100 x 500 mm, underwent testing for flexural strength following water curing at 28 days. The testing protocol was in accordance with IS 516-1959(R2004) and BS EN: 12390-5:2009, involving a two-point bending test where the load was applied at a constant rate of 2.5 kN/s.

4.4 METHODOLOGY

The casting and curing process for beams, cubes, and cylinders followed standard procedures. Surface preparation was performed, and the interior of the moulds received thorough oiling. Subsequently, concrete was mixed using a pan mixer (SKILLET MIXER), chosen for its advantages over traditional transit mixers, ensuring uniform mixing. Moulds were cast and demoulded after a 24-hour interval, followed by immersion in a curing tank. Testing was carried out on specimens at the 28 and 90 days.

5. RESULTS AND DISCUSSIONS

The mechanical properties of concrete, incorporating different proportions of Rice ask ash and Glass powder, at both 28 and 90 days, are elaborated upon in the following sections.

5.1. MECHANICAL PROPERTIES

5.1.1. Compressive Strength

In this section, the results of the compressive strength tests conducted on cube specimens from different mixtures after curing are presented and discussed. The tests were conducted at both 28 days and 90 days. Detailed information on the compressive strength of the mixtures after 28 and 90 days of curing is provided in Table 2 and Table 3, respectively.

Table 2. Compressive strength test results for 28 days

Glass powder (% addition)	Rice husk ash (% replacement)			
	0%	10%	20%	30%
0%	38.92	43.70	41.52	38.41
10%	41.48	44.63	42.56	39.53
20%	39.81	42.81	40.32	37.68

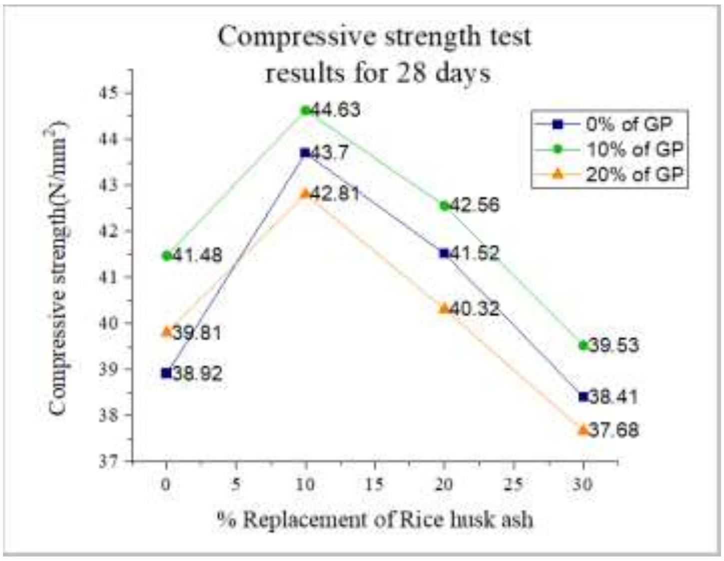

Figure 2. Variation of Compressive strength for 28 days

The provided Figure. 2 illustrates the compressive strength of concrete following 28 days of curing. The results indicate a significant enhancement in compressive strength up to a 20% replacement of Rice husk ash and the addition of 20% glass powder. This improvement can be attributed to the pozzolanic reactions initiated by Rice husk ash, as well as the fine particle characteristics of both glass powder and Rice husk ash. However, beyond this 20% threshold, there is a decrease in compressive strength. The highest observed compressive strength, reaching 44.63 N/mm^2, was achieved with a 10% replacement of Rice husk ash and a 10% addition of glass powder.

Table 3. Compressive strength Test Results for 90 days

Glass powder (% addition)	Rice husk ash (% replacement)			
	0%	10%	20%	30%
0%	44.34	50.20	47.81	43.72
10%	47.67	51.91	48.51	45.95
20%	45.82	49.20	46.31	43.20

The provided Figure 3 illustrates the compressive strength of concrete after a 90-days curing period. It's evident that the 90-day strength of slag sand concrete, when blended with Rice husk ash and the addition of glass powder, typically increases by approximately 15% compared to the

28-day strength. This increase can be attributed to the extended curing period, allowing for the continued development of the concrete's microstructure. The maximum compressive strength of concrete reached 51.91 N/mm2 after 90 days of curing, marking a significant 33.48% improvement compared to conventional concrete.

