iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: VI Month of publication: June 2023

DOI: https://doi.org/10.22214/ijraset.2023.54367

Partial Replacement of Cement with Different Wastes - A Review

Niroj Aryal[1], Pawan Ghimire[2]
[1,2]Department of Civil Engineering, Jain Deemed-to-be University, Bangalore, India

Abstract: The production of sustainable concrete, the adoption of sustainable practices, and the exploration and utilization of supplementary cementitious materials (SCM) have gained popularity worldwide. The traditional concrete practices and their environmental impact, such as greenhouse gas emissions resulting from cement production, make researchers and industries look for alternative cementitious materials. This paper reviews the SCM Bamboo leaves ash, coconut shell ash, eggshell powder, fly ash, GGBS (ground granulated blast furnace slag), paper sludge ash, waste glass powder, rice husk ash, silica fume, steel slag, sugarcane bagasse ash, water hyacinth, and wheat straw ash, their performance to improve strength and durability properties, as well as their impact on the concrete mix. The main purpose of this review paper is to study and evaluate the possibilities of cement replacement material in the production of sustainable concrete. This review article gives information about SCM and how these materials can help reduce the environmental impact of conventional concrete and promote the development of sustainable concrete and environmentally friendly construction practices.
Keywords: Sustainable concrete, SCM, Greenhouse gases, Strength, Durability

I. INTRODUCTION

One of the most popular building materials in the world is concrete. It is made up of cement, fine and coarse sand, water, and various admixtures that boost strength and durability by lowering the water content. To create concrete structures, more than 4.4 billion metric tonnes of cement are generated worldwide. According to a study, 0.91 kg of carbon dioxide is released into the atmosphere for every kg of cement. The manufacture of cement requires a finite amount of raw materials, and the process has a significant negative impact on the environment. Many researchers propose replacing cement with various types of waste, such as industrial waste, plant waste, and agricultural waste, to mitigate this effect. If the different types of waste can be reused and recycled, the use of natural resources will increase efficiency, and waste material having cementitious properties can be utilized. Hence, this helps to develop sustainable concrete.
The different waste materials are:

1) Coconut Shell Ash

Coconut shell is a waste produced by the agricultural industry. The coconut shell ash, which is obtained by burning the coconut shell, has pozzolanic properties and can be used as a partial replacement for cement in the concrete industry.

2) Steel slag

Steel slag is a by-product generated by the steel-making process. Steel slag requires a lot of effort and continues to be a burden on our environment. However, their use in concrete might be favourable and minimize cement consumption. Steel slag, which possesses pozzolanic qualities, may be crushed to a fine powder and used as an alternative material for partial replacement for cement.

3) Fly Ash

Fly ash is a finely fragmented residue formed from the combustion of pulverized or powdered coal in a thermal power plant. It possesses properties that resemble pozzolanic materials and possesses a degree of self-cementing abilities.

4) Silica Fume

A by-product of the production of silicon and ferrosilicon alloys is silica fume, an ultrafine powder. It contains a lot of amorphous silica. Silica fume can be used as a partial replacement for cement in the concrete industry. When good abrasion resistance and low permeability are required, silica-fume concrete might be helpful.

5) Glass Powder

Waste glass has a severe environmental problem, and it has been challenged to reduce and reuse the solid waste. Waste glass can be ground into powder and used as a partial replacement for cement as it has pozzolanic properties. It provides a safer place for the waste glass and reduces the use of cement in concrete.

6) Sugar Bagasse Ash

Sugar bagasse is a waste material that is collected from the plants where juice is extracted. Due to its pozzolanic qualities, burning sugar bagasse can produce ash that can be used as a partial substitute for cement in the concrete industry.

7) Water Hyacinth

Water hyacinths are aquatic blooming plants that grow in private conservatories and botanic gardens. The main factor contributing to the decline of aquatic life is water hyacinth. It quickly spread throughout the entire aquatic body. It is applicable to the concrete sector. It can be partially replaced with cement thanks to the pozzolanic qualities of the ash produced after burning it. By using water hyacinth as a substitute for cement, the impact on aquatic ecosystems is minimized.

8) Eggshell Powder

The eggshell is a hard outer covering made up of carbonate. Eggshells can be ground into powder and used in concrete production as the substitute for cement instead of being disposed of in the environment.

9) Paper Sludge and Ash

Waste produced by the paper industry is known as paper sludge. Due to its pozzolanic qualities, the unprocessed and dry paper sludge can be burnt and used as a partial substitute of cement in some applications. It contributes to lessening the environmental impact of both sludge and cement manufacture.

10) Wheat Straw Ash

Wheat straw is an agricultural waste. It contributes to environmental degradation since farmers burn it in open fields. Wheat straw may be burned under regulated conditions, resulting in ash with cementitious properties that can be used as a partial substitute for cement.

11) Rice Husk Ash

Rice husk is the outer covering that is obtained from the rice mills. Rice husk can be burned, and its ash can be used as a partial replacement alternative for cement as it has cementitious properties.

12) Bamboo Leaves and Ash

Bamboo leaves are the fallen leaves of bamboo when it reaches its mature stage. The waste leaves whose disposal ultimately harms landfills and the environment are SCM to replace cement. BLA is a good material to improve the mechanical and durability properties of concrete.

13) GGBs

It is the industrial waste generated from blast furnace slag.

In recent years, the construction sector and researchers have shown more interest in sustainable concrete due to the environmental effects of infrastructure development. Concrete, being the most frequently used construction material, has a substantial impact on developing a sustainable environment. Conventional concrete production is associated with CO2 emissions and the depletion of resources (like limestone to make cement), and a lot of waste is generated. Subsequently, researchers and industries are looking for alternative materials to replace cement in order to reduce the environmental impact of cement production and its use.

The main aim of this review paper is to study the potential of cement replacement material in sustainable concrete production. The SCM has gotten a lot of interest as they can replace cement partially or fully, which lowers the carbon footprint, reduces costs, and preserves natural resources. SCM such as Bamboo leaf ash, coconut shell ash, eggshell powder, fly ash, GGBS (ground granulated blast furnace slag), paper sludge ash, waste glass powder, rice husk ash, silica fume, steel slag, sugarcane bagasse ash, water hyacinth, and wheat straw ash are considered in this study.

These different cement replacement waste materials have distinct physical and chemical properties and qualities that make them promising alternative materials for sustainable concrete production. Bamboo leaf ash and coconut shell ash are commonly used agricultural wastes that can be utilized as pozzolanic material in order to improve the mechanical and durability properties of concrete. Eggshell powder, which is a pozzolanic material, has the potential to improve the performance of concrete.

Waste fly ash and GGBS are industrial by-products obtained from coal combustion, and blast furnace slag has cementitious properties that can partially replace cement. The SCM not only reduces CO2 and other greenhouse gas emissions but also improves the workability and performance of concrete up to a certain percentage. Based on their unique properties and potential contributions to sustainable concrete, other materials like paper sludge ash, waste glass powder, rice husk ash, silica fume, steel slag, sugarcane bagasse ash, water hyacinth, and wheat straw ash also have a significant impact on the strength and durability of concrete. This review paper aims to find a comprehensive overview of sustainable concrete and the current state of research on SCM, assessing its mechanical properties, durability, and environmental impact.

