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"Optimization of High-Performance Concrete Through the Use of Recycled Aggregates, Bagasse Ash, And Silica Fume"

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ABSTRACT: Concrete is one of the most widely used construction materials due to its high compressive strength, durability, versatility, and ability to withstand heavy structural loads. Conventional concrete is mainly composed of cement, fine and coarse aggregates, water, and reinforcing steel, with chemical or mineral admixtures used when required. However, the rapid growth of the construction industry has resulted in extensive consumption of natural resources and has generated large quantities of construction and demolition (C&D) waste. Therefore, the development of sustainable concrete using recycled and alternative materials has become increasingly important.

Recycled aggregates obtained from demolished concrete, brick masonry, construction sites, ready-mix concrete plants, and damaged structures can be used as partial substitutes for natural aggregates. Their utilization can reduce the extraction of natural resources and help minimize the environmental problems associated with construction waste disposal. Similarly, sugarcane bagasse is an important agricultural by-product generated during sugar production. After the extraction of sugarcane juice, a considerable quantity of bagasse remains, which can be processed and burned to produce bagasse ash. Due to its pozzolanic properties and silica content, bagasse ash has potential for use as a partial replacement for cement in concrete.

Silica fume is a highly reactive supplementary cementitious material obtained as a by-product of silicon and ferrosilicon alloy production. It contains a high proportion of very fine, non-crystalline silica particles. Because of its extremely small particle size and high reactivity, silica fume can improve the packing density, strength, impermeability, and durability of concrete. The combined use of recycled aggregates, bagasse ash, and silica fume can therefore provide an effective approach for producing sustainable and high-performance concrete while reducing the consumption of conventional raw materials.

The present study investigates the performance of **M25-grade concrete** by partially replacing natural coarse aggregates with recycled coarse aggregates and cement with bagasse ash and silica fume. Recycled coarse aggregates were used at replacement levels of **15%, 30%, and 45%**, while bagasse ash and silica fume were incorporated at **5%, 10%, and 15%** replacement levels. The prepared concrete mixes were evaluated to determine the effect of these materials on the performance of concrete and to identify an optimum combination.

Based on the experimental investigation, the modified concrete mixes demonstrated satisfactory and improved performance at suitable replacement levels. Among the different combinations studied, **BRC2**, containing **30% recycled coarse aggregates, 10% bagasse ash, and 10% silica fume**, was identified as the optimum mix. The study concludes that the appropriate incorporation of these recycled and supplementary materials can reduce the dependence on natural aggregates and cement while promoting waste utilization and sustainable construction.

Keywords: High-Performance Concrete, Recycled Aggregates, Bagasse Ash, Silica Fume, M25 Concrete, Sustainable Construction, Waste Utilization.

INTODUCTION: The Construction business in India is an imperative symbol of growth as it produces investment possibilities over different similar areas. With an approximate percentage of 8.2%, this sector has given approximately Rs. 670,778 crores to the country's GDP. Throughout the world, new infrastructures are being constructed each day worth billions of rupees which contribute to the development of one nation. the development in the construction industry also promotes job opportunities. Innovative ideas are being introduced in this sector from time to time so that the environmental impact can be reduced and more efficient infrastructures can be obtained. With these new ideas, 100% safety of a structure, high efficiency and large-scale production are possible without any errors. Since the beginning, the construction and innovation have walked side by side and many different structures have been constructed. The underwater tunnels, sky scrapers, extremely large span bridges etc are perfect examples of modern constructions

Behind these structures, thousands of researchers play an impeccable role and without all these researches and researchers, these enormous and complicated structures would not have been possible to construct. The work of such an industry continues even in times of pandemic and becomes essential after calamities. Thousands of companies are operating different small scaleand large-scale projects throughout the world and millions of people are working in such companies with different skill sets and different academics. Each year for the construction industry is much more innovative and focused than the previous year.

Majorly, there are three types of constructions, which are being constructed on the basis of material, that are mentioned below:

- Concrete structures
- Steel structures
- Composite structures

RECYCLED AGGREGATES

Recycling substances is a pretty traditional idea as Romans practiced reusing the materials of the destroyed art to create brand-new ones. After the Second World War, reusing elements from wrecked structures displayed an alternative low-cost solution. For a more sustainable society, the infrastructure sector and various companies are presently embedding sustainability into their raw material having different strategies, and recycling is one of the environmental control methods for obtaining a sustainable building industry. The construction sector produces enormous quantities of rubble which can be easily reused and recycled for future sustainable production of concrete. The modern construction industry obtains millions of debris throughout the world which is being thrown away as disposal. The utilization of such waste rubble material in concrete as an aggregate has great significance and can solve the disposal problem of such material.

