

EXPLORING IMPROVED CONCRETE FORMULATIONS VIA SUBSTITUTING CONVENTIONAL COMPONENTS WITH RECYCLED AGGREGATES, BAGASSE ASH, AND SILICA FUMES: A REVIEW

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ABSTRACT

The most popular kind of structure, concrete, is made of cement, aggregates, water, and steel bars for reinforcement, along with an additional external strengthening ingredient. When this material is still new, its behavior differs from that of concrete that has set. Millions of raw cements, fine and coarse sand, water, and steel bars are being produced or excavated globally to fulfill the increasing demand of the building industry. Concrete technology is the study and research of the characteristics of concrete at various stages of its use. Concrete is used for all load-bearing structures because it can support large loads with ease. Various types of cement, including OPC, PPC, and Rapid Hardening Cement, are utilized in everyday construction projects. Recycling materials is a very old concept; the Romans used the materials from their damaged artwork to make new works of art. 500 kilograms of C&D trash are produced annually on average per person. A target of reusing between 50 and 90 percent of this garbage has been established by many countries. Recycled coarse and fine aggregates are mostly found in construction sites, RMC plants, and the wrecking sites of historic buildings, as well as in the wake of frequent natural disasters like hurricanes, floods, and earthquakes. The majority of waste recycled aggregates come from brick and concrete masonry and are intended for use in construction of the same kind. Due to its massive global production, sugarcane is the largest crop. It is the primary source of sugar generation and is also used in the production of several alcoholic beverages, including cachaca and rum, as well as in the bioethanol industry. Sugarcane stalks are used to make sugar juice, often known as sugar syrup. After extracting all of the sugarcane juice, a large amount of moist bagasse—roughly 30% to 34% of the sugarcane mass—is left over. When silicon metal, particularly ferrosilicon alloys, is generated, silica dust is electrostatically seized and soothed by gasses released by electric arcs or alloys. This process produces silica fume. More than 80% of this material is non-crystalline silica with a diameter of 0.01 to 0.3 microns, which is 50–100 times smaller than cement particles. The current study examined the effects of substituting 15%, 30%, and 45% of the raw coarse aggregates with recycled coarse aggregates, and the 5%, 10%, and 15% of bagasse ash and silica fumes in cement for concrete M25. Since replacement concrete mixes produced better outcomes, the general suggestion is that the BRC2, or concrete containing 10% bagasse ash, 10% of silica fumes and 30% of recycled aggregates is the optimum concrete mix.

1. INTRODUCTION

India's construction industry is a vital sign of development since it offers opportunities for investment in a variety of related fields. This sector's approximate contribution to the nation's GDP is 8.2%, or roughly Rs. 670,778 crores. Every day, billions of rupees worth of new infrastructure are built throughout the world to support the growth of a single country. Job prospects are also promoted by the building industry's development.. From time to time, this industry presents new ideas to reduce its environmental impact and create better infrastructure. These innovative concepts provide 100% structural safety, excellent efficiency, and error-free large-scale production. Numerous unique structures have been built since the beginning as invention and construction have coexisted. Underwater tunnels, sky scrapers, extraordinarily long span bridges, and other modern projects are prime examples.

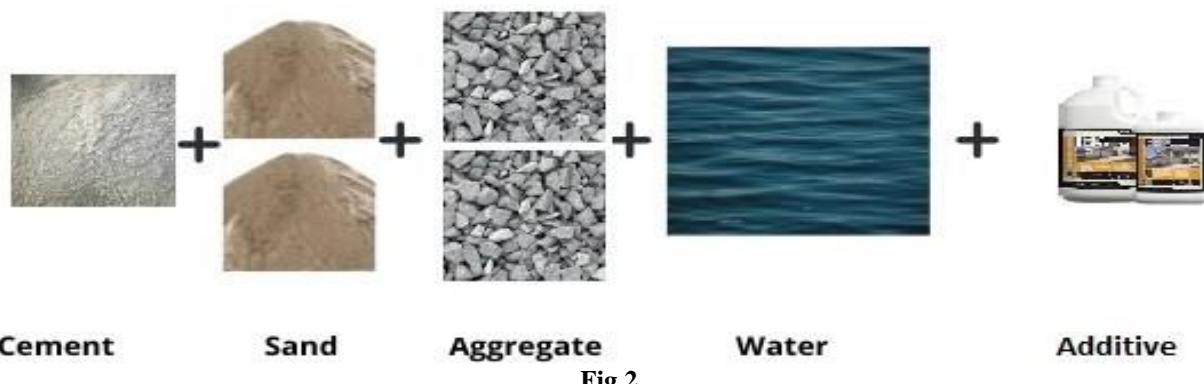


Fig.1

Thousands of scholars work tirelessly to create these constructions, and without their contributions, it would not have been feasible to build such massive and intricate structures. Such an industry becomes indispensable following disasters and continues to operate even during pandemics. Millions of people worldwide are employed by the thousands of businesses that carry out various small- and large-scale projects. with different skill sets and different academics. Each year for the construction industry is much more innovative and focused than the previous year. Majorly,