This review study seeks to contribute to the improvement of sustainable concrete production, creating a greener and more robust built environment by exploring the enormous diversity of cement replacement materials.

II. LITERATURE REVIEW

A. Partial Replacement of Cement with Coconut Shell Ash (CSA)

P. Vasanthi et al. (2020) studied the mechanical behaviour of concrete with CA replaced by CSCA and cement replaced by CSA. The broken pieces of sun-dried coconut shell were burnt for three hours in the open (uncontrolled combustion) and then calcined for six hours at 8000 °C in a muffle furnace, which changed the crystalline form of ash into an amorphous form. The chemical oxide composition of the CSA employed in the study (SiO2 + Al2O3 + Fe2O3) was determined to be 72.34%, making it appropriate for usage as a cementitious material. The mix percentage was calculated for M20 concrete. The replacement levels in cement and coarse aggregate were studied by CSA and CS for 5%, 10%, 15%, 20%, 25%, and 30%.

By substituting crushed sand for 15% of the fine aggregate and calcium silicate ash (CSA) for 10% of the cement, the concrete's capacity to endure compression was increased. However, the compressive strength gradually decreased when more crushed sand and CSA were substituted. The flexural strength of the concrete also showed a similar pattern, improving up to 15% with crushed sand and replacing 12% with CSA. The flexural strength was discovered to be equal to 11% of the comparable compressive strength.

Vignesh Kumar Nagarajan et al. (2014) studied the use of coconut shell ash as partial replacement of cement. As the cost and production of cement are increasing daily due to the increase in the need for housing and other construction requirement, it is utmost important to identify alternative materials whose properties are good enough to be used as replacement materials. The preparation of coconut shell ash involves sun-drying for 3 days to remove the meat from the inner shells, scraping the meat from the inner shells using knives or other equipment, cutting the coconut shell into pieces of size 1 sq. cm using a hammer, and putting the pieces into the stainless container. The ash is placed into a muffle furnace for carbonization at a temperature range of 600–800 degrees. Using a grinding machine, the collected char was processed into a powder. The powder was then sieved to a size of 2.2 mm.

The test results reveal that the compressive strength diminishes as the percentage of cement containing CSA increases. The 7-day strength reduced from 13.78 N/mm^2 to 6.43 N/mm^2 with 30% CSA replacement. After 28 days of curing, the strength reduced from 34.22 N/mm^2 to 13.11 N/mm2 for 30% replacement with CSA. At 10% replacement (31.78 N/mm2), the best 28-day strength for the OPC-CSA combination is recorded.

Utsev, J. T., Taku, & J. K. (2012) have used coconut shell ash as a partial replacement for cement. As Coconut shell is an environmental pollutant, to reduce this waste and hence make sustainable concrete, they collected the shells and sundried them for 2-3 days, then burned them in the open air (Uncontrolled combustion) for about 3 hours and then let them cool for about 12 hours. The ashes were collected and sieved via a 75-micron BS Sieve. CSA has a chemical composition of 37.97% SiO2, 24.12% Al2O3, and 15.48% Fe2O3.

So the amount of SiO2+Al2O3+Fe2O3 is 77.57%, which meets the ASTM C 618-78 standard of 70% for pozzolana. They have partially replaced cement with CSA at rates of 5%, 10%, 15%, 20%, 25%, and 30%, respectively. A total of 54 cubes were cast using a 1:2:4 mix ratio. The ratio of water to cement was 0.5.

The results showed that as the CSA content increases, so do the setting time and compressive strength. The best 28-day strength for the OPC-CSA combination is 10% replacement (31.78 N/mm2). Furthermore, when 10-15% of the cement was replaced with CSA, the compressive strength rose from 12.45 N/mm2 after 7 days to 31.78 N/mm2 after 28 days of curing. As a result, for the manufacturing of heavyweight and lightweight concrete, a 10-15% substitution of OPC with CSA is advised.

B. Partial Replacement of Cement with Eggshell Powder (ESP)

Mohd Yunus Ishak and Muhammad Nazrif Zamani (2019) have presented experimental data on the behaviour of eggshell powder as a partial replacement material of cement in concrete production. Chicken egg shells are collected from bakeries, hamburger stands, restaurants, and night market stalls. They are washed with tap water, sun dried for 24 hours, and then heated at 110°C for 24 hours to eliminate moisture. The chemical test on the powder shows that it is rich in calcium carbonate (93.70%).

The result shows that compressive strength, split tensile strength, and flexural strength give the optimum strength at 10% replacement, and the values are 22.50 MPa, 8.03 MPa, and 3.83 MPa at 28 days, respectively. And all the strength goes on decreasing as the percentage replacement increases. Increases in eggshell powder increase incomplete hydration and hence less C-S-H gel formation, leading to voids in concrete particles that develop and allow moisture to fill in. As a result, the density of the concrete drops, as does its water absorption, resulting in a loss in the mechanical characteristics of the specimen.

Ashfaque Ahmed Jhatial, et al. (2019), studied the use of eggshell powder as the partial replacement of cement. They gathered eggshells from nearby bakeries and food booths. The raw eggshells had a yellowish fluid that was rinsed away with clean water. The eggshell was cleaned and dried for 24 hours at 105 °C to remove any moisture that may have been gained during the cleaning. Once the eggshells were oven-dried, they were ground using a blender. The grinded eggshell was then sieved through 50 and 100micron.

The workability of concrete was determined using the BS standard, and it was discovered that the workability diminishes as the ESP content increases. This might be because of the huge surface area of the ESP, which consumes water and limits flowability. After the samples had been cured for 3, 7, 14, and 28 days, the compressive strength test was conducted in accordance with BS EN (2009b). ESPs of two different sizes were employed. ESP with 50-micron and 100-micron dimensions the optimal strength of 47 MPA at 28 days is obtained by replacing 10% of the cement with ESP (50 microns). When cement is replaced with ESP (100 microns) by 10%, the compressive strength at 28 is 45.88 MPA. The compressive strength of concrete was shown to be significantly influenced by the fineness of ESP.

Atul Kumar (2018) investigates the use of eggshell as partial replacement of cement. The cement is replaced with 5%, 10%, and 15% of ESP. The concrete was designed for the M30 grade. The ratio of water-to-cement was 0.4. As the replacement rate of EPS rises, the concrete's capacity to absorb water declines. The compressive strength was conducted at 7^{th} day and 28^{th} day. The results show that a 10% replacement of EPS gives the optimum strength of 32.78 MPa at 28 days.

Parthasarathi, M. Prakash, and K. S. Satyanarayanan (2017) have done an experimental study on concrete by partially replacing cement with eggshell powder and silica fume. Firstly, the egg shells were collected and washed using normal water, and then sundried for the whole day in order to make them completely dry, which makes grinding ESP easy. From grinding, it has been found that 1 teaspoon of ESP is produced from each egg shell. Ball millers were used to grind the eggshell to make it as fine as cement, then sieve it through a 90-micron sieve. The chemical composition test shows the highest percentage of SiO_2 (90.21) in silica fume and CaO (50.7%) in eggshell powder. These two materials are blended in order to match the chemical composition of this material with that of the cement. In addition to replacing silica fume by 2.5%, 5%, and 7.5% of the cement's weight, they have been replaced by 5%, 10%, and 15%, respectively.