Figure: Reclaimed Recycled Aggregates

BAGASSE ASH

Bagasse is the trash from a sugarcane plant, fruit plants or seeds when the juice of such plants 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. There are many applications of this bagasse which entails soil improvement, used as a fertilizes in many materials, animal diet, combustible fuel, or in concrete.

SILICA FUMES

Silica fume is a result of electrostatic seizing and soothing 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. This material is 'super pozzolan' that can be used to improve ordinary cement properties. It transforms the physical properties of fresh cement paste and the microstructural features of hardened cement. Previous researches have sone the by replacing cement with silica fumes, concrete shows more strength than the conventional concrete which is a result of improves fresh and hardened properties

OBJECTIVES

To perform the present investigation of the study titled "A Study on High-Performance Concrete by Replacing Raw Materials with Recycled Aggregates, Bagasse Ash and Silica Fumes", following objectives are defined:

- To study the properties of waste material i.e. recycled aggregates, bagasse ash and silica fume in concrete production.
- To design M25 grade of concrete as per the codal provisions IS 10262:2019
- To study the effect of replacing raw coarse aggregates with recycled coarse aggregates (15%, 30% and 45%) and cement with bagasse ash (5%, 10% and 15%) and silica fumes (5%, 10% and 15%).
- To optimize combine proportions of all the replacement materials for designing M25 grade concrete.

LITERATURE REVIEW:

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

This paper reports the recycling of bagasse ash (waste product of sugar industries) as a cement replacement in concrete, which provides a satisfactory solution to environmental concerns associated with waste management. The impact of bagasse ash content as a partial replacement of cement has been investigated on physical and mechanical properties of hardened concrete, including compressive strength, splitting tensile strength, chloride diffusion, and resistance to chloride ion penetration. The results indicate that bagasse ash is an effective mineral admixture and pozzolan with the optimal replacement ratio of 20% cement, which reduced the chloride diffusion by more than 50% without any adverse effects on other properties of the hardened concrete.

Singha Roy Dilip K., Sil Amitava, (2012) "Effect of Partial Replacement of Cement by Silica Fume on Hardened Concrete" [3] 8

The use of Silica Fume (SF) in short period of time had one of the most dramatic impacts on the industry's ability to routinely and commercially produce SF modified concrete of flowable in nature but yet remain cohesive, which in turn would develop both high early and high later-age strengths including resistant to aggressive environments. This paper features an experimental study on the nature of SF and its influences on the properties of fresh and hardened concrete. In the present study, an attempt has been made to investigate the strength parameters of concrete made with partial replacement of cement by SF. Very little or no work has been carried out using silica fume as a replacement of cement. Moreover, no such attempt has been made in substituting silica fume with cement for low/medium grade concretes (viz. M20, M25). Properties of hardened concrete viz Ultimate Compressive strength, Flexural strength, Splitting Tensile strength has been determined for different mix combinations of materials and these values are compared with the corresponding values of conventional concrete. The present investigation has been aimed at to bring awareness amongst the practicing civil engineers regarding advantages of these new concrete mixes.

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

A self-compacting concrete (SCC) is the one that can be placed in the form and can go through obstructions by its own weight and without the need of vibration. Since its first development in Japan in 1988, SCC has gained wider acceptance in Japan, Europe and USA due to its inherent distinct advantages. Although there are visible signs of its gradual acceptance in the North Africa through its limited use in construction, Libya has yet to explore the feasibility and applicability of SCC in new construction. The contributing factors to this reluctance appear to be lack of any supportive evidence of its suitability with local aggregates and the harsh environmental conditions. The primary aim of this study is to explore the feasibility of using SCC made with local aggregates of Eastern Province of Libya by examining its basic properties characteristics. This research consists of: (i) Development of a suitable mix for SCC such as the effect of water to cement ratio, limestone and silica fume that would satisfy the requirements of the plastic state; (ii) Casting of concrete samples and testing them for compressive strength and unit weight. Local aggregates, cement, admixtures and industrial waste materials were used in this research. The significance of this research lies in its attempt to provide some performance data of SCC made in the Eastern Province of Libya so as to draw attention to the possible use 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 evaluated the effect of fully replacing natural aggregate (NA) with several sources of recycled concrete aggregate (RCA) on the various mechanical properties of multiple concrete mixtures having equivalent compressive strength and slump (compressive strengths between 40 and 60 MPa and slumps between 75 and 125 mm). The RCA concrete (having equivalent compressive strengths as the NA concrete) had modulus of elasticity values up to 19% lower than NA concrete. The average secant modulus of elasticity of bulk RCA was evaluated and was shown to be proportional to the modulus of elasticity of concrete incorporating the RCA as coarse aggregate. Fracture energy of RCA concrete was measured using single edge notched double-cantilevered (SENDC) 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]