CONCRETE STRUCTURES

The most popular kind of structure, concrete, is made of cement, aggregates, water, and steel bars for reinforcement, along with an additional external strengthening ingredient. When this material is still new, its behavior differs from that of concrete that has set. Millions of raw cements, fine and coarse sand, water, and steel bars are being produced or excavated globally to fulfill the increasing demand of the building industry. Concrete technology is the study and research of the characteristics of concrete at various stages of its use. Concrete is used for all load-bearing structures because it can support large loads with ease. Various types of cement, including PPC, OPC, and rapid-setting cement, are utilized in daily constructional work.



To achieve the desired strength of concrete, various materials that are its primary ingredients are mixed together in exact amounts. As M indicates the concrete mix and 5, 10, 15, 20, 25, etc. provide the compressive strength in kN/m² during 28 days of curing, the strength of the mix is denoted by M5, M10, M15, M20, M25, M30, etc.

Table: 1 Different Concrete Grades

Concrete Grade	Mix Ratio	Compressive Strength	
		MPa (N/mm ²)	Psi
M10	1 : 3 : 6	10 MPa	1450 psi
M15	1 : 2 : 4	15 MPa	2175 psi
M20	1 : 1.5 : 3	20 MPa	2900 psi
M25	1 : 1 : 2	25 MPa	3625 psi
M30	Design Mix	30 MPa	4350 psi
M35	Design Mix	35 MPa	5075 psi
M40	Design Mix	40 MPa	5800 psi
M45	Design Mix	45 MPa	6525 psi

RECYCLED AGGREGATES

Recycling materials is a very old concept; the Romans used the materials from their damaged artwork to make new works of art. After World War II, recycling parts from damaged buildings offered a different, less expensive approach. Recycling is one of the environmental management approaches for attaining a sustainable building industry. The infrastructure sector and other companies are currently integrating sustainability into their raw material having diverse tactics in order to create a more sustainable society. Massive amounts of debris are produced by the building industry, much of which can be recycled and reused for the sustainable manufacturing of concrete in the future. Millions of pieces of debris are obtained by the contemporary construction sector worldwide and are disposed of by throwing them away. The use of such waste rubble material as an aggregate in concrete is very important and can help with the material's disposal issue.



Fig 3: Reclaimed Recycle Concrete

500 kilograms of C&D trash are produced annually on average per person. A target of reusing between 50 and 90 percent of this garbage has been established by many countries. Recycled coarse and fine aggregates are mostly found in construction sites, RMC plants, and the wrecking sites of historic buildings, as well as in the wake of frequent natural disasters like hurricanes, floods, and earthquakes. The majority of waste recycled aggregates come from brick and concrete masonry and are intended for use in construction of the same kind. Following the acquisition of such demolished C&D waste, the material is crushed into smaller pieces and recycled aggregates are graded.

BAGASSE ASH

Bagasse is the residue left behind after the juice has been taken from sugarcane, fruit plants, or seeds. Once viewed as a waste in the prehistoric era, this end product is today valued highly and is used as a raw material substitute in numerous sectors. Bagasse has a lot of fiber, which promotes strong binding. Bagasse has a wide range of uses, including improving soil, fertilizing various materials, feeding animals, making combustible fuel, and making concrete. Due to its massive global production, sugarcane is the largest crop. It is the primary source of sugar generation and is also used in the production of bioethanol and other alcoholic beverages, including rum, cachaca, etc.



Fig.: 4 Different forms of Bagasse Ash

Sugarcane stalks are used to make sugar juice, often known as sugar syrup. After extracting all of the sugarcane juice, a large amount of moist bagasse—roughly 30% to 34% of the sugarcane mass—is left over. Given that the disposal issue is endangering the ecosystem and causing significant environmental harm, it is evident that controlling this remaining material is crucial from an environmental standpoint. It's interesting to note that using this bagasse in concrete could yield positive outcomes. Bagasse ash can be used in little or large quantities to replace raw materials, improving concrete's strength, resolving the disposal issue, and removing ecological risk. thousands of researches have been conducted and they all proved that this material can be used in concrete and shows better results than conventional concrete.

