Review Paper – Effect of Various Temperatures on Strength of Concrete With Partial Replacement of Cement By Rice Husk Ash And Partial Replacement of Coarse Aggregate By Blast Furnace Slag

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Abstract- *This study aims to investigate the strength of concrete under various temperatures by using partial replacement of cement with Rice Husk Ash and partial replacement of coarse aggregate with Blast Furnace Slag. Concrete does not burn, it cannot be 'set on fire' like other materials in a building and it does not emit any toxic fumes when affected by fires. It will also not produce smoke or drip molten particles, unlike some plastics and metals, so it does not add to the fire load. For this reason concrete is said to have a high degree of fire resistance and in the majority of applications, concrete can be described as virtually 'Fire Proof '.This excellent performance is due in the main to concrete's constitute materials. (i.e. Cement and Aggregate) which when chemically combined with concrete, form a material that is essentially inert and importantly for fire safety design has a relatively poor thermal conductivity. It is this slow rate of heat transfer (conductivity) that enables concrete to act as an effective fire shield not only between adjacent spaces, but also to protect itself from fire damage. The rate of increase of temperature through the cross section of concrete element is relatively slow and so internal zones do not reach the same high temperature as surface exposed to flames. When concrete is exposed to the high temperatures of a fire, a number of physical and chemical changes can take place.*

Keywords- Rice husk ash, blast furnace slag, Elevated Temperature, Mix proportion.

I. INTRODUCTION

Any engineering advancement is for betterment of human life. Shelter is considered as one of the basic needs for human beings. The buildings constructed should give protection from heat, cold, rain, and also from disasters like fire, floods and earthquakes. Fire is considered as one of the disastrous event which causes loss or damage to human life and property. When there is an accidental fire in a structure, the duration of fire will be less but the intensity of heat produced will be more, this heat causes damage to the structures. In addition to accidental fire there are some special structures which are subjected to high temperatures, like take-off areas of jet aircraft, rocket launching pads, nuclear reactors, chimneys, metallurgical or chemical industries, glass, cement industry, coke ovens, storage tanks for hot crude oil and hot water, where the localized areas of concrete are subjected to high temperatures, The material used for construction should be capable of resisting high temperatures and it should also give minimum time for the inmates to escape.

The rapid growth of modern cities inspired much Speculative building and the structures usually were built close to one another because of the disorganized manner in which construction was proceeding. As more and more people congregate closer and closer together in settlements as urbanization increases, risks associated with fire increase. If there, fire will be occur; it is difficult to save life of residents live in such places. Fire in human settlements is caused predominantly accidentally, usually in relation to the use of various fuel types for open-flame cooking, lighting and heating in buildings. Fire-safety education and law and order can be the major factors in reducing the causes offires.

With the increased incidents of major fires and fire accidents in buildings; assessment, repair and rehabilitation of fire damaged structures has become a topical interest. This specialized field involves expertise in many areas like concrete technology, material science and testing, structural engineering, repair materials and techniques etc. Research and development efforts are being carried out in these related disciplines. Any structure can undergo fire accident, but because of this the structure cannot be denied neither abandoned. To make a structure functionally viable after the damage due to fire has become a challenge for the civil engineering community. The problem is where to start and how to proceed. It is vitally important that we create buildings and structures that protect both people and property as effectively as possible. One of the advantages of concrete over other building materials is its inherent fire-resistive properties. However, concrete structures must still be designed for fire effects. Structural components must still be able to withstand dead & imposed loads without collapse even though the rise in temperature causes a decrease in the strength & modulus of elasticity for concrete & steel reinforcement.

Fire resistance is measured in terms of structural stability, structural integrity and insulation. Stability refers to the ability to remain standing without collapse. Integrity refers to the ability to remain intact and not move and buckle to create openings through which flames can escape. Insulation relates to the ability to either contain the fire within the building and not to ignite any material outside, or to insulate what is inside the building from being ignited by a fire outside