This paper presents the results of an experimental program related with the failure and mechanical behavior of Recycled Aggregate Concrete (RAC) under different load scenarios. The particular type of RAC considered herein is characterized by the partial or total replacement of natural coarse aggregates by recycled ones obtained from the crushing of waste concrete. The aim of this research is to deepen the existing knowledge related to RACs by analyzing the degradation in physical and mechanical properties when recycled coarse aggregates are used. In particular, its behavior under triaxial compression is examined. A normal strength concrete with natural coarse aggregates was designed and used to produce cylindrical samples which, after being tested, were crushed and reused as coarse aggregates in the elaboration of RAC. Samples were subjected to uniaxial compression, splitting tensile and triaxial compression tests. Experimental results related to the physical properties of recycled aggregates, fresh concrete properties, and hardened concrete mechanical behavior are presented and discussed. Moreover, the Performance Dependent Failure Criterion based on an objective definition of concrete quality, was extended and applied to predict peak stresses of RAC under triaxial compression. The comparison of experimental and numerical results demonstrated that this criterion originally developed for standard concrete is also suitable for RAC.

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

This paper presents the experimental results of a study on comparing the difference in properties of recycled aggregates (RAs) with varying amounts of old adhered mortar obtained from different sources and evaluating the influence of the different RAs on the mechanical and durability properties of recycled aggregate concrete (RAC). Four concrete mixes (one with natural aggregate and three others with recycled aggregates) with 28 days target compressive strength varying from 30 MPa to 80 MPa are designed by using each RA to fully replace NA. The properties of RAC are also modeled by using the artificial neural networks (ANN) method. The experimental results show that the performance of RAs from different sources varied greatly and RA of good quality can be used to produce high strength concrete with hardened properties comparable to those of the corresponding natural aggregate concrete (NAC). The comparison of the predicted results based on the ANN models and the experimental values indicated that the ANN method could be used to evaluate the properties of RAC made with RAs derived from different sources. This will facilitate the wider application of RA in concrete.

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

An agro-industrial waste product of sugar mills - Bagasse Ash was used to replace cement in concrete, up to a certain extent. Laboratory test results show that only up to 2% of cement can be replaced by the Bagasse ash without adverse effect on the concrete. It is concluded that Bagasse ash does not provide improvement of concrete strength. As a result, the use of Bagasse ash as concrete additive or cement replacement may need to be combined with other bonding materials, such as 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]

Experimental studies for determining the mechanical and the physical properties of the recycled aggregate concrete (RAC) with and without silica fume (SF) is inspired by the Urban Renewal Law which regulates circumstance of existing structures in Turkey. According to this law, the structures which have been built lacking quality engineering, built without considering urban planning, and are risk prone (i.e. susceptible to earthquakes), will be demolished and rebuilt using recent Turkish Standards. Implementing this law is expected to increase the quantity of waste concrete. Minimizing waste disposal through structural and non-structural areas without a harmful effect on nature has a vital importance in Turkey. In this study, demolished-building-rubble is used as recycled aggregate (RA) with and without SF in concrete mixtures. Twelve concrete mixtures in three groups are produced, and the mechanical properties of the concrete specimens such as compressive strength, tensile splitting strength and elasticity modulus, and physical properties of the concrete specimens such as density and water absorption ratio are determined. The proportion 30% of RA in concrete mixtures is proposed as the optimum ratio. Low regression coefficient of RAC with SF is observed in the short-term. It is found that 5% SF content in the RAC is more convenient to improve the low properties of RAC (i.e. compressive strength).