SILICA FUMES

The process of producing silicon metal, particularly ferrosilicon alloys, involves the electrostatic seizing and calming of silica dust with gasses released from electric arcs or alloys. This process produces silica fume. With a diameter ranging from 0.01 to 0.3 microns—roughly 50–100 times smaller than cement particles—this material contains more than 80% non-crystalline silica. "Super pozzolan" is this substance, which can be utilized to enhance the typical cement's qualities. Both the microstructural characteristics of hardened cement and the physical characteristics of new cement paste are altered by it. Prior studies have shown that silica fumes can be used in place of cement to increase the strength of concrete, giving it better qualities both when it's new and when it hardens.

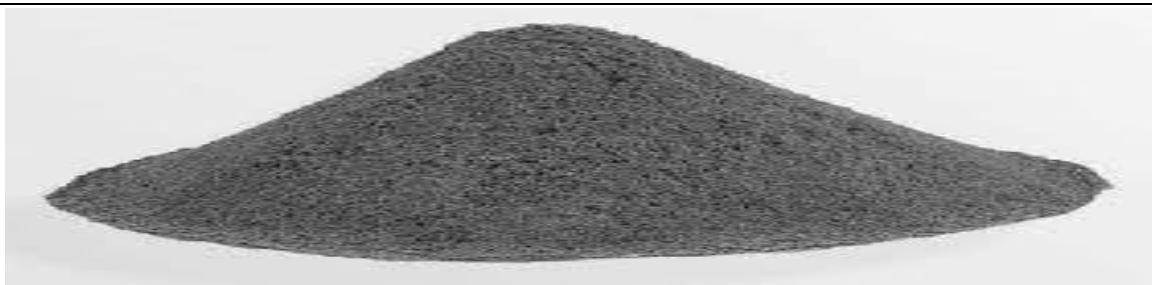


Fig.:5 Silica fumes.

Objectives

The following goals are established in order to carry out the current examination of the study entitled "A Study on High Performance Concrete by Replacing Raw Materials with Recycled Aggregates, Bagasse Ash, and Silica Fumes": Studying the characteristics of waste materials used in the manufacturing of concrete, such as recycled aggregates, bagasse ash, and silica fume; designing M25 grade concrete in accordance with IS 10262:2019 codal regulations.

- To investigate the impact of substituting 15%, 30%, and 45% of the raw coarse aggregates with recycled coarse aggregates, and 5%, 10%, and 15% of the cement with bagasse ash and silica fumes.
- To design M25 grade concrete by combining all replacement materials in the best possible proportions.

2. LITERATURE REVIEW

Corinaldesi Valeria, Moriconi Giacomo, (2009) "Influence of mineral additions on the performance of 100% recycled aggregate concrete" [1]

A prudent use of resources, such as by-products and waste materials, and a smaller environmental impact, such as minimizing carbon dioxide emissions and virgin aggregate mining, allow for sustainable construction development. When suitable concrete characteristics are established, recycled aggregate concrete (RAC) including supplementary cementitious materials (SCM) can be used as a sustainable construction material. In this study, concrete examples were created by replacing all fine and coarse materials with recycled aggregates from a rubble recycling factory. In addition, RAC with fly ash (RA + FA) or silica fume (RA + SF) were investigated. In the first experiment, concrete parameters were assessed using compressive strength and modulus of elasticity. The second experimental section examined compressive and tensile splitting strength, dynamic modulus of elasticity, drying shrinkage, reinforcing bond strength, carbonation, chloride penetration were studied. Satisfactory concrete properties can be developed with recycled fine and coarse aggregates with proper selection and proportioning of the concrete materials.

Amin Noor-ul, (2011) "Use of Bagasse Ash in Concrete and Its Impact on the Strength and Chloride Resistivity" [2]

This study describes the recycling of bagasse ash, a waste product of the sugar industry, to replace cement in concrete. This effectively addresses environmental issues related to waste management. Researchers have looked into how the partial replacement of cement with bagasse ash affects the mechanical and physical characteristics of hardened concrete, such as resistance to chloride ion penetration, splitting tensile strength, and compressive strength. With an ideal replacement ratio of 20% cement, bagasse ash is an excellent mineral additive and pozzolan that reduced chloride diffusion by more than 50% without negatively affecting other parameters of the cured concrete, according to the results.

Singha Roy Dilip K., Sil Amitava, (2012) "Effect of Partial Replacement of Cement by Silica Fume on Hardened Concrete" [3]

One of the most significant effects of using silica fume (SF) in a short amount of time was on the industry's capacity to regularly and profitably produce SF-modified concrete that was cohesive but flowable, which in turn developed high early and high later-age strengths, including resistance to harsh environments. An experimental investigation of the nature of SF and how it affects the characteristics of both fresh and cured concrete is presented in this work. An attempt has been made to look into the strength parameters of concrete that has had some of the cement replaced with SF in the current study. Very little, if any, research has been done on substituting silica fume for cement. Furthermore, no such effort has been made while using cement instead of silica fume in low- to medium-grade concretes (M20, M25). The ultimate compressive strength, flexural strength, splitting tensile strength, and tensile strength of hardened concrete have been measured for various material mix combinations, and these results are contrasted with those of standard concrete. The goal of the current study is to raise awareness among practicing civil engineers about the benefits of these novel concrete mixes.

Alsanusi S., (2013) "Influence of silica fume on the properties of self-compacting concrete" [4]

Concrete that can be put into a form and overcome obstacles on its own weight without the need for vibration is known as self-compacting concrete, or SCC. Owing to its unique features, SCC has become more popular in Japan, Europe, and the USA since it was initially developed there in 1988. Libya has not yet investigated the viability and applicability of SCC in new building, despite apparent indications of its progressive acceptance in North Africa from its restricted use in construction. The severe weather and the absence of any proof that it would work well with local aggregates seem to be the main causes of this resistance. This study's main goal is to investigate whether employing SCC is feasible created using regional aggregates from Libya's Eastern Province by analyzing its fundamental features. This study is divided into two parts: (i) creating a mix that is appropriate for SCC by analyzing factors such the ratio of water to cement, silica fume, and limestone to meet the criteria of the plastic state; and (ii) casting concrete samples and evaluating their compressive strength and unit weight. In this study, local aggregates, cement, admixtures, and industrial waste materials were employed. The research's significance stems from its attempt to offer some performance statistics on SCC produced in Libya's Eastern Province in order to highlight the potential applications of SCC.

Butler L., West J.S., Tighe S.L. (2013). "Effect of recycled concrete coarse aggregate from multiple sources on the hardened properties of concrete with equivalent compressive strength" [5]

This study assessed how different concrete mixtures with equivalent compressive strengths and slumps (between 40 and 60 MPa and 75 and 125 mm) would behave mechanically when natural aggregate (NA) was completely replaced with recycled concrete aggregate (RCA) from various sources. Despite having comparable compressive strengths to the NA concrete, the RCA concrete's modulus of elasticity was up to 19% lower than that of the NA concrete. The modulus of elasticity of concrete including RCA as coarse aggregate is proportional to the average secant modulus of elasticity of bulk RCA, according to the evaluation. Fracture energy of RCA concrete was measured using single edge notched double-cantilevered (SEDC) beam specimens and was measured to be up to 32% lower in comparison to the NA concrete specimens. Fracture energy of RCA concrete was found to increase with an increase in aggregate strength.

Folino Paula, Xargay Hernán, (2014) "Recycled aggregate concrete – Mechanical behavior under uniaxial and triaxial compression" [6]

The experimental program's findings regarding the mechanical behavior and failure of recycled aggregate concrete (RAC) under various load scenarios are presented in this study. The specific kind of recycled aggregate concrete (RAC) that is being examined here is distinguished by the partial or complete substitution of recycled coarse aggregates that are acquired from the crushing of leftover concrete. The objective of this study is to enhance the current understanding of recycled aggregates (RACs) by examining the deterioration of their mechanical and physical attributes when recycled coarse aggregates are employed. Its behavior under triaxial compression is specifically investigated. Following testing, the cylindrical samples made from a normal strength concrete mixed with natural coarse aggregates were crushed and repurposed as coarse aggregates in the creation of RAC. Triaxial compression, splitting tensile, and uniaxial compression tests were performed on the samples. We show and analyze experimental data pertaining to the mechanical behavior of hardened concrete, fresh concrete properties, and recycled aggregates' physical characteristics. In addition, an objective description of concrete quality served as the foundation for the Performance Dependent Failure Criterion, which was expanded upon and used to forecast the peak stresses of RAC under triaxial compression. This criterion was originally created for conventional concrete, but it is equally applicable to RAC, as shown by the comparison of experimental and numerical findings.

Duan Z.H., Poon C.S. (2014). "Properties of recycled aggregate concrete made with recycled aggregates with different amounts of old adhered mortars" [7]

The experimental results of a study comparing the various qualities of recycled aggregates (RAs) with different amounts of old adhered mortar from various sources are presented in this paper. Additionally, the study evaluates the impact of the various RAs on the mechanical and durability properties of recycled aggregate concrete (RAC). Each RA is used to completely replace NA in four different concrete mixes (one with natural aggregate and three with recycled aggregates) with target compressive strengths ranging from 30 MPa to 80 MPa over a 28-day period. Additionally, RAC traits are mimicked by the use of artificial neural networks (ANN). According to the trial results, RAs from different sources performed quite differently, and high-quality RAs can be used to create concrete with high strength and hardened qualities that are on par with matching natural aggregate concrete (NAC). The ANN approach might be used to assess the qualities of RAC created with RAs derived from various sources, according to a

comparison between the experimental values and the projected outcomes based on the ANN models. This will make it easier to use RA in concrete on a larger scale. Rowland

Otoko George (2014) "Use of Bagasse Ash as Partial Replacement of Cement in Concrete" [8]

To a certain extent, bagasse ash, an agro-industrial waste product of sugar mills, was substituted for cement in concrete. According to laboratory test results, Bagasse ash can replace up to 2% of cement in concrete without having a negative impact on it. It is determined that bagasse ash does not increase the strength of concrete. Because of this, using bagasse ash as a substitute for cement in concrete may require combining it with other bonding ingredients like fly ash or slag.

Dilbas H., Simsek M., Cakir O. (2014). "An investigation on mechanical and physical properties of recycled aggregate concrete (RAC) with and without silica fume" [9]

The Urban Renewal Law in Turkey serves as an inspiration for experimental investigations aimed at assessing the mechanical and physical qualities of recycled aggregate concrete (RAC) with and without silica fume (SF). This regulation states that buildings that were constructed with poor engineering, without taking urban planning into account, or that are risk prone—that is, prone to earthquakes—will be demolished and reconstructed in accordance with current Turkish Standards. The amount of leftover concrete is anticipated to rise as a result of this law's implementation. In Turkey, it is crucial to reduce the amount of garbage disposed of in both structural and non-structural regions without endangering the environment. In this study, recycled aggregate (RA) made of demolished building debris is employed in concrete compositions both with and without SF. The mechanical parameters of the concrete specimens, such as compressive strength, tensile splitting strength, and elasticity modulus, as well as the physical properties, such as density and water absorption ratio, are determined after twelve concrete mixtures divided into three groups are created. The ideal percentage for RA in concrete mixtures is suggested to be 30%. In the short term, a low regression coefficient between RAC and SF is noted. Research indicates that adding 5% of SF to RAC makes it easier to improve the material's low qualities, such as compressive strength.

Andreu G., Miren E. (2014). "Experimental analysis of properties of high performance recycled aggregate concrete" [10]

The use of recycled concrete aggregates (RCA) in high performance concrete (HPC) needs to be examined due to the rise in the destruction of high strength concrete structures and the need of precast concrete companies to become more competitive. In this investigation, natural coarse aggregates were substituted with 20%, 50%, and 100% of RCA to form HPC. Three different RCA kinds were employed; they were created by crushing original concrete with compressive strengths of 100, 60, and 40 MPa. Analyses were conducted on the mechanical, physical, and durability characteristics of ordinary concrete and concretes with recycled aggregates. The findings demonstrated that when RCA were made from original concrete with a minimum compressive strength of 60 MPa, it would be possible to replace 100% of the natural coarse particles while taking mechanical qualities into account. Concrete made with up to 50% RCA might be utilized in the creation of HPC when durability attributes were taken into account.

Muller A, Scrivener K.L., Skibsted J., Gajewicz A.M. and McDonald P.J., (2015) "Influence of silica fume on the microstructure of cement pastes: New insights from H- NMR relaxometry" [11]

Utilizing 10% weight percentage of silica fumes, white Portland cement paste has been characterized using H-NMR. Samples were not allowed to dry out during the hydration process; they were measured sealed. The computation of paste compositions and C-S-H features is based on relaxation analysis and 1 H NMR signal intensities. The outcomes are contrasted with a related investigation of standard white cement paste. The chemical composition is affected by silica fume, but C-S-H densities are not much affected by it. When 10% of silica fume is added to the white cement after 28 days of sealed hydration, the Ca/(Si + Al) ratio of the C-S-H is 1.33 and the H2O/(Si + Al) ratio is 1.10. Over time, a densification of the C-S-H is seen. There are no major changes in capillary, C-S-H gel and interlayer pore sizes for the paste containing silica fume compared to the plain white cement paste. However, the gel/interlayer water ratio increases in the silica fume blend.

Singh Lakhbir, Kumar Arjun, Singh Anil, (2016) "Study Of Partial Replacement Of Cement By Silica Fume" [12]

The capacity to regularly and commercially make silica fume modified concrete that is cohesive but flowable has had a significant impact on industries. This produces strong early and later age strength, as well as resistance to harsh conditions. The nature of silica fume and how it affects the characteristics of fresh concrete are the subjects of this experiment. The strength properties of concrete have been studied when silica fume has been used in place of some of the cement. Prior to studying the strength parameters of concrete with silica fume partial replacement, cubes and cylinders were placed on a compression testing machine (CTM) to study the strength properties of concrete without

any partial replacement. For both the cube and the cylinder, silica fume was utilized to replace 0% to 15% of the cement by weight at intervals of 5%. The findings demonstrated that the compressive strength of the cube and split tensile strength cylinder were significantly impacted by the partial replacement of cement with silica fume. The ideal value of compressive strength is reached at 10% replacement, and the strength of concrete grows quickly as the silica fume level is increased. Similar to the split tensile strength, which increases to 10% before beginning to decrease under the uniform load condition of 2 KN, it begins to decrease after 10% under the conditions of 4 KN.

Mangi Sajjad Ali, Jamaluddin N, (2017) “Utilization of sugarcane bagasse ash in concrete as partial replacement of cement” [13]

The appropriateness of sugarcane bagasse ash (SCBA) in concrete used as a partial substitute for cement is the subject of this study. M15 and M20 concrete grades were the two that were used in the experimental analysis. SCBA was used to partially replace the cement in normal strength concrete (NSC) at weights of 0%, 5%, and 10%. This study's novel approach is comparing the performance of two grades of concrete mixes when cement is swapped out for sugarcane bagasse ash. 150 mm x 300 mm cylindrical specimens that had been cured for 7, 14, and 28 days were employed and put to the test. Through the experimental investigation, it was found that adding SCBA to concrete increases its compressive strength. According to the results, the average amount of compressive strength in concrete (M20) rose by 12% when SCBA was added at a 5% concentration in comparison to concrete of normal strength. The results of this investigation suggest that at 5% substitution of cement with SCBA, the maximum strength of concrete might be achieved. Additionally, the SCBA provides compatible slump values that improve concrete's workability.

3. MATERIALAND PROPERTIES

Cement- According to IS: 8112, regular Portland cement (grade 43) was used. Laboratory experiments were used to establish a number of cement parameters, including consistency, setting time, specific gravity, and others. The results are listed in the table.

Table:2 Physical Properties of OPC 43 grade.

S. No.	Properties	OPC 43 Grade	Requirement As Per IS Code
1.	Standard Consistency	28.8%	-
2	Initial Setting Time (min.)	135	>30
3	Final Setting Time (min.)	346	<600
4	Specific Gravity	3.15	3-3.15
5	Specific Surface Area (cm ² /g)	2736	>2250
6	Soundness	Nil	10 (max.)

Fineaggregate

The aggregates of size ranging from 4.75mm to 150 microns is used as a fine aggregate. The physical properties and sieve analysis confirming to IS 383:2016 of these aggregates are represented in the Table

Table:3 Physical Properties of Fine Aggregates

Test	Result
Specific Gravity	2.64
Fineness Modulus	2.84
Water Absorption	1.16%

Table:4 Sieve Analysis of Fine Aggregates Confirming to IS 383:2016.

IS SieveSize	AverageWeight Retained (gm)	% WeightRetained	Cumulative % Weight Retained		% Passing	GradingZone	
10 mm	5.0	0.50	0.50		99.50		
4.75mm	32.55	3.26	3.76		96.25		
2.36mm	115.46	11.55	15.30	84.70			
1.18mm	214.60	21.46	36.76	63.24			
600mic	154.62	15.46	52.22	47.78			

300mic	260.43	26.04	78.27	21.73	Confirming to Zone II sand
150mic	191.84	19.18	97.45	2.55	
75mic	19.54	1.95	99.40	0.60	
Pan	5.96	0.60	100.00	0.00	

Coarse aggregate- Crushed and angular aggregates were used in current work. The Coarse aggregate of size 10 mm were collected from local area. Various tests on coarse aggregates were conducted to determine the specific gravity, water absorption values confirming to IS 383:2016.

Table: 5 Physical Properties of Graded Coarse Aggregates

Test	Result
Color	Grey
Shape	Angular
Specific Gravity	2.68
Water absorption	0.61%

Table:6 Sieve Analysis of Coarse Aggregate Confirming to IS 383: 2016.

Sieve Size	Average Weight Retained (gm)	% Weight Retained	Cumulative % Weight Retained	% Passing
12.5mm	0	0	0	100.00
10mm	26.43	2.64	2.64	97.36
4.75mm	795.12	79.51	82.16	17.85
2.36mm	130.00	13.00	95.16	4.85
Pan	48.53	4.85	100.00	0

Water

Portable water available at the work place is used for mixing and curing.

Recycled aggregates- The construction sector produces enormous quantities of rubble waste which can be easily reused and recycled for future sustainable production of concrete and the utilization of this material in concrete as an aggregate has great significance and can solve the disposal problem of such material. The recycle concrete aggregates was collected from local source

Table:7 Physical Properties of Graded Recycled Aggregates

Test	Results
Specific Gravity	2.35
Water Absorption	3.09 %

Bagasse ash (ba) - It is waste end product of sugarcane industry when the juice has been extracted. This end product which was considered as a waste in primitive times is now considered a very useful material and can be utilized in many industries which replace raw material. Bagasse is abundant in fibers which helps in good binding. The specific gravity of sugarcane bagasse ash is 1.85 g/cc.

Table:8 Chemical Composition of BA.

S. No.	Composition	Proportion (%)
1.	SiO ₂	66.48
2	Al ₂ O ₃	28.65
3	Fe ₂ O ₃	29.11
4	CaO	1.95
5	MgO	0.83
6	SO ₃	0.54
7	Loss of ignition	0.75

Silica fumes- Silica fume is a result of electrostatic seizing and sooting of silica dust with gasses emitted from electric arcs or alloys in the generation method of silicon metal, especially ferrosilicon alloys. This substance has more than eighty percent non-crystalline silica with a dia ranging between 0.01 and 0.3 microns, which is approximately 50 to 100 times finer than particles of cement. The specific gravity of sugarcane bagasse ash is 2.25 g/cc.

Table:9 Chemical Composition of Silica Fume.

S. No.	Composition	Proportion (%)
1.	SiO ₂	93.15
2	Al ₂ O ₃	0.82
3	Fe ₂ O ₃	1.45
4	CaO	0.81
5	MgO	0.24
6	SO ₃	-
7	Na ₂ O	0.70
8	K ₂ O	0.70

MIX DESIGNATION

Cement is replaced with silica fumes and bagasse ash at proportion of 5%+5%, 10%+10%, 15%+15% and this replacement levels are denoted as A, B and C respectively. In addition to this, coarse aggregates were replaced by recycled aggregates at proportion of 15%, 30% and 45% which shall be denoted as RC1, RC2 and RC3.

Table:10 Designation of Various Concrete Mix

Mix Designation	Partial replacement of cement with bagasse ash and silica fume	Partial replacement of Raw coarse Aggregates with RCA
CM	0%	0%
ARC1	5%+5%	15%
ARC2	5%+5%	30%
ARC3	5%+5%	45%
BCR1	10%+10%	15%
BCR2	10%+10%	30%
BCR3	10%+10%	45%
CRC1	15%+15%	15%
CRC2	15%+15%	30%
CRC3	15%+15%	45%

LABORATORY TESTS

Compressive Strength - Examine Every time concrete is created, this test—which is the most important one—is conducted. In this test, 150 mm x 150 mm x 150 mm concrete cubes are used to measure the strength of the material. For every batch replacement, the amounts of water, replacement material, coarse and fine aggregate, and cement were measured individually. Before adding the water, this mixture was combined with fine aggregate in a dry form. In order to remove any voids from the concrete mass, the resultant concrete mix was put into the casting molds and compacted with a steel rod. In order to prevent concrete from sticking to the molds and to make it easier to remove, the molds were lubricated before the casting process.

After that, the samples were kept at room temperature. Subsequently, the cubes were taken out of the molds and allowed to cure in a water tank. The 7 and 28-day curing periods were completed.

The cubes underwent compressive strength testing in a compression testing machine (CTM) following the curing time. Until the failure happens, the load is applied to the sample's cross-section continuously in the machine at a set rate of 140 kg/cm² per minute. The sample's cross-sectional area is divided by the load at failure to determine the compressive strength.

Split Tensile Strength- To ascertain the split tensile strength of the mix, three cylindrical samples, each measuring 100 mm by 200 mm, of each conventional concrete mix and replacement concrete mix were constructed. For every batch replacement, the amounts of water, replacement material, coarse and fine aggregate, and cement were measured individually.

Before adding the water, this mixture was combined with fine aggregate in a dry form. The preparation of the concrete mix was done in the same way as the compressive strength. Three layers of both the replacement and traditional concrete mixes were poured into the cylindrical molds, and the steel rod was used to compact each layer. After casting cylindrical samples, they were placed in a room temperature for 24 hours. After removing samples from the moulds, the samples were left for curing for 7 days and 28 days, and upon finishing the curing period these samples were tested in a Universal Testing Machine (UTM) for split tensile strength of conventional and green concrete.

$$T = 2P/\pi dl$$

$$T = 0.637P/dl$$

Where,

T = Split Tensile Strength in MPa P = Applied load,

d = Diameter of Concrete cylinder sample in mm. L = Length of Concrete cylinder sample in mm.

As per IS 456, split tensile strength of concrete = $0.7f_{ck}$

Water Absorption Strength- The ASTM C642-81 criteria were followed in order to determine the water absorption capacity of the concrete. For this test, 150 x 150 x 150 mm cubes were cast and dried. The control mix and green concrete samples were allowed to cure for a total of twenty-eight days. Following a 24-hour oven drying process at 105 degrees Celsius, the dried weight of the concrete samples was noted as W_1 .

Subsequently, the concrete samples were submerged in water for a duration of 48 hours, and once more, their weight was measured as W_2 , following which the surface was cleaned using a dry towel.

A formula that is described below was then used to determine the percentage of water absorption.

$$\text{Water Absorption} = (\text{Saturated weight } W_2 - \text{Dry weight } W_1) / \text{Dry weight } W_1 * 100$$

4. CONCLUSION

- a) The current study shows that recycled concrete aggregates (15%, 30%, and 45%), bagasse ash (5%, 10%, and 15%), and silica fumes (5%, 10%, and 15%) may all be used to create green concrete with improved qualities.
- b) The concrete slump value dropped as the percentage of replacement material in the mix increased. In summary, then, it was rather difficult to produce workable concrete when the amounts of bagasse ash, silica fumes, and recycled particles in the concrete were higher. However, adding small amounts of substitute components to the concrete mix resulted in a workable mix.
- c) When bagasse ash, silica fumes, and recycled aggregates are substituted for raw ingredients, the concrete's compressive strength is somewhat increased in comparison to the control mix. The BRC2 concrete mix achieved the highest compressive strength of 23.1 MPa at 7 days and 32.2 MPa at 28 days, whereas the control mix showed a compressive strength of 21.4 MPa at 7 days and 30.6 MPa at 28 days. Comparing BRC2 to control mix (CM), there was a nearly 8% improvement in compressive strength after 7 days and a 6% increase at 28 days. The results also showed that CRC3 had the greatest drop in compressive strength, which was around 13% after 7 days and 14% at 28 days, respectively to control mix concrete.
- d) When compared to a control concrete mix, the split tensile strength is somewhat increased when raw materials are substituted with bagasse ash, silica fumes, and recycled aggregates. The BRC2 concrete mix achieved the highest split tensile strength of 2.13 MPa at 7 days and 3.02 MPa at 28 days, whereas the control mix showed split tensile strengths of 2.1 MPa at 7 days and 2.85 MPa at 28 days. In comparison to control mix CM, split tensile strength increased by nearly 2% in 7 days and 6% in 28 days in BRC2. Nonetheless, CRC3 experienced the greatest reduction in split tensile strength, measuring roughly 17% at 7 days and 12% at 28 days as comparison to control mix concrete.
- e) The low water absorption of the different concrete samples indicates that the concrete mixtures are less porous. It was discovered that the water absorption at 0% replacements was 2.98%, while the water absorptions for the other design mixes—ARC1, ARC2, ARC3, BRC1, BRC2, BRC3, CRC1, CRC2, and CRC3—were 2.58%, 2.52%, 2.54%, 2.37%, 2.32%, 2.29%, 2.35%, 2.30%, and 2.23%, in that order.
- f) As a result, the article suggests that the best concrete mix is BRC2, or concrete that contains 10% bagasse ash, 10% silica fumes, and 30% recycled aggregates.)

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