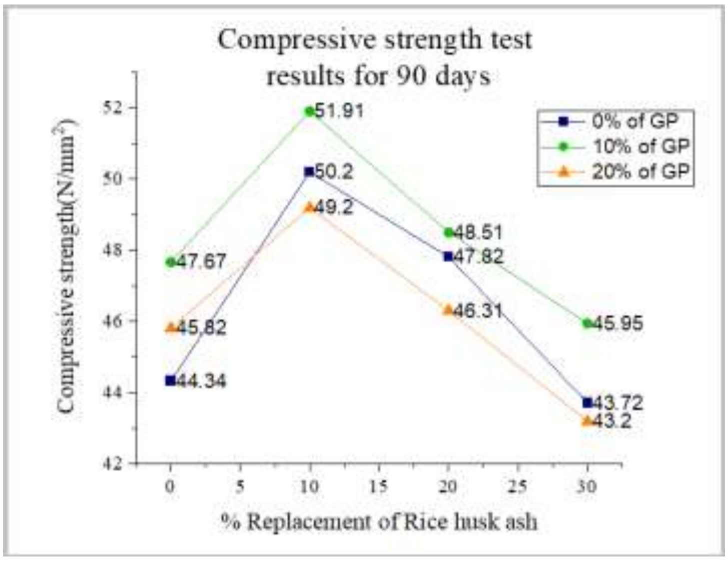

Figure 3. Variation of Compressive strength for 90 days

5.1.2. Split tensile strength

In this section, the outcomes of the split tensile strength test conducted on concrete specimens with different mixtures are presented and discussed. The table below provides details on the variation in split tensile strength among all the mixtures after 28 days of curing.

Table 4. Split tensile strength Test Results for 28 days

Glass powder (% addition)	Rice husk ash (% replacement)			
	0%	10%	20%	30%
0%	3.19	4.02	3.68	3.29
10%	3.75	4.27	3.82	3.65
20%	3.43	3.74	3.49	3.16

The provided Figure 4 illustrates the split tensile strength of slag sand concrete after 28 days. It is evident that a 20% addition of glass powder and a 30% replacement of cement with Rice husk ash result in reasonable split tensile strength when compared to ordinary concrete. The combination of 90% cement, 10% Rice husk ash, and a 10% addition of glass powder yields the highest mean strength for M30 grade slag sand concrete. The optimal split tensile strength achieved from this mixture is 4.27 N/mm^2, representing a substantial 28.6% improvement compared to conventional concrete.

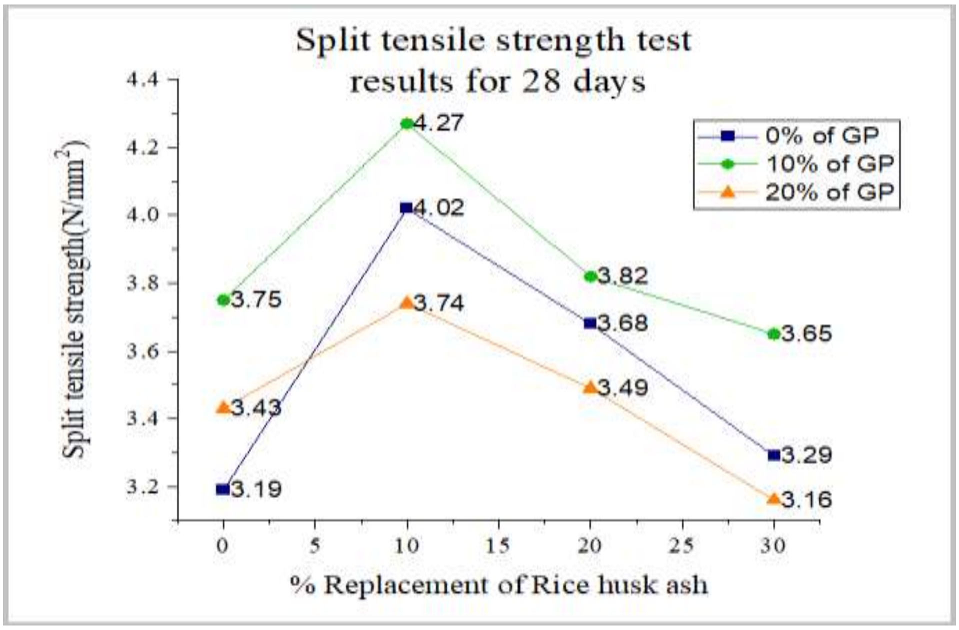

Figure 4. Variation of Split tensile strength for 28 days

5.1.3. Flexural strength

Beam specimens were subjected to flexural strength testing at the 28 days to evaluate their performance. The table below provides details on the variation in flexural strength across all the mixtures.

Table 5. Flexural strength Test Results for 28 days

Glass powder (% addition)	Rice husk ash (% replacement)			
	0%	10%	20%	30%
0%	6.72	7.15	6.84	6.37
10%	7.98	8.52	7.86	7.21
20%	7.28	7.75	6.97	6.54

The provided Figure 5 illustrates the flexural strength of slag sand concrete after 28 days. It is evident that a 20% addition of glass powder and a 30% replacement of cement with Rice husk ash result in reasonable flexural strength compared to ordinary concrete. This improvement can be attributed to the synergy of these supplementary cementitious materials, which enhances the interconnectivity of hydration products, leading to improved bonding and crack resistance. The combination of 90% cement, 10% Rice husk ash, and a 10% addition of glass powder yields the highest flexural strength for M30 grade slag sand concrete. The optimal flexural strength achieved from this mixture is 8.52 N/ mm^2, marking a significant 30.9% enhancement compared to conventional concrete.