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

Due to the increase in the demolition of high strength concrete structures and the interest of precast concrete companies in being more competitive, it is necessary to analyze the use of recycled concrete aggregates (RCA) in high performance concrete (HPC). In this study, HPC were produced using 20%, 50% and 100% of RCA on substitution of natural coarse aggregates. Three types of RCA were used, they were produced crushing original concrete of 100, 60 and 40 MPa of compressive strength. The physical, mechanical and durability properties of the recycled aggregates concretes and conventional concrete were analyzed. The results showed that considering mechanical properties, the 100% natural coarse aggregates' replacement would be possible when RCA were produced from original concrete with a minimum compressive strength of 60 MPa. When durability properties were considered, concrete produced with up to 50% of RCA could be used in HPC production.

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]

H-NMR has been used to characterize white Portland cement paste incorporating 10 wt.% of silica fumes. Samples were measured sealed throughout the hydration without sample drying. Paste compositions and C–S–H characteristics are calculated based on 1 H NMR signal intensities and relaxation analysis. The results are compared with a similar study of plain white cement paste. While the presence of silica fume has little influence on C–S–H densities, the chemical composition is impacted. 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 when 10% of silica fume is added to the white cement. A densification of the C–S–H with time is observed. 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 use of silica fume had major impact on industries, ability to routinely and commercially produce silica fume modified concrete of flow able in nature but yet remain cohesive, which in turn produces high early and later age strength including resistant to aggressive environments. This study is an experimental on the nature of silica fume and its influences on the properties of fresh concrete. The partially replacement of cement by silica fume the strength parameters of concrete have been studied. First the strength parameters of concrete without any partial replacement were studied then strength parameters by partial replacement with silica fume have been studied by placing cube and cylinder on compression testing machine (CTM). Silica fume were used to replace 0% to 15% of cement, by weight at increment of 5% for both cube and cylinder. The results showed that partial replacement of cement with silica fume had significant effect on the compressive strength of cube and split tensile strength cylinder. The strength of concrete increases rapidly as we increases the silica fume content and the optimum value of compressive strength is obtained at 10% replacement. After 10% its start decreasing under uniform load condition of 4 KN and similarly the split tensile strength increases up to 10% and then start decreasing under the uniform load condition of 2KN.

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

This research addresses the suitability of sugarcane bagasse ash (SCBA) in concrete used as partial cement replacement. Two grades of concrete M15 and M20 were used for the experimental analysis. The cement was partially replaced by SCBA at 0%, 5%, and 10%, by weight in normal strength concrete (NSC). The innovative part of this study is to consider two grades of concrete mixes to evaluate the performance of concrete while cement is replaced by sugarcane bagasse ash. The cylindrical specimens having size 150 mm x 300 mm were used and tested after curing period of 7, 14 and 28 days. It was observed through the experimental work that the compressive strength increases with incorporating SCBA in concrete. Results indicated that the use of SCBA in concrete (M20) at 5% increased the average amount of compressive strength by 12% as compared to the normal strength concrete. The outcome of this work indicates that maximum strength of concrete could be attained at 5% replacement of cement with SCBA. Furthermore, the SCBA also gives compatible slump values which increase the workability of concrete.

Loganayagan S., et.al, (2019) "Sugarcane bagasse ash as alternate supplementary cementitious material in concrete" [14]

In this study, we examined the characteristics of sugarcane bagasse ash (SCBA) as a additional material in the mixture of concrete cubes. The additive material was collected from several sugarcane juice shop from Sathyamangalam and the bagasse get dried in sunlight for two days, sugarcane bagasse is burnt and ash is get collected and its chemical and physical properties was investigated. Sugarcane bagasse ash was replaced with cement in various proportions in the range of 5%–15%. The SCBA mixed with cement and checked the quality tests on consistency and its time check on initial and final setting. The strength property due to compression of sugarcane bagasse ash concrete for different ratio was tested. The dumping of this material may cause environmental issues around the factories so the bagasse ash used as useful material. Therefore, we decided to replace 10% in cement by sugarcane bagasse ash. The results of SCBA seem to be similar as concrete properties and replacement percentage could be increased and tested the performance of the concrete.

Amin Muhammad Nasir, Ashraf Muhammad and Kumar Rabinder, (2020) "Role of Sugarcane Bagasse Ash in Developing Sustainable Engineered Cementitious Composites" [15]

Sugarcane bagasse is an agricultural waste that can be transformed by incineration into a cement replacement material for various cementing purposes. This study investigated the role of finely ground bagasse ash (GBA) in producing engineered cementitious composites (ECCs) with the addition of polyvinyl alcohol (PVA) fibers. The main focus of this study was to develop a green ECC with higher strength capabilities (compressive, tensile, and flexural) and greater tensile ductility. To develop this composite, GBA

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was added into ECC mixes at different proportions, i.e., 10, 20, and 30%. The proportions of PVA fibers and the water-to-binder ratio were kept constant. The results revealed that the ECC mix containing 10% GBA exhibited higher compressive strength compared to that of a control and the other ECC mixes. The tensile and flexural strengths of the ECCs exhibited patterns almost similar to that of compressive strength. Moreover, the deflection in the control mix was higher compared to that of the GBA-ECC mixes at an initial curing age. The ECC mix containing 10% GBA exhibited better ductile behavior among all the ECC mixes used in this study.

Ahmad Bhat Javed, (2021) "Effect of strength of parent concrete on the mechanical properties of recycled aggregate concrete" [16]

The effect of quality of original concrete, from which coarse recycled concrete aggregate particles were derived, on mechanical properties of three grades of recycled 14
aggregate concrete (RAC) has been investigated for the following two weight replacement levels of natural coarse aggregates (NCA) with the recycled aggregates: 50% and 100%. The original concrete samples made with natural coarse aggregates were designed for 28-day nominal cube crushing strengths of 20 MPa, 40 MPa and 60 MPa. The results indicated that the grade of original concrete did not have a significant effect on the mechanical properties viz. compressive strength, splitting tensile strength and flexural strength of the three grades of RCA concretes of this investigation. All the aforesaid properties were inferior to those of the control concrete made only with NCA. However, in case of the high-strength parent concrete, the mechanical properties of the resultant RAC were superior as compared to RAC made with normal and medium strength parent concrete.

RESEARCH METHDOLOGY

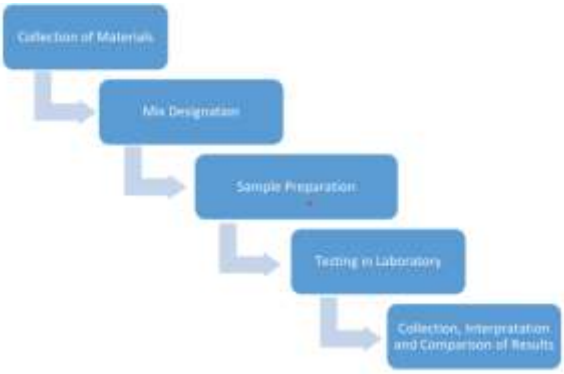

Figure: Block Diagram Explaining the research Methodology

Collection of raw and replacement material

Table: Physical Properties of OPC 43 grade.

S. No.	Properties	OPC43Grade	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.)

Table: Physical Properties of Fine Aggregates

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

Table: Physical Properties of Graded Coarse Aggregates

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

Table: 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.

Silica Fumes: Silica fume is a result of electrostatic seizing and soothing 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

Mix Designation

Table: 4.9. 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%
BRC1	10%+10%	15%
BRC2	10%+10%	30%
BRC3	10%+10%	45%
CRC1	15%+15%	15%
CRC2	15%+15%	30%
CRC3	15%+15%	45%

RESULT AND DESCUSSION

EFFECT ON WORKABILITY

The consistency of various concrete mix i.e. control concrete mix and different green concrete mix entailing different proportions of bagasse ash and silica fume and recycled concrete Aggregates had been assessed through slump test. The test results of workability

Table: Slump Values of Control Concrete mix and Green Concrete mix.

Mix Designation	Slump in mm
CM	80
ARC1	77
ARC2	71
ARC3	58
BRC1	72
BRC2	68
BRC3	60
CRC1	62
CRC2	55
CRC3	51

EFFECT ON COMPRESSIVE STRENGTH

The compressive strength test of concrete is very imperative aspect of concrete as it gives an idea of concrete capacity in compression and it is considered as an index of overall quality of any concrete mix. The compressive strength test of various concrete mixes was carried out on 7 days and 28 days.