II. LITERATURE REVIEW

S. Andavan(2018) This paper summarizes that in order to increase the demand of construction materials and need for providing a sustainable growth in construction field. For this objective, use of agricultural by product (rice husk ash) on the cement in order to mitigate the availability, affordability, quality and pollution issues. Solid cubes of size 150*150*150, cylinders and prisms of M20 grade were casted by three different levels of replacement of cement to RHA by weight at 0%, 10%, 20%. Specimens were made ready for testing after 7, and 28 days curing in water served as the control by IS methods. Testing was included for the strength (compressive, flexure and split tensile). The test results revealed that strength are slightly better than the standard concrete by satisfying the limits initiated endorsed by standard. Initially at 7 days compressive strength test, with the increase in replacement percentage the strength decreases. Laterat 28 days test, it is observed that the strength increases with the increase in replacement percentage of cement with glass powder.
The max strength is obtained at 10%replacement

Er. Ravi bhushan(2017) This paper summarizes the feasibility of using partial rice husk ash on the cement in order to mitigate the availability, affordability, quality and pollution issues. Solid masonry blocks size 150*150*15 of M20 grade were casted by replacement of cement to RHA by weight at 0%,5%,10%,15%,20%,25%. Cubes were made ready for testing after 7, and 28 days curing in water served as the control. Testing was included for the strength (compressive, flexure and split tensile), workability (water binding ratio and setting time), costing analysis. The test results revealed that the workability and strength are slightly better than the standard concrete by satisfying the limits initiated endorsed by standard.

Gupta Priyanka(2017) In every year approximately 12 million tons of peddy produced in India this gives around 24 million tons of rice husk and 4.4 million tons of rice husk ash every year, major 3 use of rice husk ash in steel, cement & refractory bricks industries. this r.h.a is a great environment threat causing damage to the land and the surrounding area in which it is dumped lots of way are being through of for disposing them by making commercial use of this r.h.a. R.H.A is a good pozzolan. This super pozzolana can be used in a big way to make special concrete mixes. These is a growing demand for fine amorphous silica in the production of special cement and concrete mixes, high performance concrete, high strength, low permeability concrete .concrete for use in bridge, marine environments nuclear power plants etc.in this project evaluate how different contents of RHA added to concrete may influme i ts physics of mechanical properties. sample cube were tasted with different percentage of rha and different w/c ratio ,replacing in mass the cement properties like compressive strength ,water absorption and slump retention were evaluated. Fly ash and Rice husk ash is found to be superior to other supplementary materials like slag, and silica fume. RHA used in this study is efficient as a pozzolanic material; it is reach in amorphous silica. Due to low specific gravity of RHA which lead storeduction in mass per unit volume, thus adding it reduces the dead load on the structure.
Compressive strength increases with the increase in the percentage of Fly ash and Rice Husk Ash up to replacement (20% RHA) of Cement in Concrete for different mix proportions.

Chandraulkirti(2015) This paper summarizes the research work on the properties of Rice Husk Ash (RHA) when used as partial replacement for Ordinary Portland Cement (OPC) in concrete. OPC was replaced with RHA by weight at 0%, 5%, 7.5%, 10%, 15% and 20%. 0% replacement served as the control. Slump cone test was carried out on fresh concrete while Compressive Strength test was carried out on hardened150mmconcretecubesafter7,14and28dayscuringinwater.TheresultsrevealedthattheslumpconeincreasedasthepercentagereplacementofOPCwithRHAincreased.ThecompressiveandtensilestrengthofthehardenedconcretealsoincreasewithincreasingOPCreplacementwithRHA.Itisrecommended that further studies be carried out to gather more facts about the suitability of partial replacement of OPC with RHA in concrete. The result of the Tensile strength of concrete cubes shows that the

Tensile strength up to 12.5% replacement gives good result and reduced as percentage of RHA increase after 12.5%.

Manjitkaur(2012) Ground granulated Blast furnace slag (GGBFS) is a waste of industrial materials, it is relatively more recent pozzolanic material that has received considerable attention in both research and application. It is a non-metallic product consisting essentially of Silicates and Alumino silicates of calcium's developed simultaneously with iron in a blast furnace and is granulated by quenching the molten material in water or steam, and air. The present Investigation has been undertaken to study the effect of Ground granulated blast furnace slag and saw dust on the mechanical properties of concrete, when coarse aggregates is replaced by Ground granulated blast furnace slag and saw dust is replaced in different percentages i.e. 0%,5%,10%,15%,20%,and 25% with the Fine aggregates(sand). The main parameters investigated were cube compressive strength and weight of concrete. The tests were conducted on concrete with ratio 1:1.5:3.The test results indicate that with the use of blast furnace slag by fully replacing coarse aggregates and partially replacing saw dust by fine aggregates in different percentages i.e. 0%,5%,10%,15%,20%,and 25%,the weight of concrete decreases with the increase in the percentage of saw dust. The compressive strength decrease with the increase in percentage of saw dust. The reduction percentage in the compressive strength is 27.14%, 44.16%, 50.46%, 64%, 76.53%, 80.60% Replacement of sand by saw dust reduce the unit weight of concrete and make it light weight. The cost of concrete also decreases with the increase in percentage of saw dust. Test result show that, the concrete become lighter than conventional concrete and reducing the environmental hazard and making the concrete economical. GGBFS Concrete can be effectively used by replacing sand up to 15% with sawdust.