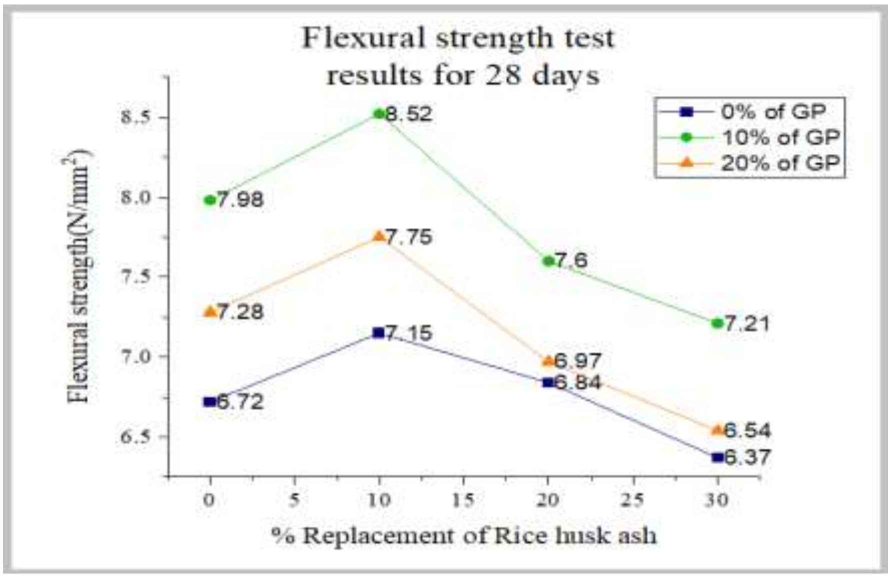

Figure 5. Variation of Flexural strength for 28 days

6. CONCLUSION

The present study investigates the impact of incorporating glass powder and Rice husk ash in slag sand concrete. The following key findings emerged from this research:

- The observed strength improvement in slag sand concrete blended with Rice husk ash and glass powder can be attributed to the combined effects of pozzolanic reactions, enhanced particle packing, improved bonding, reduced cracking tendencies, enhanced workability, and increased durability.
- Concrete formulations that replaced 10% and 20% of cement with Rice husk ash, along with the addition of 10% and 20% glass powder, yielded better results when compared to ordinary concrete.
- The optimal values for compressive strength, tensile

strength, and flexural strength were achieved when using a 10% replacement of cement with Rice husk ash and a 10% addition of glass powder.

- The incorporation of Rice husk ash and glass powder in concrete can enhance strength, cost-effectiveness, and environmental sustainability. However, an excessive usage of these additives may dilute the cementitious content in the mixture, diminishing the positive effects and resulting in reduced concrete strength. Therefore, it is essential to carefully consider the dosages and proportions of these materials to maximize their benefits while avoiding any adverse effects on concrete strength.

7. REFFERENCES

[1] Saraswathy V. and Song, H.W. (2007). Corrosion I'erformance of Rice Husk Ash Blended Concrete. Construction and Building Materials. 2 1 (8), 1779-1 784.

[2] Kartini, K, Mahmud HB, Hamidah MS (2008) “Strength properties of Grade 40 rice husk ash concrete.” 31st Conference on Our World in Concrete and Structures; 2006.

[3] Idir R., Cyr M., and Tagnit-(amou A. î‘TT9Ȍ Use of Waste Glass as Powder and Aggregate in Cement-Based Materials SBE)DCO – 1st International Conference on Sustainable Built Environement Infrastructures in Developing Countries ENSET Oran (Algeria).

[4] Kannan, V, Ganesan, K, 2012, 'Strength and water absorption properties of ternary blended cement mortar using Rice Husk Ash and Metakaolin', vol.1, pp. 51-59.

[5] Mudasir hussain pandit, Mrs. D. Renuka, permasehwari " High Density Concrete, Using Flyash, Microsilica and Recycled Aggregate ".Department of Civil Engineering SRM University Chennai, India. (International Journal of Engineering Trends and Technology, Vol 10, Issue 1, April 2014

[6] Rakesh Sakale, Sourabh Jain and Seema Singh, DzExperimental investigation on Strength of Glass Powder Replacement by Fine Aggregate in Concrete with Different Dosages. international Journal of Advanced Research in Computer Science and Software Engineering, Vol.5, Issue 12, December 2015, pp. 386390, ISSN: 2277-128X.

[7] Mohseni, E, Yazdi, M A, Miyandehe B M, Zadshir M and Ranjbar M M (2017), ‘Combined effects of metakaolin, rice husk ash and polypropylene fibre on the engineering properties and microstructure of mortar. Journal of Materials in Civil Engineering, vol.29, no.7.

[8] Bheel N, Jokhio MA, Abbasi JA, Lashari HB, Qureshi MI,

Qureshi AS (2020) Rice husk ash and fly ash effects on the mechanical properties of concrete. Engineering, Technology & Applied Science Research 10(2):5402–5405