The optimum compressive strength was obtained at 15% replacement. The compressive strength and flexural strength of cubes were found to be higher as compared to normal concrete cubes, with up to 15% replacement of ESP. With more powder present, the split tensile strength dropped. Additionally, silica fume exhibits a slight strength gain, but from an economic standpoint, ESP powder substitution is sufficient to provide the requisite greater strength of concrete.

C. Partial Replacement of Cement with Fly Ash

Prof. K. Yugandhar Reddy (2022), In this study, cement and coarse aggregate have been partially replaced by fly ash, rice husk ash, and coarse aggregate, respectively. Rice husk is the outer layer of ripe rice grains, fly ash is a result of the coal industry, and steel slag is a byproduct of the steel industry.

From the workability test, it has been found that the slump value decreases as the percentage rate of the RHA increases in concrete. The compressive strength test result shows that 30% fly ash, 0% rice husk ash, and 5% steel slag in coarse aggregate have obtained an optimum strength of 18.45 MPa, which is very low as compared to the control mix (27.67 MPa) at 28 days of curing. Similarly, 25% fly ash, 5% rice husk ash, and 10% steel slag in coarse aggregate give a split tensile strength of 6.44 MPa.

Conhyea M. and Goodary R. (2020) have examined how fly ash affects the use of cement substitutes in the partial replacement of cement in the manufacturing of concrete. Waste from industries that burn coal is called fly ash. Fly ash is a relatively small particle with a mean diameter of 5 to 15 microns that was collected from a nearby thermal power plant. They have replaced cement partially with CSA at the rates of 5%, 10%, 15%, 20%, 25%, 30%, 40%, and 50%, respectively.

The experimental test result shows that the compressive strength increases as the percentage of fly ash increases to 25%, and then there are significant drops starting above 25% partial replacement. The fly ash gives optimum strength at 15%, which is 36.9 MPa, which is less than conventional concrete (33.1 MPa) at 28 days. The flexural strength remains static at 40% of fly ash replacement, and they have observed a drastic drop at 50% of fly ash replacement.

Shankh Agrawal and Honey Gaur (2019), summarises the impact of fly ash production on global warming in this research. Depending on the source and arrangement used to burn the coal, different amounts of fly ash are created during coal combustion. The fly ash contains SiO2 and CaO as its main constituents. The casting of cubes has been done for M10, M20, and M30 grades of concrete with 10%, 20%, and 30% replacement of fly ash with cement.

Since the water-to-cement ratio remained constant throughout the test, the consumption of admixtures dropped as the amount of fly ash replaced by cement decreased. The 10% fly ash replacement has given the optimum strength for all grades of concrete, and there is a marginal reduction in strength for the 20% and 30% fly ash replacements for all grades of concrete. The good thing about using fly ash is that it improves the workability of the concrete up to a certain percentage. So, in the overall concrete mix, either the water content or the admixture dosage should be reduced to improve the strength of the concrete mixture.

Prof. Jayeshkumar Pitroda, Dr. L.B. Zala, and Dr. F.S. Umrigar (2012) examined the properties of concrete utilising fly ash as a cement substitute. The Maize Products power plant at Kathwada, in Gujarat's Ahmedabad District, provides fly ash for this project. Maize Products is a part of Sayaji Industries Ltd. According to IS 1062:2009, a combination of M25 and M40 grades was created. For M25, the water-cement ratio is 0.4, while for M40, it is 0.3. Cement was substituted at 0%, 10%, 20%, 30%, and 40%. The concrete was poured into 150-mm cube moulds. Demoulded specimens were cured for 7, 14, and 28 days.

Compressive strength tests were performed, and it was discovered that for the M25 grade mix design, 10% cement substitution with fly ash resulted in an optimal strength of 34.67 MPa on the 28th day. A typical concrete cube has a compressive strength of 44.59 MPa. It demonstrates that compressive strength diminishes as the fly ash replacement percentage increases.

On the 28th day, the compressive strength of the M40 grade mix design for conventional concrete was determined to be 52.74 MPa. On the 28th day, the optimal compressive strength was determined in the 10% replacement of fly ash as compared to the other percentages of fly ash replacement, and it was 38.22 MPa. This demonstrates that compressive strength reduces as the percentage of fly ash substitution increases in comparison to conventional concrete.

The split tensile tests were performed on both blended designs. 10% replacement provides marginal strength for the M25 grade mix design as compared to the traditional one, and that strength was 3.52 MPa. Beyond this point, the tensile strength gradually declines. In comparison to ordinary concrete, 10% replacement gives an optimal strength of 4.10 MPa for the M40 grade of mix design. Beyond that, the split tensile strength of the cylinder gradually decreases.

D. Partial Replacement of Cement with GGBS

Yogendra O. Patil, Prof. P.N. Patil, and Dr. Arun Kumar Dwivedi (2013) have conducted a concrete experiment utilizing GGBS, or ground granulated blast furnace slag. In this study work, GGBS, a waste product produced by the iron production sector, was used as a partial replacement for cement in order to lower greenhouse gas emissions and create sustainable concrete. The main chemicals present in GGBS are Sio2-34.4%, Al203-21.5%, and Cao-33.2%. The cement is partially replaced with GGBS, from 0% to 40%.

The outcome demonstrates the difference between the percentage increase in GGBS and concrete's compressive strength. After 90 days of curing, the GGBS with 20% replacement has adequate strength. In comparison to regular concrete, GGBS concrete needs more time to cure. The workability increased with GGBS percentage replacement. Hence, the water-cement ratio shall be decreased. The optimum strength was obtained at 10% of GGBS replacement, but the rest of the result shows that up to 20% replacement can be done based on the strength requirement of a concrete mixture. Santosh Kumar Karri, G.V. Rama Rao, and P. Markandeya Raju (2015) have studied the use of GGBS as the partial replacement of cement. The current study focuses on the characteristics of M20 and M40-grade concrete with ground limestone replacing some of the cement and 30%, 40%, and 50% granulated blast furnace slag (GGBS) as a substitute for cement. Specimens were also cured for 90 days in 1% H2SO4 acid and 1% HCl acid and for 28 days in 5% H2SO4 acid and 5% HCl acid. The workability of concrete improves as the proportion of GGBS substitution rises, giving M20 grade concrete a 40 mm slump at ordinary concrete and a 52 mm slump at 50% GGBS, and similarly, M40 grade concrete a 22 mm slump and a 44 mm slump. For both M20 and M40 concrete, optimum compressive strength was obtained at 40% replacement and began to fall when the amount of GGBS was taken over 40%. The strengths of conventional and 40% GGBS-replaced concrete for M20 and M40 grades of concrete are 46.2 MPa, 52.49 MPa, and 54.22 MPa, 57.46 MPa, respectively. For both grades of concrete specimens, the maximum values of split tensile strength and flexural strength are also attained at 40% GGBS. The durability test reveals that the concrete impacted by HCL has stronger compressive strength than the concrete influenced by H_2SO_4.

E. Partial Replacement of Cement with Waste Paper Sludge (WPS)

Krishnakumar. P., Vijayakumar. M., Athipathy. M. (2021), Investigated the partial replacement of cement with paper sludge ash. Paper sludge was burned and sieved via a 90-micron sieve before being used to partially replace cement. An M25 mix with a water-cement ratio of 0.45 was designed. Fresh concrete was made with 0%, 5%, 10%, and 15% cement supplemented by Paper sludge ash. As more paper sludge ash is substituted in fresh concrete, its workability decreases.