George Washington(2017) In this experiment the partial replacement i.e of RHA has been done at 10%, 20% and 30% respectively to make concrete and the results were compared with plain cement concrete which is without any replacement of RHA. The water requirement was found to be increased and compressive strength of concrete was found slightly decrease, Initial and Final setting time were also delayed, Slump value increased. The compressive strength of concrete was found to be 35.05Mpa for 10 %, 30.37Mpa for 20% and 24.6 for 30 % replacement respectively. From the Overall study, it was observed that it can be a good replacement of cement i.e. 10% and 20% which can be recommended for construction purposes.

Harshitvarshney(2015) This paper summarizes the experimental work of concrete in which ordinary Portland cement (OPC) cement were replaced by Rice husk ash (RHA). Partial replacement of OPC cement was carried out at 0% to 20% in steps of 5% and compared with 0% replacement. In this work different tests were performed as slump test, compaction factor, compression test and split tensile test to find the suitable percentage replacement of cement by RHA. Compression and split tests were performed for 7days and 28 days of curing and result shows some variation in both tests in every proportion. After performing tests, the results suggest that up to 15% replacement of RHA for cement is suitable for making concrete. The workability of concrete made with 5% RHA has found to be decreased with increased w/c ratio when compared to normal concrete and compacting factor also found decreased with increased w/c cement ratio when compared to normal concrete. The compressive strength of concrete increased with increase the percentage of RHA up to 15% after 7 and 28 days curing and found decreased after 15% of RHA.

Bassam Z. Mahasneh(2005), studied fire resistance of Polymeric Fiber Reinforced Concrete (PFRC). The effect of fire on compressive strength, tensile strength and pullout is investigated. Results from several cylinder specimens having different aspect ratios as well as cube specimens are also investigated. These results indicated that PFRC strength is controlled by the composite action of both fiber and concrete. This Polymeric fiber shows an increase in the ductility, fire resistance and enhancement of the composite material properties. This study provides a good understanding of the behavior of fiber polymers on composite concrete properties and the effect of polymeric reinforced polymer on unprotected concrete.

Katy Branthwaite(2006), models of concrete columns reinforced with FRP-reinforcing bars were made. They varied in cover thickness given to the FRP and were assumed to be surrounded by a fire following a standard fire curve. A uniformly distributed load was applied on top of the columns and the columns were then tested at thirty minute intervals to analyse the effects of the fire. The resultant displacements and stresses were interpreted in order to make a comparison between the effects of cover thickness and fire exposure time to the FRPreinforced concrete columns in a simulated fire.

Aka Adefemi (2013),studied on Ordinary Portland Cement (OPC) Concrete which deteriorates considerably when exposed to aggressive environment such as fire or elevated temperatures. A addition of certain materials obtained from agricultural and industrial wastes to OPC concrete could improve its performance in this environment. This paper investigated the effect of Carbide Waste (CW) on the compressive strength of concrete when exposed to fire. This was achieved by partially replacing OPC with 5, 10, 15 and 20 percent (%) of CW to produce 150 x 150 x 150mm concrete cubes. Sample of 100% OPC were also produced and served as the control. The quantities of cement, fine aggregate and coarse aggregate used forthe production of concrete specimens were obtained through absolute volume method of mix design. Water/cement (w/c) ratio of 0.65 was adopted for OPC/CW concrete and the control. For the purpose of the research, Ninety (90) concrete cubes were produced for the two specimens. The specimens produced were cured in ordinary water for 28days after which they were heated in a furnace at varying temperatures of 200, 300, 400, 600, and 800^{o}C. Specimens were heated for 2 hours at each testing temperature to achieve the thermal steady state after which their compressive strengths were determined. Increase in compressive strength was observed in the control specimen up to 300^{o}C after which the specimen suffered severe loss with further increase in temperatures up to 800^{o}C. However, the compressive strength of CW concretes increases with increase in temperature up to 500^{o}C and then, decreases with further increase in temperatures. 10% replacement of OPC with CW performs satisfactorily better than other replacement level at all temperatures. Replacement of OPC by 10% CW increases concrete resistance to fire by 14% of OPC concrete.