Table: Compressive Strength Test Results

Mix Designation	C.S.at7 days	C.S.at28 days
CM	21.4	30.6
ARC1	20.6	28.9
ARC2	21.1	29.3
ARC3	20.2	28.2
BRC1	22.9	31.5

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BRC2	23.1	32.2
BRC3	22.2	31.2
CRC1	20.5	27.6
CRC2	19.9	27
CRC3	18.7	26.2

EFFECT ON SPLIT TENSILE STRENGTH

The split tensile strength test was carried at 7 days and 28 days for every concrete mix group. Table 5.4 represents the results of split tensile strength of all concrete mixes

Table: Split Tensile Strength Test Results.

Mix Designation	S.T.S. at 7days	S.T.S. at 28days
CM	2.1	2.85
ARC1	1.85	2.73
ARC2	1.95	2.82
ARC3	2.05	2.85
BRC1	2.00	2.81
BRC2	2.13	3.02
BRC3	1.98	2.79
CRC1	1.89	2.75
CRC2	1.82	2.66
CRC3	1.73	2.51

EFFECT ON WATER ABSORPTION

Water absorption test was conducted in the laboratory and test results have been represented in Table

Table: Water absorption Test Results

Mix Designation	Water Absorption %
CM	2.98
ARC1	2.58
ARC2	2.52
ARC3	2.54
BRC1	2.37
BRC2	2.32
BRC3	2.29
CRC1	2.35
CRC2	2.3
CRC3	2.23

CONCLUSION

1. The present study illustrates that it is possible to design green concrete with enhanced properties while using bagasse ash (5%, 10% and 15%), Silica fumes (5%, 10% and 15%) and recycled concrete aggregates (15%, 30% and 45%).
2. With an increment in the percentage of replacement material in concrete mix, concrete slump value was decreased. Therefore, it can be concluded in the gist that some difficulty was faced while producing workable concrete when concrete is having higher proportions of bagasse ash, silica fumes and recycled aggregates. However, workable mix was produced when low proportions of replacement materials were added in concrete mix.
3. The replacement of raw materials with bagasse ash, silica fumes and recycled aggregates increases the compressive strength up to some extent when compared with control concrete mix. The maximum compressive strength was attained by BRC2 concrete mix i.e. 23.1 MPa at 7 days and 32.2 MPa at 28 days, whereas, the compressive strength of control mix was 21.4 MPa at 7 days and 30.6 MPa at 28 days. An almost of 8% increase in compressive strength at 7 days and 6% at 28 days was seen in BRC2 with respect to control mix (CM). It was also observed from the results that the maximum decrease in compressive strength was seen in CRC3 of about 13% at 7 days and 14% at 28 days with respect to control mix concrete.
4. The replacement of raw materials with bagasse ash, silica fumes and recycled aggregates increases the split tensile strength up to some extent when compared with control concrete mix. The maximum split tensile strength was attained by BRC2 concrete mix i.e. 2.13 MPa at 7 days and 3.02 MPa at 28 days, whereas, the split tensile strength of control mix was 2.1 MPa at 7 days and 2.85 MPa at 28 days. An almost of 2% increase in split tensile strength at 7 days and 6% increases at 28 days was seen in BRC2 with respect to control mix CM. However, the maximum decrease in split tensile strength was seen in CRC3 of about 17% at 7 days and 12% at 28 days with respect to control mix concrete.
5. The water absorption of various concrete samples was low which reveals less porosity of the concrete mixes. Water absorption at 0% replacements was found out to be 2.98%, whereas for the other design mixes i.e. ARC1, ARC2, ARC3, BRC1, BRC2, BRC3, CRC1, CRC2 and CRC3 the water absorptions was 2.58%, 2.52%, 2.54%, 2.37%, 2.32%, 2.29%, 2.35%, 2.30% and 2.23% respectively.
6. Therefore, it is suggested in the gist that the BRC2 i.e. concrete having 10% of bagasse ash, 10% of silica fumes and 30% of recycled aggregates is the optimum concrete mix.

FUTURE SCOPE

1. Further experimental investigation shall be carried out on the same study by increasing the dosage percentage of bagasse ash, silica fumes and recycled concrete aggregates to fully understand the behavior of these replacement materials.
2. Further experimental study shall be carried out by keeping the same proportions of bagasse ash, silica fumes and recycled concrete aggregates while performing different laboratory tests to assess the durability and strength aspects of various concrete mixes.
3. Further experimental study shall be carried out by replacing 100% of cement by bagasse ash and silica fumes while keeping other parameters same as the present study. The comprehension of the behavior of Geopolymer concrete can be of great significance.

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