The compressive strength tests exhibit that 5% replacement provides the best strength, which was 32.3 MPa on the 28th day when compared to standard concrete. Furthermore, 5% substitution provides an optimal Split tensile strength of 2.68 MPa when compared to the traditional one.

VIKAS MEHTA et al. (2020) examined the characteristics of concrete with waste paper sludge used to replace some of the cement. The raw materials (waste paper sludge) for this research were gathered at Baddi, Solan (Himachal Pradesh), India. This project required the sieving of paper sludge ash through a 90-micron screen.

IS 1062:2009 was used to create a mix of M20 grades. The used water-to-cement ratio is 0.5. The cubes were cast with varied ratios of 5%, 10%, 15%, and 20% waste paper sludge as a partial replacement for cement. The workability of fresh concrete mix declines as the percentage of WPSA substitution increases.

The 10% replacement has the optimum strength in comparison with normal and other various percentage replacement. The split tensile strength of a 10% WPSA replacement is 2.92 MPa, which is higher than regular concrete and other percentage replacements. The water absorption of hardened concrete increases as the percentage replacement of WPSA increases.

Sajad Ahmad et al. (2013) show that the study shows the effect and performance of paper sludge concrete and conventional concrete. The JML Waste Paper Corporation in Punjab, India provided the paper sludge waste. The sludge was sun-dried, incinerated to convert it into ash, and sieved using a 90-micron IS Sieve. The chemical composition of sludge ash shows a higher percentage of Silica (60.57%) and Calcium (14.94%). In this research, cement is partially replaced with paper sludge ash at rates of 5%, 10%, 15%, and 20%.

At 28 days, a 5% substitution of cement with sludge ash results in a 15% improvement in compressive strength. The split tensile strength is greatest at 5% replacement, which is higher than ordinary concrete, and begins to decrease as the percentage rate of sludge ash increases. As the proportion of sludge ash in the concrete grew, so did its water absorption.

F. Partial Replacement of Cement with Recycled Glass Powder.

Amurutha Raj et al. (2021) reviewed the use of glass powder to control environmental problems, produce low-cost concrete, and evaluate the performance of powder on concrete strength. The replacement percentage was 5%, 10%, 20%, 30%, and 40% glass powder as a partial replacement for cement.

The 10% replacement enhanced the flexural strength, compressive strength and split tensile strength. Additionally, using glass powder in concrete may cut CO2 content by around 1 tonne for every 6 t of concrete and costs by up to 14%, making it both affordable and ecologically benign.

K.I.M. Ibrahim (2021) studied the use of recycled waste glass powder as a partial replacement for cement in concrete. In this study, waste glass was collected from a glass plant, pulverised by abrasion (Los Angeles), and processed in a mill. Glass powder with a grain size of less than 0.075mm was used. In this study, a Sika Company superplasticizer was used at a concentration of 0.3–4% of the binder. The replacement percentage was 0%, 5%, 10%, 15%, and 20%. The workability of new concrete improved as the WGP rose.

The compressive strength results showed that the strength was 36 MPa on the 28th day and was optimal at 5% replacement. Then it was reduced after this percentage replacement. Tensile strength, like compressive strength, was 3.65 MPa at 5% replacement and dropped after that. With an increase in WGP replacement, the water absorption falls. Therefore, 5% was determined to be the ideal dose for WGP replacement.

Nafisa Tamanna and Rabin Tuladhar (2020), invested on the use of recycled glass powder as a cement substitute in concrete. Mixed soda-lime glass was collected for this investigation from the Claims Regional Council's kerbside household garbage collection in Australia.. The glass crushing was done in three phases: the impeller, the shearing unit, and the sanding unit. The impeller's revolving blade smashed the glass. Glass particles are then removed to the shearing unit, where they are further crushed, and the impurities are removed in the sanding unit. The glass powder was further crushed in the sanding unit. The glass powder was sieved through 45 microns and collected. The chemical composition of RGP was found to be 74% SiO_2+Fe_2O_3+Al_2O_3 and suitable to use as the replacement material. The replacement percentage of RGP were10%, 20%, and 30%. The workability was obtained in a target range of 80–100 mm for 10% and 20% replacement, but it increased with 30% replacement.

The optimum strength was found at 10% replacement and it was 32MPa at 28th day. The addition of RGP had no influence on flexural strength, but it decreased tensile strength as the RGP replacement amount increased. The results of this investigation showed that replacing up to 10% of the cement with RGP is feasible.

M. Sadiqul Islam, M. H. Rahman, and Nayem Kazi (2017) have used waste glass powder as a partial replacement for cement to prepare sustainable concrete. The glass powder was prepared using a ball mill, and the chemical composition of both clear and coloured glass powder has been determined using XRF-1800. This shows the main chemical constituents in clear glass powder as SiO2 (68.1%), CaO (14.5%), and CaO (12%), respectively. During chemical composition testing, 20% of the binder is added to 80% of the glass powder in order to keep the material in place, and then the mix is pressed using 140 KN pressing force. The Polycarboxylate ether-based superplasticizer was used in the mortar strength test to evaluate the pozzolanic effect. The flow and compressive strength tests was carried on mortar and concrete by using glass powder of varying percentage ranges from 0 to 25% at a constant water-to-binder ratio.

The oxide compositions (SiO2 + Al2O3 + Fe2O3) should be more than 70%. The compressive strength of mortar was maximum at 10% replacement in 90 days of curing, and in 180 days, the optimum percentage was observed at 15% replacement. After 1 year of curing, it was observed that 20% replacement gave optimum strength, which is 8% higher as compared to conventional mortar. The concrete cube shows an optimum strength value at 10% replacement. In the long term (above 90 days of curing), the 10%, 15%, and 20% replacements show higher strength as compared to conventional cubes. So, the flow test of concrete increases slightly with an increase in the percentage replacement; 20% glass powder replacement gives optimum compressive strength at 90 days for both concrete and mortar. The addition of superplasticizer has improved the early strength of the mortar and concrete cube, and its replacement can reduce the cost of cement production by up to 14%.

G. Partial Replacement of Cement with Silica Fume

In Israr Ahmed et al. (2020), silica fume, an industrial by-product, was used to determine its effect on conventional concrete. In this research, they have replaced sulfate-resisting cement at rates of 0%, 5%, 10%, and 15%, respectively. Further, by maintaining the zero slump value in all mixes, an experimental test was performed. The chemical composition was found (SiO_2+ Al_2O_3+Fe_2O_3) to be 94.21%.

The optimum compressive strength of the cylinder was obtained at 5% silica fume replacement (32.121 MPa), and 10% replacement gives slightly less strength (31.551 MPa) as compared to 5% replacement. As compared to conventional concrete cubes, Silica fume-based cubes have shown more strength for all percentage replacements at 28 days of curing.

Shivam Malviya, Arbaz Baig, and Yash Liladia (2020), investigated the use of silica fume as the partial replacement of cement. The replacement percentage was 0%, 5%, 10%, and 15%. A mix of M25 was designed for this project.

The compressive strength results showed that it increases continuously from 5% to 10%, and after 10% it starts decreasing. The 10% replacement of silica fume has an optimum strength of 34.93 MPa on the 28th day.