M. S. Morsy, S. H. Alsayed and M. Aqel(2010),an experimental investigation was conducted to evaluate the influence of elevated temperatures on the mechanical properties, phase composition and microstructure of silica flour concrete. Blended cement used in this investigation consists of ordinary Portland cement (OPC) and silica flour. The OPC were partially replaced by 0, 5, 10, 15 and 20% of silica flour. The blended concrete paste was prepared using the water-binder ratio of 0.5 wt% of blended cement. The fresh concrete pastes were first cured at 100% relative humidity for 24 hours and then cured in water for 28 days. The hardened concrete was thermally treated at 100, 200, 400, 600 and 800^{o}C for 2 hours. The compressive strength, indirect tensile strength, phase composition and microstructure of silica flour concrete were compared with those of the pure ordinary Portland concrete. The results showed that the addition of silica flour to OPC improves the performance of the produced blended concrete when exposed to elevated temperatures up to 400^{o}C.

Mohamed Saafi(2001),studied the Fire resistance of concrete members reinforced with fiber reinforced polymer (FRP).Rebars is an extremely crucial area that needs to be investigated prior to implementing FRP composite materials in buildings and other fire vulnerable structures. This work examines analytically the performance of FRP reinforced concrete beams subjected to high temperatures. Methods for estimating the residual flexural and shear strengths of FRP reinforced concrete beams exposed to fire for a certain duration of time were developed. The proposed methods are based on the assessment of the reduction in the initial strengths of concrete and FRP reinforcement resulting from the high temperatures developed inside the beam. A parametric study was carried out to study the effect of concrete cover, fire exposure time on the FRP temperatures and shear and flexural capacities of reinforced beams. It was found that the FRP temperatures decrease with increasing the concrete cover, and FRP reinforced concrete beams exhibited significant degradation in shear and flexural strengths. This study recommends a minimum concrete cover for fire resistance of 64 mm (2.5 in.) for FRP reinforced concrete.

Muna Mohammed Karim(2011), studied the increased use of high strength concrete (HSC) in buildings which has resulted in concern regarding the behavior of such concrete in fire. In the present work, an attempt is made to study the effect of fire flame exposure on compressive strength and splitting tensile strength of plain and fiber reinforced high strength concrete. High strength concretes were prepared in two series, with and without steel fiber reinforcement. Plain and steel fiber reinforced high strength concrete (PHSC) and (FRHSC) were subjected to the same fire temperatures and same burning time to reveal the effect of steel fiber on concrete strength at different heat levels as well as fire duration.

The concrete specimens for (PHSC) and (FRHSC) were subjected to fire flame temperature ranging between (300- 600 $^{\circ}$C) at different ages 30 and 60 days. Three temperature levels (300, 500 and 600 $^{\circ}$C) chosen with two exposure periods of 1.0 and 1.5 hours. The test specimens were cubes (100 mm) and cylinders (100*200 mm). After burning, the concrete specimens were allowed to cool in air. The results obtained from this study indicated that damage of concrete caused by exposure to fire depends on the temperatures range and the duration of exposure to fire.The results showed that (PHSC) higher rates of strength loss than (FRHSC).

D. V. ReddyK. Sobhan J. Young(2006)[7],This paper presents an experimental investigation for evaluating the effects of fire exposure on properties of structural elements retrofitted by carbon fiber reinforced polymers (CFRPs). Mechanical properties of CFRP-strengthened reinforced concrete (RC) members, protected with secondary insulation, were investigated, before and after (residual) direct fire exposure. Direct fire contact resulted in a reduction in capacity of 9-20% for CFRP-strengthened RC beams, and 15-34% for CFRP-strengthened RC columns. Furthermore, a similitude analysis was developed for a heat transfer relationship between full and small-scale specimens, allowing a ¼ exposure time reduction for the latter. Results from the experimental investigations demonstrate the benefits of employing secondary fire protection to CFRP-strengthened structures, in spite of the glass transition temperature being exceeded in the early stages of the elevated-temperature exposure. Therefore, it is suggested, that fire protection is necessary for a CFRP-strengthened structure to retain integrity throughout the duration of the fire exposure, and upon return to ambient temperature. The conclusions of this investigation are important to designers and practicing engineers for using CFRP materials in retrofitting RC structures with adequate fire resistance. This study shall contribute to the missing information for fire protection requirements and structural behavior of CFRP-strengthened structures affected by fire, which is not available in codes of practice for applicability of CFRP materials.

Ahmad,A.H.(2009),the research work includes an experimental investigation to study the effect of high temperatures on the mechanical properties of concrete containing admixtures. A comparative study was conducted on concrete mixes, reference mix without an additive and that with an admixture. Concrete was exposed to three levels of high temperatures (200,400,600)° C, for a duration of one hour, without any imposed load during the heating. Five types of admixtures were used, superplasticizer, plasticizer, retarder and water reducing admixture, an accelerator and an air entraining admixture. Mechanical properties of concrete were studied at different high temperatures, including: compressive strength, splitting tensile strength, modulus of elasticity and ultimate strain. Test results showed a reduction in the studied properties by different rates for different additives and for each temperature, the decrease was very limited at temperature up to (200°C) but was clear at (400,600)° C.

J.A. Larbi , R.B. Polder (2000) studied on microscopic method consisting of stereomicroscopy and polarising and fluorescent microscopy were used to assess the effectiveness of the pp-fibres in reducing explosive spalling in concrete elements subjected to fire attack. Rapid Chloride Migration test was also performed on standard specimens to establish whether the presence of the fibres might adversely affect the permeability and durability of the elements Specifications and Standards

Long T. Phan, Nicholas J. Carino (2000), studied fire test data which shows distinct behavioral differences between high-strength concrete (HSC) and normal strength concrete (NSC) at elevated temperature is presented. The differences are most pronounced in the temperature range of 20 °C to 400 °C. What is more important is the observed explosive spalling of HSC specimens during fire tests.. A comparison of test results with current code provisions on the effects of elevated temperatures on concrete strength shows that the CEN Eurocodes and the CEB provisions are unconservative. Aspects of analytical modeling for predicting the buildup of internal pressure during heating are discussed. The paper concludes with recommended research needs, identified at a workshop on fire performance of HSC, convened at NIST in February 1997

National Slag Association (NSA)gives the brief study on Fire Resistance And Heat Transmission Properties Of Concrete And Masonry Made With Blast Furnace Slag Aggregate

David N. Bilow(2008), done the calculation of temperatures, the mechanical properties at various times during the period of the fire must be determined. This paper provides structural engineers with a summary of the complex behavior of structures in fire and the simplified techniques which have been used successfully for many years to design concrete structures to resist the effects of severe fires.

S.Peskova, P.P.Prochazka(2011), studied the various combinations of fibers, such as a compound of PP and steel, also a carbon and steel combination and the normal concrete have been tested for temperature to 1000 C. Cubes with dimension of 70 x 70 x 70mm^3 serve as the test specimens, which are heated to 150, 500, 600 or 1000^0C. This dimension is in full compliance with the existing norms. The loading is due to a one-sided heating, while the other sides of the cubes will be held at room temperature.

Khaled Mohammed Nassar (2011),studied the behavior of the reinforced concrete columns at high temperatures. Several samples of reinforced concrete columns with Polypropylene (PP) fibers were used. Three mixes of concrete are prepared using different contents of Polypropylene ;(0.0 kg/m³, 0.5 kg/m³ and 0.75 kg/m³). Reinforced concrete columns dimensions are (100 mm x100 mm x300 mm). The samples are heated for 2, 4 and 6 hours at 400 C°, 600 C° and 800°C and tested for compressive strength. Also, the behavior of reinforcement steel bars at high temperatures is investigated. Reinforcement steel bars are embedded into the concrete samples with 2 cm and 3 cm concrete covers, after heating at 800°C for 6 hours. The reinforcement steel bars are then extracted and tested for yield stress and maximum elongation ratio. The analysis of results obtained from the experimental program showed that, the best amount of PP to be used is 0.75 kg/m³, where the residual compressive strength is 20 % higher than of that when no PP fibers are used at 400 C for 6 hours. Moreover, a 3 cm of concrete cover is in useful improving fire resistance for concrete structures and providing a good protection for the reinforcement steel bars, where it is 5 % higher than the column samples with 2 cm concrete cover at 6 hours and 600 C°.