Rohit Sharma (2018) investigated the use of silica fume as a partial replacement for cement. In this trial, he employed M20-grade concrete. The replacement percentages were 0%, 5%, 10%, 15%, and 20%. The specimens were cured for 7 and 28 days.

The compressive strength test result shows the optimum strength of the concrete cube at 15% replacement in 7 days (16.25 KN), and 10% replacement shows the optimum strength (34.93 KN) in 28 days of curing.

Lakhbir Singh, Arjun Kumar, and Anil Singh (2016) studied the use of silica fume as the partial replacement of cement in concrete. For this research, silica fume was obtained from the alloy production industry. A mix of M20 grades was designed for this project. Three percentage replacements, i.e., 5%, 10%, and 15%, were done.

The compressive strength increased continuously from 5% to 10%, respectively, and after 10% it started decreasing. The results showed that 10% replacement has an optimum strength of 34.93 MPa at 28 days. The optimum split tensile strength was obtained at 10% replacement and it was 4.91MPa on the 28th day.

H. Partial Replacement of Cement with Steel Slag

Shreyash Nitinrao Wakode (2022**)**: This paper uses steel slag, which is a by-product of the steel industry. So, to reduce the disposal problem and possible environmental impact, he used steel slag as a partial replacement for cement. The different percentage replacements of steel slag are 0%, 5%, 10%, 15% and 20%. The workability results showed that it decreases with the content of steel slag.

The compressive strength results showed that 15% and 20% replacement enhanced the strength.

Anjali P. and Sajitha Beegom A. (2022) investigated the effect of steel slag on concrete. Locally accessible steel slag fines were employed in this study. The slag passing through a filter with a mesh size of 90 microns. Standard mortar mixes with a 1:3 ratio of binder and M sand aggregates were made. Steel slag fines were used to substitute cement by 10%, 20%, and 30%, respectively.

The compressive strength of the mortar sample increases up to 20% before gradually dropping. With the 20% replacement of steel slag, a 2.99% reduction of compressive strength was obtained, and it was 51.8 MPa on the 28^{th} day for 20% steel slag and 53.4 MPa for ordinary mortar on the 28^{th} day.

Yogesh Nathuji Dhoble and Sirajuddin Ahmed (2019) utilized steel slag by partially replacing cement and also studied the cementitious properties of steel slag. The steel slag contains CaO (46.21%), Fe2O3 (14.89%), and SiO2 (9.52%). They cast a mortar block by replacing cement with 5%, 10%, 15%, and 20% steel slag.

The study shows that the size of the slag varied from 0.75 microns to 4mm in diameter and had free lime, which reacts with water to produce calcium hydroxide and further reacts with C-S-H gel. The free line causes soundness in mortar. The 10% replacement has the optimum strength and decreases as the percentage replacement increases. Hence, Fine steel lag can be used to replace cement up to 10%.

Affan Jalil et al. (2019) determined the impact of partially replacing cement with steel slag. They acquired industrial waste slag from a nearby steel plant for this project. It was crushed to a fine powder using a ball milling machine, and the particles were filtered using screen #100. The overall oxide content (SiO2, Fe2O3, and Al2O3) is 70.63%, indicating a pozzolanic nature. Polycarboxylate ether was employed as a plasticizer. Steel slag was used to replace between 10% and 20% of the cement. The workability results showed that workability declines as the percentage replacement of steel slag increases.

The compressive strength findings indicated that for 10% and 20% cement substitution by industrial slag, the strength drops to 86% and 74%, respectively. On the 28th day, the compressive strengths of 0%, 10%, and 20% replacement are 32.05 MPa, 27.5 MPa, and 23.9 MPa, respectively. The split tensile strength is reduced to 93% and 71%, respectively. Flexural strength and stiffness are reduced by 90% and 69%, respectively.

I. Partial Replacement of Cement with Sugarcane Bagasse ash (SCBA)

Nancy T. Hussien and Ahmed F. Oan (2022) examined the possibility of replacing some of the cement with sugarcane trash. For this study, bagasse was gathered from juice extraction factories. It was then dried in the sun after being cleaned in a water tank. The ashes were then allowed to completely burn up to 6000 degrees Celsius in the air. To remove the remaining biological debris, the ashes were heated to 2000 degrees Celsius for two hours. The ash was pulverised further to get finer particles. Sugar bagasse ash was used to replace 5%, 7.5%, and 10% of the cement. The cement-water ratio was 0.5. The workability test on fresh concrete demonstrates that as the amount of Sugar bagasse ash increases, so does the workability.

The 5% replacement has the optimum strength of 30.4 MPa at 28^{th} day. The split tensile test reveals that on the 28th day, 5% replacement had an optimal strength of 2.97 MPa.

Sajjad Ali Mangi et al. (2017), determined the effect of sugar bagasse ash in concrete as a partial replacement for cement. For this project, sugar bagasse was brought from the vicinity and burned in a closed drum (uncontrolled burning). The obtained ash is sieved through 300micron. The oxide composition (SiO2, Fe2O3, and Al2O3) of SCBA was found to be 78.12%. Concrete mixes M15 and M20 were designed.

This experiment shows the use of SCBA increases the workability of concrete, so there is no use of superplasticizer to make the concrete mix. It gives higher strength at 5% in comparison to conventional concrete cubes. The compressive strengths of M15 and M20-grade conventional concrete cubes and 5% SCBA are 23.805 KN, 26.775 KN, and 25.525 KN, respectively, at 28 days of curing. Hence, SCBA can be used to makes concrete economical, minimizes the disposal of waste, and also improves strength.

J. Partial Replacement of Cement with Water Hyacinth

Ashima Manoj, Aleena Eldho, and Saju Sujitha S. (2019) have used water hyacinth ash to partially replace cement. The collected water hyacinth was washed, made small pieces and sundried for 1-2 weeks. The water hyacinth was ground to make it finer and oven-dried at 800 degrees Celsius. The prepared ash was sieved using a 150-micron Sieve. The percentage replacement was 0%, 5%, 10%, and 15% by the weight of cement.

The replaced water hyacinth ash gives optimum strength at 10% replacement (31.91 MPa), which is more as compared to normal concrete strength (30.22 MPa), and the strength goes on decreasing as the percentage replacement increases. The use of hyacinth increases the consistency of cement, setting time, and workability with an increase in the percentage of water hyacinth ash. The split

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

tensile strength of the cylinder for the convention was 2.97 MPa and is less at an optimum percentage (10%) of hyacinth ash, whose value is 3.5 MPa at 28 days.

Murugesh, Dr. N. Balasundaram, and Dr. T. Senthil Vadivel (2018) studied the durability of partial replacement of cement with water hyacinth ash in concrete. The replacement percentages were 0% and 10%. A mixed design of M30 was prepared. The water absorption test was conducted on the cube after 28 days, and it was found that the water absorption of 10% replacement of water hyacinth ash was lower than that of the conventional concrete cube. The chloride resistance test results showed the average mass loss for 0% and 10% replacement was 1.279% and 0.862%, respectively.

Mohammed et al. (2017), determined the effect of the partial replacement of cement with water hyacinth ash in concrete. For this experiment, water hyacinth was gathered from the river and sun-dried before being burned in a furnace at temperatures ranging from 500^0C to 700^0C to produce ash. After grinding, the burned ash was sieved using a 75-micron BS sieve. The oxide composition conformed to the standard and can be used as Pozzolanic materials. The mix design M15 was prepared using a 1:2:4 mix ratio. The cement was replaced with 30%, 40%, and 50% water hyacinth ash. The workability test on fresh concrete shows that workability decreases with the increase in water hyacinth ash.