Mohammed M.Kadhum(2002),studied the some mechanical properties and deflection behavior of rectangular reinforced concrete beams under the effect of fire flame exposure is presented. The properties investigated were compressive strength and load-deflection behavior of rectangular reinforced concrete beams under the effect of fire flame exposure. The concrete specimens and beams were subjected to fire flame temperatures ranging from (25-800) °C at different ages of 30, 60 and 90 days, three temperature levels of 400, 600 and 800 °C where chosen for exposure duration of 2.0 hours. The test results showed that the residual compressive strength ranged between (67-76 %) at 400 °C, (58-66 %) at 600 °C and (28-51 %) at 800 °C. It was noticed that the load-deflection relation to specimens exposed to fire flame are flat , representing softer load deflection behavior than that of the control beams. Also, it was found that the shrinkage values increase with temperature increase.

U.S. Nuclear Regulatory Commission Office of Nuclear Regulatory Research, provide an overview of the effects of elevated temperature on the behavior of concrete materials and structures. In meeting this objective the effects of elevated temperatures on the properties of ordinary Portland cement concrete constituent materials and concretes are summarized. The effects of elevated temperature on high-strength concrete materials are noted and their performance compared to normal strength concretes. A review of concrete materials for elevated temperature service is presented. Nuclear power plant and general civil engineering design codes are described. Design considerations and analytical techniques for evaluating the response of reinforced concrete structures to elevated-temperature conditions are presented. Pertinent studies in which reinforced concrete structural elements were subjected to elevated temperatures are described.

TarekKhalifa(2011),the research done in the area covering other materials is presented providing an introduction to the behavior of different systems under elevated temperature. The experimental programs consider the glass transition temperature and thermal decomposition of the different systems and examine the tensile strength of the different systems under different temperature regimes. The results of experimental programs are presented and then a connection between the thermo mechanical properties of the resins and the overall strength of the system is established. The research demonstrates that the glass transition temperature of the resin used for an FRP strengthening system is the main determinant of the performance at high temperatures.

DP Bentz (2011), this article focuses on a characterization of the thermal properties, namely, specific heat capacity and thermal conductivity. The raw materials and the finished products (mortars and concretes) are evaluated using a transient plane source method. Because the specimens being examined are well hydrated, estimates the specific heat capacity based on a law of mixtures, with a 'bound water' specific heat capacity value being employed for the water in the mixture, provide reasonable predictions of the measured performance. As with most materials, thermal conductivity is found to be a function of density, while also being dependent on whether the aggregate source is siliceous or limestone. The measured values should provide a useful database for evaluating the thermal performance of high-volume fly ash concrete structures.

III. CONCLUSION ON LITERATURE REVIEW

- The workability of concrete made with 5% RHA has found to be decreased with increased w/c ratio when compared to normal concrete and compacting factor also found decreased with increased w/c cement ratio when compared to normal concrete. The compressive strength of concrete increased with increase the percentage of RHA up to 15% after 7 and 28 days curing and found decreased after 15% of RHA.
- By using this Rice husk ash in concrete as replacement the emission of greenhouse gases can be decreased to a greater extent. As a result there is greater possibility to gain more number of carbon credits.
- The technical and economic advantages of incorporating Rice Husk Ash in concrete should be exploited by the construction and rice industries, more so for the rice growing nations of Asia.
- RHA based sand cement block can significantly reduce room temperature. Hence use of air conditioner will be less resulting in electric energy saving.
- Moreover with the use of rice husk ash, the weight of concrete reduces , thus making the concrete lighter which can be used as light weight construction material.
- As the Rice Husk Ash is waste material, it reduces the cost of construction. Use of RHA shows a drastic increase in the amount of water required during the preparation. Standard mixes of concrete uses less amount of water as compared to RHA.
- GGBFS Concrete becomes light weight by partially replacing sand with sawdust. The concrete made by using slag as coarse aggregates and partially replacing sand with saw dust used for lean mixes. GGBFS Concrete can be effectively used by replacing sand up to 15% with sawdust. The cost of concrete is less than conventional

concrete. The concrete becomes environment friendly, due to use of waste industrial material.

- The elevated temperatures considered in this study had a minor effect on the compressive strength of the unwrapped specimens.
- A maximum strength loss of about 13% was recorded after exposure to 300°C.

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