The compressive strength results showed that 30% replacement had an optimum strength of 6.67 MPa on the 28^{th} day of curing, and that of conventional concrete was 24.22 MPa on the 28^{th} day. It showed that the replacement of water hyacinth drastically reduced the compressive strength.

K. Partial Replacement of Cement with Wheat Straw Ash

Irfan Ali Shar et al. (2019) studied the effect of wheat straw ash as a partial replacement for cement in concrete. The ash was collected by burying the wheat straw at an uncontrolled temperature. The replacement percentage was 0%, 5%, 10%, 15%, and 20%. The concrete cubes were cured for 7 days, 28 days, and 90 days.

The test result shows that the compressive strength of conventional concrete cubes is less than that of wheat straw ash-based cubes at 5%, 10%, and 15% replacement. However, the replaced cube gives optimum strength at 10% replacement.

Faizan ul Haq and Ashish Sharma (2022) studied the properties of the partial replacement of cement with wheat straw ash. For this project, the wheat was collected from local farmers in Anantnag, Kashmir. It was dried and burned in the open, and the ash was sieved through the No. 200 BS sieve. The oxide composition of WSA (SiO2, Fe2O3, and Al2O3) was found to be 11.4% per weight. A mixed design of M25 was prepared. The cement was replaced by 15%, 20%, 25%, and 30% by weight of cement. The workability test showed that workability decreased with the increase in WSA.

On the 28th day, the compressive strength findings revealed that the 15% replacement had the highest strength of 24.41 MPa among the various replacements. The compressive strength was somewhat lower when compared to standard concrete, which had a compressive strength of 27.31 MPa. According to the flexural strength test findings, a 15% replacement has the maximum strength when compared to other percentage replacements. The flexural strengths of 0% and 15% replacement were 3.48 MPa and 2.92 MPa, respectively. The split tensile strength test results showed that 15% has the highest strength among various replacements. The split tensile strengths of 0% and 15% replacement were 2.33 MPa and 1.96 MPa, respectively.

L. Partial Replacement of Cement with Rice husk ash (RHA)

Vashisht Patil and Prof. M. C. Paliwal (2020) studied the properties of partial replacement of cement with rice husk ash in concrete. For this project, rice husk is purchased from Ambika traders. A mixed M20 grade was designed for this project. The percentage replacement was 0%, 5%, 10%, 15%, 20%, and 25%.

The compressive strength results showed that the compressive strength continuously increased up to 15% replacement and decreased after 15%. The optimum compressive strength was found at 15%, and it was 32.78 MPa at the 28^{th} day, which is greater than a normal concrete cube. The split tensile test showed that 15% has optimum strength, which is 1.69 MPa, which is greater than the normal concrete cube.

N Kaarthik Krishna, S Sandeep, and K M Mini (2016) studied the properties of partial replacement of cement with RHA. The rice husk ash was directly brought from two places, and the one with higher silica was used for the investigation. The oxide compositions of the two samples were 81.14% and 75.29%, respectively. The ratio water-cement was 0.55, and the mix percentage ratio was 1:1.64:3.41. By weight of cement, the RHA replacement percentages were 5%, 10%, 15%, and 20%. The workability values revealed that workability declines as RHA content increases.

The compressive strength was obtained at optimum at 10% replacement, and it was 29.3 MPA at the 28^{th} day. This strength was greater than that of a normal concrete cube. Also, the split tensile strength of 10% replacement was 2.52 MPa, which is higher than that of normal concrete. The optimum flexural strength was obtained at 10% replacement, and it was 2.53 MPa. The water absorption result showed that it increased with the increase in RHA content.

Marthong (2012) studied the effect of the partial replacement of cement with rice husk ash in concrete. For this project, the rice husk was collected from a local mill and burned in a furnace to produce ash. The burned ashes were ground using a Los Angeles machine. The oxide composition of RHA was 77.58%. The percentage replacement of RHA was 10%, 20%, 30%, and 40%. In this project, three grades of OPC were used: OPC 33, OPC 43, and OPC 53. A mix of M30 was designed with a water-cement ratio of 0.38. The workability of fresh concrete decreases with an increase in the percentage of RHA.

In all grades of OPC, the compressive strength test revealed that strength declines with RHA concentration. At 28 days, the strength drop was smaller for higher grade OPC, and it was discovered that RHA with 43 and 53 grade OPC obtained around 60% strength as compared to regular concrete; however, RHA with 33 grade OPC only attained 50% strength. In terms of long-term strength gain, RHA (Rice Husk Ash) grades 43 and 53 of OPC (Ordinary Portland Cement) achieved approximately 75% of the strength compared to concrete with no RHA replacement. On the other hand, RHA grade 33 OPC showed a strength gain of only about 55%. This comparison clearly indicates that the strength of RHA concrete slightly increases with age in all three grades of OPC. Therefore, it suggests that replacing RHA in 43 and 53 grade OPC is more favourable in terms of achieving ultimate strength gain compared to the use of RHA in 33 grade OPC. 10% replacement of RHA has a marginal reduction in compressive strength as compared to conventional concrete.

The water absorption results showed that water absorption decreased RHA content by up to 20% for all grades of OPC concrete.

M. Partial Replacement of Cement with Bamboo Leaves Ash (BLA)

According to S.O. Odeyemi et al. (2022), to achieve long-term strength and durability, high-performance concrete is manufactured by introducing supplemental Cementitious Materials (SCM) into concrete. Several SCMs, however, have been studied in HPC. The bamboo leaves were calcined in an electric furnace at 700 degrees Celsius. The ash was examined and found to be Pozzolanic characteristics with a silica concentration of more than 70%. The replacement percentage of BLA was 5%, 10%, 15%, and 20% by weight of cement. They investigated the compressive and splitting tensile strengths of concrete prepared from these combinations after 7, 28, and 56 days of curing.

The 5% replacement of BLA has the optimum strength at 56th days.

Cecielle N. Dacuan et al. (2021) have employed bamboo leaf ash in mixed cement to boost corrosion resistance. In this project, the usefulness of bamboo leaf ash as a supplemental cementitious material for improving the durability qualities of hardened concrete was investigated.

According to this study, 10% of BLA has good performance, stronger resistance to acid penetration, and longer corrosion resistance. With the use of BLA, the crack breadth and frequency were minimal. As an additive, BLA enhances its durability, residual strength, and serviceability. Overall, the results reveal that replacing 10% of the cement with BLA enhanced the strength, while replacing 15-20% of the cement with BLA decreased the strength due to increased initial setting time, final setting time, and loss of workability. So, the optimum percentage of BLA to replace cement is 10% to obtain maximum strength in concrete.

Onikeku et al. (2019) investigated the effect of partial replacement of cement with BLA. BLA was calcined at 650°C. The replacement percentage was 0%, 5%, 10%, 15%, and 20%. The ratio of water-cement was 0.5 with varying the amount of superplasticizer.

It was found that 10% replacement enhanced the concrete’s compressive strength, flexural strength and split tensile strength.

Mujedu K. A. et al. (2018) investigated the physical and mechanical characteristics of concrete in this article by substituting cement with increasing percentages of bamboo leaf ash, namely 0%, 5%, 10%, 15%, 20%, and 25%. The addition of bamboo ash to cement paste has improved its soundness, consistency, water absorption, air porosity, and initial and final setting times.

III. CONCLUSIONS

In this paper, the use of different types of waste, i.e., industrial waste and agricultural waste, as a partial replacement for cement was reviewed. The intention of this study was to identify the characteristics of SCM and their effect on the Workability, mechanical properties, and durability properties of concrete. There are various types of waste available; it is not feasible to use all types of waste in practical applications. The abundant material, which has a low environmental impact, causes low damage to concrete, has better performance, and gives good strength as compared to conventional concrete, is suitable for the development of sustainable concrete and sustainable development. Most of the waste materials give optimum strength in the range of 5–15%, and the strength goes on decreasing as the percentage replacement increases.

This review presents the idea that in the future, this waste material will be quite important and useful in the building and construction sectors for the development of infrastructure.

REFERENCES

[1] Vasanthi, P., Selvan, S. S., Murthi, P., Reddy, I. R., & Poongodi, K. (2020, December). Impact of partial replacement of cement by coconut shell ash and coarse aggregate by coconut shell on mechanical properties of concrete. In IOP Conference Series: Materials Science and Engineering (Vol. 981, No. 3, p. 032080). IOP Publishing.
[2] Nagarajan, V. K., Devi, S. A., Manohari, S. P., & Santha, M. M. (2014). Experimental study on partial replacement of cement with coconut shell ash in concrete. International Journal of science and research, 3(3), 651-661.
[3] Utsev, J. T., & Taku, J. K. (2012). Coconut shell ash as partial replacement of ordinary Portland cement in concrete production. International Journal of Scientific and Technology Research, 1(8), 86-89.
[4] Ishak, M. Y., & Zamani, M. N. (2020, May). Eggshell as the partial replacement of Portland cement in the production of concrete. In IOP Conference Series: Materials Science and Engineering (Vol. 849, No. 1, p. 012034). IOP Publishing.
[5] Jhatial, A. A., Sohu, S., Memon, M. J., Bhatti, N. U. K., & Memon, D. (2019). Eggshell powder as partial cement replacement and its effect on the workability and compressive strength of concrete. Int. J. Adv. Appl. Sci, 6(9), 71-75.
[6] Atul kumar (2018). Egg Shell Powder Partial Replaced with Cement Concrete. International Journal of Science and Research (IJSR),7(9),91-94
[7] Parthasarathi, N., Prakash, M., & Satyanarayanan, K. S. (2017). Experimental study on partial replacement of cement with egg shell powder and silica fume. Rasayan Journal of Chemistry, 10(2), 442-449.
[8] Reddy, K. Y., Quayyum, S. D., Srinivasulu, K., Sumanth, S., & Likitha, B. Partial Replacement of Cement with Fly Ash & Rice Husk Ash and of Coarse Aggregate with Steel Slag in Concrete.
[9] Akber, T., Kumar, A., Rizvi, S. H., & Lashari, A. R. (2022). Effect of Sugarcane Bagasse Ash as Cement Replacement on Properties of Concrete. International Research Journal of Modernization in Engineering Technology and Science, 4(3), 991-995.
[10] Agrawal, S., & Gaur, H. (2019). Partial replacement of cement by fly-ash in concrete.
[11] Pitroda, J., Zala, L. B., & Umrigar, F. S. (2012). Experimental Investigations on Partial Replacement of Cement with Fly ash in design mix concrete. International Journal of Advanced Engineering Technology, 3(4), 126-129.
[12] Patil, Y. O., Patil, P. N., & Dwivedi, A. K. (2013). GGBS as partial replacement of OPC in cement concrete–An experimental study. International Journal of Scientific Research, 2(11), 189-191.
[13] Karri, S. K., Rao, G. R., & Raju, P. M. (2015). Strength and durability studies on GGBS concrete. SSRG International Journal of Civil Engineering (SSRG-IJCE), 2(10), 34-41.
[14] Vijayakumar, M., Krishnakumar, P., & Athipathy, M. (2021). An Experimental Investigation on Dew Drain Water for Drinking Purpose. Alinteri Journal of Agriculture Sciences, 36(2).
[15] Vikas, M., Thakur, M. S., & Ashok, P. (2020). Waste paper sludge ash as supplementary material for cement. Annals of Agri Bio Research, 25(1), 164-169.
[16] Ahmad, S., Malik, M. I., Wani, M. B., & Ahmad, R. (2013). Study of concrete involving use of waste paper sludge ash as partial replacement of cement. IOSR Journal of Engineering, 3(11), 06-15.
[17] Raj, A., Divya, C. J., Biju, A., Jacob, A. C., & Viswambaran, A. (2021). Waste Glass Powder as Partial Replacement of cement Review. International Journal of Engineering Research & Technology, 9(9), 109-112.
[18] Ibrahim, K. I. M. (2021). Recycled waste glass powder as a partial replacement of cement in concrete containing silica fume and fly ash. Case Studies in Construction Materials, 15, e00630.
[19] Tamanna, N., & Tuladhar, R. (2020). Sustainable use of recycled glass powder as cement replacement in concrete. The Open Waste Management Journal, 13(1).
[20] Islam, G. S., Rahman, M., & Kazi, N. (2017). Waste glass powder as partial replacement of cement for sustainable concrete practice. International Journal of Sustainable Built Environment, 6(1), 37-44.
[21] Ahmed, I., Kumar, A., Rizvi, S. H., Ali, M., & Ali, S. (2020). Effect of silica fume as partial replacement of cement on compressive strength of roller compacting concrete. Quaid-E-Awam University Research Journal of Engineering, Science & Technology, Nawabshah., 18(2), 145-149.
[22] Akshana, V., Arasu, A. N., & Karthigaiselvi, P. (2020). EXPERIMENTAL STUDY ON CONCRETE BY PARTIAL REPLCAMENT CEMENT WITH SILICA FUME. Journal of critical reviews, 7(17), 3801-3.
[23] Sharma, R. (2018). Partial replacement of cement by silica fume. Int. J. Engg. Dev. Res, 6, 330-337.
[24] Singh, L., Kumar, A., & Singh, A. (2016). Study of partial replacement of cement by silica fume. Int. J. Adv. Res, 4(7), 104-120.
[25] Shreyash Nitinrao Wakode (2022). EXPERIMENTAL INVESTIGATION OF PARTIAL REPLACEMENT OF CEMENT BY USING STEEL SLAG. IJARIIE-ISSN(O)-2395-4396, 8(3).
[26] Anjali, P., & Sajitha Beegom, A. (2022). A study on the utilization of activated steel slag as partial replacement of cement in concrete. Int. J. Eng. Res. Technol (IJERT), 11(01).
[27] Dhoble, Y., & Ahmed, S. (2018). Study on cementitious properties of steel slag by partial replacement of cement. Global Journal of Engineering Science and Researches, 5(7), 213-220.
[28] Jalil, A., Khitab, A., Ishtiaq, H., Bukhari, S. H., Arshad, M. T., & Anwar, W. (2019). Evaluation of steel industrial slag as partial replacement of cement in concrete. Civil Engineering Journal, 5(1), 181-190.
[29] Hussien, N. T., & Oan, A. F. (2022). The use of sugarcane wastes in concrete. Journal of Engineering and Applied Science, 69(1), 1-9.
[30] Mangi, S. A., Jamaluddin, N., Ibrahim, M. W., Awal, A. A., Sohu, S., & Ali, N. (2017, November). Utilization of sugarcane bagasse ash in concrete as partial replacement of cement. In IOP conference series: materials science and engineering (Vol. 271, No. 1, p. 012001). IOP Publishing.
[31] Ashima Manoj, Aleena Eldho, & Saju Sujitha S (2019). Experimental Investigation on Water Hyacinth Ash as a Supplementary Cementing Material. International Journal of Scientific Research & Engineering Trends,5(3),683-685.

[32] Murugesh, V., Balasundaram, N., & Vadivel, T. S. (2018). Experimental studies on durability studies of concrete with partial replacement of cement by water hyacinth ash. International Journal of Engineering & Technology, 7(3.35), 22-24.

[33] Mohammed, I. S., Aliyu, M., Ibrahim, A. A., Ndanaimi, Y., & Abdullahi, L. (2017). POTENTIALS OF WATER HYACINTH ASH IN PARTIAL REPLACEMENT OF CEMENT.

[34] Shar, I. A., Memon, F. A., Bheel, N., Shaikh, Z. H., & Dayo, A. A. (2019, December). Use of wheat straw ash as cement replacement material in the concrete. In International Conference on Sustainable Development in Civil Engineering, Jamshoro, Pakistan.

[35] Faizan ul Haq, Ashish Sharma (2022), Use of Wheat Straw Ash as Cement Replacement Material in Concrete, International Journal of Innovative Research in Engineering & Management (IJIREM), Vol-9, Issue-6, Page No-107-110], (ISSN 2347 - 5552). www.ijirem.org

[36] Patil, V., & Paliwal, M. C. (2020). Partial Replacement of Cement with Rice husk ash in cement concrete. International Journal of Engineering Research & Technology, 9(12), 322-325.

[37] Krishna, N. K., Sandeep, S., & Mini, K. M. (2016, September). Study on concrete with partial replacement of cement by rice husk ash. In IOP conference series: materials science and engineering (Vol. 149, No. 1, p. 012109). IOP Publishing.

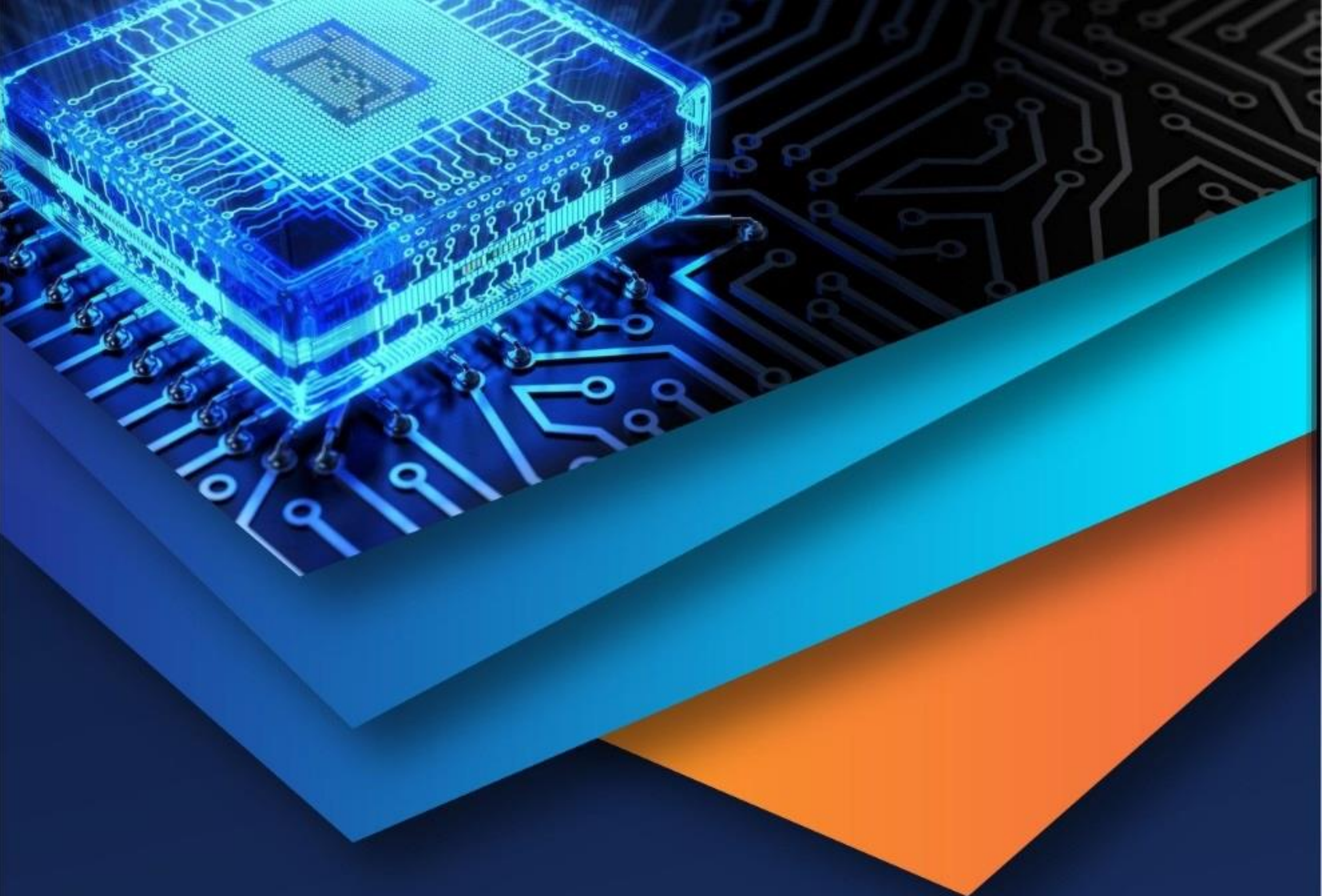
[38] Marthong, C. (2012). Effect of rice husk ash (RHA) as partial replacement of cement on concrete properties. International Journal of Engineering Research & Technology, 1(6), 1-9.

[39] Odeyemi, S. O., Atoyebi, O. D., Kegbeyale, O. S., Anifowose, M. A., Odeyemi, O. T., Adeniyi, A. G., & Orisadare, O. A. (2022). Mechanical properties and microstructure of high-performance concrete with bamboo leaf ash as additive. Cleaner Engineering and Technology, 6, 100352.

[40] Dacuan, C. N., Abellana, V. Y., & Canseco, H. A. R. (2021). Assessment and evaluation of blended cement using bamboo leaf ash BLASH against corrosion. Civil Engineering Journal, 7(6), 1015-1035.

[41] Onikeku, O., Shitote, S. M., Mwero, J., & Adedeji, A. (2019). Evaluation of characteristics of concrete mixed with bamboo leaf ash. The Open Construction & Building Technology Journal, 13(1).

[42] Mujedu, K. A., Lamidi, I. O., Olomo, R. O., & Alao, M. O. (2018). Evaluation of physical and mechanical properties of partially replaced bamboo ash cement mortar. The International Journal of Engineering and Science, 7(3), 35-41.



10.22214/IJRASET

INDEX COPERNICUS

45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY