# 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 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 it has a relatively poor thermal conductivity. Its 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***- Partial replacement, 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.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. MATERIALS

### 1. BLAST FURNACE SLAG

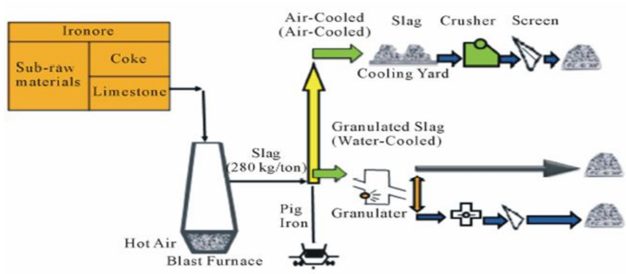
Throughout the world there is an increasing focus on the need to recycle and to more fully utilise co-products of manufacturing processes in an attempt to conserve our finite natural resources. Technical evaluation supported by field experience has shown that co-products such as blast furnace slag have, in many applications, properties suitable to replace or supplement and improve traditional materials used.

Blast furnace slag

Term 'slag' used throughout this publication refers specifically to metallurgical slag produced in modern blast furnaces (i.e. blast furnace slag and not basic oxygen steel slag or electric arc furnace slag which are generally referred to as 'steel furnace slags').

Although the term 'recycling' is referred to when slag is used in any of its applications, strictly speaking slag is not a recycled material. As a co-product in the manufacture of iron, blast furnace slag is considered a recovered resource material. The slag has not been previously used but was formed as part of and during the iron making process. Slag has a controlled chemistry and leaves the blast furnace in a molten form free from foreign matter.

### BLAST FURNACE OPERATION AND SLAG PRODUCTION




General schematic view of blast furnace operation and slag production

Blast furnace slag is a non-metallic by-product produced in the process of iron making (pig iron) in a blast furnace and 300kg of Blast furnace slag is generated when 1 ton of pig iron produced. In India, annual productions of pig iron is 70-80 million tons and corresponding blast furnace slag are about 21-24 million tons. Blast furnace slag is mildly alkaline and exhibits a pH in solution in the range of 8 to 10 and does not present a corrosion risk to steel in pilings or to steel embedded in concrete made with blast furnace slag cement or aggregates. The blast furnace slag could be used for the cement raw material, the roadbed material, the mineral admixture for concrete and aggregate for concrete, etc. The property of blast furnace slag is similar to coarser aggregate, the price is cheap and the output is large too, could be regarded as the substitute of the coarser aggregate. But there is no experience about application of blast furnace slag coarse aggregate in concrete and the reports about the research are also few.

### TYPES OF BLAST FURNACE SLAG

#### a) BLAST FURNACE ROCK SLAG (BFS)

Molten slag on leaving the furnace is directed into ground bays where it air-cools to form a crystalline rock-like material. BFS is suitable for varied uses in building applications as aggregates in concrete, construction of roads in base and sub-base courses either unbound or bound. It can also be mixed with other materials for mechanical stabilising or as a cementing or stabilising binder10. When compacted, BFS develops a high degree of mechanical particle interlock resulting in high shear strength partly due to the rough texture (vesicular nature) of the slag. The chemical reactivity of the slag causes it to be self-cementing and produces engineering fill, which over a period of time forms a semi-rigid mass.

BFS can be crushed and screened to a full range of aggregate sizes. BFS should not be simply substituted for natural aggregate in an existing concrete mix without considering differences in grading, particle shape, water absorption and particularly particle density. As for any aggregate, a concrete mix should be specifically designed to suit the characteristics of the aggregate. Therefore, the slightly lower particle density and higher water absorption of slag, due to its vesicular structure, should be taken into account in the mix design.

Blast Furnace Rock Slag

**b) GRANULATED BLAST FURNACE SLAG (GBFS)**

Molten slag, on leaving the blast furnace is directed into a specialised plant known as a granulator in which high pressure, high volume, cold water sprays to rapidly cool the molten slag resulting in the formation of an amorphous, coarse sand sized material exhibiting hydraulic cementitious properties.

Although the principal use of GBFS is in the manufacture of slag blended cement and Ground Granulated Blast Furnace Slag, it can be used as lightweight aggregate where its high fire resistance and insulation properties make it an excellent aggregate for concrete and masonry units where high fire resistance is required. It can also be used in geopolymer concrete, as an additive for glass manufacture, as a lightweight fill and in engineered fill applications.

Granulated Blast Furnace Slag

**c) GROUND GRANULATED BLAST FURNACE SLAG (GGBFS)**

Granulated Blast Furnace Slag when dried and milled to cement fineness and in the presence of a suitable activator becomes a cementitious binder (Figure 4). Currently, GGBFS is predominately used in the form of blended cement to manufacture concrete or as a direct supplementary cementitious material addition in concrete manufacture.

Ground Granulated Blast Furnace Slag (GGBFS)

**BENEFIT OF BLAST FURNACE SLAG USE IN CONCRETE**

- Environmentally friendly energy by product.
- Enhances concrete durability.
- Continued strength gain.
- Reduces heat in concrete.
- Early age plastic and hardened concrete property.

**2. RICE HUSK ASH**

Rice milling industry generates a lot of rice husk during milling of paddy which comes from the fields. This rice husk is mostly used as a fuel in the boilers for processing of paddy. Rice husk is also used as a fuel for power generation. Rice husk ash (RHA) is about 25% by weight of rice husk when burnt in boilers. It is estimated that about 70 million tons of RHA is produced annually worldwide. This RHA is a great environment threat causing damage to the land and the surrounding area in which it is dumped. During milling of paddy about 78 % of weight is received as rice, broken rice and bran .Rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. This husk contains about 75 % organic volatile matter and the balance 25% of the weight of this husk is converted into ash during the firing process, is known as rice husk as (RHA). This RHA in turn contains around 85% - 90% amorphous silica. So for every 1000 kgs of paddy milled, about 220 kgs (22 %) of husk is produced, and when this husk is burnt in the boilers, about 55 kgs (25%) of RHA is generated.

**APPLICATION OF RICE HUSK ASH**

RHA is a carbon neutral green product. Lots of ways are being thought of for disposing them by making commercial use of this RHA. RHA is a good super-pozzolan. This super-pozzolan can be used in a big way to make special concrete mixes. There 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, for use in bridges, marine environments, nuclear power plants etc. This market is currently filled by silica fume or micro silica, being imported from Norway, China and also from Burma. Due to limited supply of silica fumes in India and the demand being high the price of silica fume has risen to as much as US$ 500 / ton in India.

**OTHER USES OF RICE HUSK ASH**

This product can be used in a variety of applications like green concrete, high performance concrete, refractory, ceramic glaze, roofing shingles, waterproofing chemicals, oil spill absorbent, specialty paints, flame retardants, carrier for pesticides, insecticides and bio fertilizers etc.


**PHYSICAL AND CHEMICAL PHENOMENON IN CONCRETE**

In the event of a fire, a very sharp rise in temperature may trigger physic-chemical changes in the concrete, such as dehydration by drying of the concrete and decarbonatation. These phenomena can cause shrinkage, losses of resistance and rigidity of the materials. Dehydration and decarbonatation are endothermic reactions they absorb energy and therefore slow down heating. Therefore they go hand in hand with absorption of heat which slows down the heating of the material exposed to the fire. If the capillary pores are too fine, the steam pressure that builds up may generate tensile stresses in the concrete at this point such that the concrete limit of resistance is exceeded. This phenomenon is all the more pronounced because the humidity of the concrete is high and the rise in temperature rapid.

For concrete, the loss of resistance results mainly from the formation of internal cracks and the degradation/disintegration of the cement paste. The paste in fact contracts while the granulates expand. Apart from these internal cracks, at these very high temperatures cracks can be seen to form between the cement paste and the aggregate.

## III. SCOPE AND OBJECTIVE

- Study the effect of new age concrete (using additives) over conventional concrete.
- Study the effect of fire on new age concrete over conventional concrete.
- Study of effect of fire on compressive strength split tensile and flexural strength on new Age concrete over conventional concrete.
- Suggest suitable combination of partial replacement of additives in concrete.

## IV. LITERATURE REVIEW

**S. Andavan (2018)[1]**

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. Laterat28daystest,itisobservedthatthestrengthincreases with the increase in replacement percentage of cement with glass powder. The max strength is obtained at 10%replacement.

**Er. Ravi Bhushan(2017)[2]**

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), and 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)[3]**

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 R.H.A. R.H.A is a good pozzolan.thissuperpozzolanacanbeusedinabigwaytomakespeci alconcretemixes.theseis a growing demand for fineamorphous 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 inflame its physics of mechanical properties. Sample cube were tasted with different percentage of R.H.A 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 RHAwhichleadstoreductioninmass perunitvolume,thus addingitreducesthedeadloadonthestructure.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 mixproportions.

**Chandraul Kirti(2015)[4]**

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 hardened 150 mm concrete cubes after 7, 14 and 28 days curing in water. The results revealed that the slump cone increased as the percentage replacement of OPC with RHA increased. The compressive and tensile strength of the hardened concrete also increase with increasing OPC replacement with RHA. It is recommended 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)[5]**

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 concreteeconomical. GGBFS Concrete can be effectively used by replacing sand up to 15% with sawdust.

**George Washington(2017)[6]**

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.

**Harshit Varshney (2015)[7]**

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.

**Rafat Siddique, Deepinder Kaur (2011)[8]**

Normal strength (NSC) and high-performance concretes (HPC) are being used extensively in the construction of structures that might be subjected to elevated temperatures. The behaviour of concrete structures at elevated temperatures is of significant importance in predicting the safety of structures in response to certain accidents or particular service conditions. This paper deals with the mechanical properties of concrete made with ground granulated blast furnace slag (GGBFS) subjected to temperatures up to 350℃. For this purpose, normal concrete having compressive strength of 34 MPa was designed using GGBFS as partial replacement of cement. Cylindrical specimens (150 · 300 mm) were made and subjected to temperatures of 100, 200 and 350℃. Measurements were taken for mass loss, compressive strength, splitting tensile strength, and modulus of elasticity. This investigation developed some important data on the properties of Concrete exposed to elevated temperatures up to 350℃.

**Alaa A. Bashandy (2013)[9]**

In this investigation, the effects of elevated temperatures of 200, 300, 500℃ for 2 and 4 hours on the main mechanical properties of economical type of reactive powder concrete (RPC) are studied. The main variables in this study are cement content and steel fibres content in reactive powder concrete samples as well as elevated temperature and heating time. Compressive strength and tensile strength of RPC are obtained after exposure to elevated temperatures. It is found that, RPC can be used at elevated temperature up to 300°C for heating times up to 4 hours taking into consideration the loss of strength. Also, using steel fibres enhance the residual strength of high cement content RPC samples.

**B G Buddhdev1, Dr. H R Varia (2014)[10]**

Concrete is the most-used man-made product in the world. Concrete is widely used for making many types of structural components for different civil engineering applications. In this modern era, cement concrete pavements are in demand as compared to bituminous pavements in highway projects. Due to limitation of quality natural resources for making concrete, the waste utilization in production of concrete especially for pavements are major concern in advances of civil engineering. Blast furnace slag is one of the wastes produced from steel processing plants around the globe. Rajkot (Gujarat) is well known for its small scale industries for long time and one of the fastest developing cities of India is hub of steel and allied industries. Rajkot itself produces blast furnace slag of amount 2500T/month from its 2000 steel processing units. This enormous quantity of blast furnace slag is generally dumped in unscientific manner create environmental issues and little is used for landfill purpose without any technical input. It is interesting to know whether Blast Furnace Slag (BFS) can be utilized as a fine aggregates (i.e. as a sand) to produce concrete mainly for pavements or not. In this paper, the comprehensive experimental programme is taken up to study the feasibility of this BFS used as a fine aggregate in pavement concrete. In this regard the chemical and physical properties of the BFS are observed in this study. These properties depend upon the raw materials used and methods of processing at plants. Based on results of experimentation, variations in chemical and physical properties are studied and checked the suitability of utilizing this BFS for pavement concrete. The results indicate that BFS can be utilized as a fine aggregate in pavement concrete.

**P. Jyotsna Devi, Dr. K. Srinivasa Rao (2014)[11]**

The present study aims at investigating the performance of steel fibre reinforced concrete at high temperatures. It also aims at comparing the flexural and split tensile strengths of normal (M30) and high strength concrete (M60) when mixed with 1% volume fractions of steel fibres. To study flexural strengths prisms of size 100x100x500mm were casted and to study splitting tensile strength cylinders of 150mm diameter and 300mm length were casted. The samples are cured for 7, 28 and 91 days. After specified period of curing, the specimens were air dried and then exposed to 100, 200, 300, 400 and 500oC (apart from 27oC), for duration of one hour and then allowed to cool. The prisms are tested in Universal Testing machine for flexure and cylinders are tested for split in compression testing machine. The use of fibres in high strength concrete is of good advantage than using in normal Strength concrete. By adding steel fibres fracture resistance of concrete can be increased.

**Khaled Mohammed Nassar, Prof. Samir Shihada(2011)[12]**

Fire has become one of the greatest threats to buildings. Concrete is a primary construction material and its properties of concrete to high temperatures have gained a great deal of attention. Concrete structures when subjected to fire presented in general good behaviour. The low thermal conductivity of the concrete associated to its great capacity of thermal insulation of the steel bars is the responsible for this good behaviour. However, there is a fundamental problem caused by high temperatures that is the separation of concrete masses from the body of the concrete element "spalling phenomenon ". Spalling of concrete leads to a decrease in the cross section area of the concrete column and thereby decrease the resistances to axial loads, as well as the reinforcement steel bars become exposed directly to high temperatures. With the increase of incidents caused by major fires in buildings; research and Developmental efforts are being carried out in this area and other related disciplines. This research is to investigate the behaviour of the reinforced concrete columns at high temperatures. Several samples of reinforced concrete columns with Polypropylene (PP) fibres were used. Three mixes of concrete are prepared using different contents of Polypropylene ;( 0.0 kg/m$^3$, 0.5 kg/m$^3$ and 0.75 kg/m$^3$). 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 behaviour 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/m$^3$, where the residual compressive strength is 20% higher than of that when no PP fibres 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°.

**Rahul Subhash Patil (2014)[13]**

The present work is aimed to study the effect of elevated temperature ranging from 200oC to 600oC on the compressive strength on M20 grade concrete with percentage of polypropylene fibre (0.22%) & steel fibre (0.5%) by volume of concrete. Tests were conducted on 150mm side cube concrete specimens. The specimens were heated to different temperatures of 200oC, 400oC, and 600oC for 6 hour durations. After the heat treatment the specimens were cooled by wet and dry cooling condition and then they were tested for compressive. The results were analysed and presented with comparison of compressive strength of specimens with & without fibres for different cooling conditions. The concrete containing fibre exhibited better performance than without fibre for high temperature. Strength loss was more significant on specimens cooled in water.

**Rajesh Kumar, Amiya K. Samanta and D. K. Singha Roy (2014)[14]**

At present in India, about 960 million metric tons of solid waste is being generated annually as by products during industrial, mining, municipal, agricultural and other processes. Advances in solid waste management resulted in alternative construction materials as a substitute to traditional materials like bricks, blocks, tiles, aggregates, ceramics, cement, lime, soil, timber and paint. To safeguard the environment, efforts are being made for recycling different wastes and to utilize them in value added applications. The cement industries have been making significant progress in reducing carbon dioxide ($CO_2$) emissions through improvements in process technology and enhancements in process efficiency, but further improvements are limited because $CO_2$ production is inherent to the basic process of calcinations of limestone. In the past two decades, various investigations have been conducted on industrial wastes like fly ash, blast furnace slag, Silica fume, rice husks and other industrial waste materials to act as cement replacements .This paper consist of a review extensively conducted on publications related to utilization of waste materials as cement replacement with an intention to develop a process so as to produce an eco-friendly concrete having similar or higher strength and thus simultaneously providing a remedy to environmental hazards resulting from waste material disposal.

**K.G. Hiraskar and Chetan Patil (2013)[15]**

The Iron industries produce a huge quantity of blast furnace slag as by–product, which is a non–biodegradable waste material from that only a small percentage of it is used by cement industries to manufacture cement. In the present investigation Blast Furnace Slag from local industries has been utilised to find its suitability as a coarse aggregate in concrete making. Replacing all or some portion of natural aggregates with slag would lead to considerable environmental benefits. The results indicate that the unit weight of Blast Furnace Slag aggregate concrete is lower than that of the conventional concrete with stone chips. The experimental result show that replacing some percentage of natural aggregates by slag aggregates causes negligible degradation in strength. The compressive strength of Blast Furnace Slag aggregate concrete is found to be higher than that of conventional concrete at the age of 90 days. It has also reduced water absorption and porosity beyond 28 days in comparison to that of conventional concrete with stone chips used as coarse aggregate.

## V. CONCLUDING REMARK

After study of these papers, it has been concluded that rice husk ash can be used as a partial replacement in cement and blast furnace slag can be used as a partial replacement in cement as well as in aggregate. It gives higher strength than conventional concrete. Short needle like steel fibre enhances the tensile strength of concrete. It has also been concluded that at elevated temperature the tensile strength, flexural strength and compressive strength decreases.

## VI. TESTING OF MATERIALS

### GENERAL

The aim of the testing of materials is to compare the properties of concrete made with and without Rice husk ash and blast furnace slag with steel fibre used as cementious material. The basic tests carried out on ingredients of concrete are discussed.

### CEMENT

**Physical Properties of Cement**

| SR.NO | PROPERTIES | RESULT OBTAINED | STANDARD VALUES |
|---|---|---|---|
| 1 | Standard Consistency | 35% | - |
| 2 | Initial Setting Time (minutes) | 33 | Not be less than 30 minutes |
| 3 | Final Setting Time( minutes) | 330 | Not be greater than 600 minutes |
| 4 | Soundness(mm) | 5 | <10 |
| 5 | Fineness | 1.39 | <10 |
| 6 | Specific gravity | 3.15 | - |

### FINE AGGREGATES

**Physical Properties of fine aggregates**

| SR. NO. | PROPERTIES | RESULT OBTAINED |
|---|---|---|
| 1 | Type | Natural |
| 2 | Specific Gravity | 2.69 |
| 3 | Bulkage | 6% |
| 4 | Dry Loose Bulk Density | 1560 kg/m$^3$ |
| 5 | Fineness Modulus | 2.48 |
| 6 | Surface Texture | Smooth |
| 7 | Particle Shape | Rounded |
| 8 | Grading Zone ( Based on percentage passing 0.60 mm) | Zone-II |
| 9 | Silt Content | 1.6% |

### COARSE AGGREGATE

**Physical Properties of Coarse Aggregates (20 mm)**

| SR. NO. | PROPERTIES | RESULT OBTAINED |
|---|---|---|
| 1 | Type | Natural |
| 2 | Specific Gravity | 2.73 |
| 3 | Dry Loose Bulk Density | 1830 kg/m$^3$ |
| 4 | Fineness Modulus | 7.246 |
| 5 | Surface Texture | Rough |
| 7 | Particle Shape | Angular |

### WATER

Generally, water that is suitable for drinking is satisfactory for use in concrete. Water from lakes and streams that contain marine life also usually is suitable. When water is obtained from sources mentioned above no sampling is necessary. When it is suspected that water may contain sewage, mine water or waste from industrial plants or canneries, it should be avoided since the quality of water could change due to low water by intermittent tap water is used for casting.

### PROPERTIES OF STEEL FIBRE

| | PROPERTIES | STEEL FIBRE |
|---|---|---|
| | Density(kg/$m^3$) | 7840 |
| | Tensile Strength (MPa) | 1100 |
| | Length(mm) | 60 |
| | Diameter(mm) | 1 |
| | Steel fibre addition (%) | 1 |
| | Aspect ratio | 60 |

### TESTING ON BLAST FURNACE SLAG

**CHEMICAL PROPERTY OF BFS**

| SR. NO | TEST PARAMETER | RESULTS(%WT) |
|---|---|---|
| 1 | CaO | 39.20 |
| 2 | $SiO_2$ | 40 |
| 3 | $Al_2O_3$ | 13.5 |
| 4 | MgO | 3.6 |
| 5 | $Fe_2O_3$ | 1.8 |
| 6 | MnO | 0.63 |
| 7 | S | 1.0 |
| 8 | $P_2O_5$ | 0.21 |
| 9 | $Cr_2O_3$ | 0.06 |

**PHYSICAL PROPERTY OF BFS**

| SR. NO. | PROPERTIES | BFS |
|---|---|---|
| 1 | Specific gravity | 2.86 |
| 2 | Bulk density(kg/m³) | 1717 |
| 3 | Flakiness index | 41.16 |
| 4 | Elongation index | 46.05 |

**TESTING ON RHA**

**CHEMICAL PROPERTY OF RHA**

| SR. NO | TEST PARAMETERS | RESULTS |
|---|---|---|
| 1 | $SiO_2$ | 92.76 |
| 2 | $Na_2O$ | 0.41 |
| 3 | $K_2O$ | 0.22 |
| 4 | $Fe_2O_3$ | 0.74 |
| 5 | $Al_2O_3$ | 0.79 |

**PHYSICAL PROPERTY OF RHA**

| SR. NO | TEST PARAMETER | RESULTS |
|---|---|---|
| 1 | Specific Surface( $m^2$/gm) | 15 |
| 2 | Density(kg/$m^3$) | 711 |
| 3 | Moisture | 0.94% |

**MIX DESIGN**

For M25 grade Adapted mix design

| CEMENT | WATER | FINE AGGREGATE | COARSE AGGREGATE |
|---|---|---|---|
| 413 | 185 | 682 | 1022.39 |
| 1 | 0.45 | 1.65 | 2.47 |

## VII. TEST RESULT & DISCUSSION

**.CASTING SCHEDULE OF CONVENTIONAL CONCRETE**

Casting date: 25/01/2019

| SR.NO | SPECIMEN | NO. OF SPECIMEN | CURING PERIOD |
|---|---|---|---|
| 1 | CUBE (150 mm x150 mm x150mm) | 3 | 7DAYS |
| | | 3 | 14DAYS |
| | | 3 | 28DAYS |
| 2 | CYLENDER (dia. 150mm x height 300mm) | 3 | 7DAYS |
| | | 3 | 14DAYS |
| | | 3 | 28DAYS |
| 3 | BEAM (100mm x 100mm x 700mm) | 3 | 7DAYS |
| | | 3 | 14DAYS |
| | | 3 | 28DAYS |

**CASTING SCHEDULE OF CONCRETE WITH ADMIXTURE**

Curing period-28daysExposure time-1hour

| SR. NO. | COMBINATION | SPECIMEN | TEMPERATURE °C |
|---|---|---|---|
| 1 | 5%RHA+20%BFS+1%Steel fibre (C1) | Cube | 200°C, 400°C, 600°C, 800°C, 1000°C |
| | | Cylinder | |
| | | Beam | |
| 2 | 10%RHA+20%BFS+1%Steel fibre (C2) | Cube | |
| | | Cylinder | |
| | | Beam | |
| 3 | 5%RHA+40%BFS+1%Steel fibre (C3) | Cube | |
| | | Cylinder | |
| | | Beam | |
| 4 | 10%RHA+40%BFS+1%Steel fibre (C4) | Cube | |
| | | Cylinder | |
| | | Beam | |
| 5 | 5%RHA+60%BFS+1%Steel fibre (C5) | Cube | |
| | | Cylinder | |
| | | Beam | |
| 6 | 10%RHA+60%BFS+1%Steel fibre (C6) | Cube | |
| | | Cylinder | |
| | | Beam | |

**TESTING REPORT OF HARDENED CONCRETE**

Compression test = load / area

Split tensile test =2 x load / $\pi$ x dia x length

Flexural strength = 1.5p x l/ w$d^2$

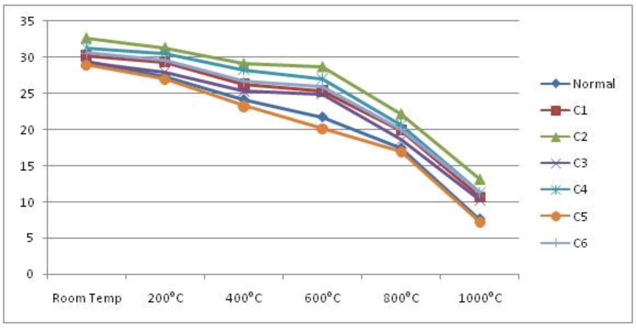
| SR. NO | TESTING DATE | SPECIMEN | CURING PERIOD | AVG. STRENGTH ($N/mm^2$) |
|---|---|---|---|---|
| 1 | 02/02/2019 | cube | 7days | 17.12 |
| | | cylinder | 7days | 1.68 |
| | | beam | 7days | 1.22 |
| | | | | |
| 2 | 09/02/2019 | cube | 14days | 20.63 |
| | | cylinder | 14days | 2.49 |
| | | beam | 14days | 1.42 |
| 3 | 23/02/2019 | cube | 28days | 29.41 |
| | | cylinder | 28days | 3.01 |
| | | beam | 28days | 1.62 |

**HARDENED CONCRETE TEST**

**COMPRESSIVE STRENGTH ($N/mm^2$)**

| TEMP. | NORMAL | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|---|
| Room Temp | 29.41 | 30.24 | 32.63 | 29.32 | 31.32 | 28.93 | 30.61 |
| 200⁰C | 27.32 | 29.31 | 31.32 | 27.92 | 30.62 | 26.95 | 29.52 |
| 400⁰C | 24.1 | 26.25 | 29.1 | 25.31 | 28.32 | 23.26 | 26.69 |
| 600⁰C | 21.69 | 25.31 | 28.69 | 24.96 | 27.01 | 20.16 | 25.92 |
| 800⁰C | 17.41 | 19.91 | 22.19 | 18.63 | 20.69 | 16.97 | 20.05 |
| 1000⁰C | 7.6 | 10.68 | 13.18 | 10.31 | 11.31 | 7.2 | 11.37 |

## GRAPHICAL REPRESENTATION (Strength in N/mm$^2$vs Temperature in $^0$C)



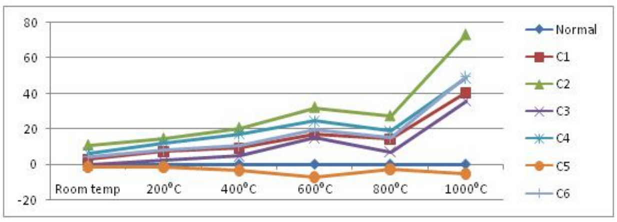

## OBSERVATIONS

| SR. NO. | OBSERVATION | JUSTIFICATION |
|---|---|---|
| 1 | Maximum strength is found for C2(10%RHA+20%BFS+1%Steel Fiber) over conventional concrete(Normal) at room temperature. | ➢ This increase of compressive strength of concrete with RHA was attributed to the increase in pozzolanic action.<br>➢ The enhancement of strength may be due to the strengthening of Interfacial Transition Zone (ITZ) by the silica content present in RHA.<br>➢ This may be due to the fact that even though ITZ is one of the weakest link in concrete, the existence of silica content in RHA makes a stronger and denser ITZ when compared to the normal concrete. |
| 2 | As temperature increase strength is going to reduce. | ➢ Slow capillary water loss and reduction in cohesive forces as water expands.<br>➢ C-S-H gel dehydration.<br>➢ Gypsum decomposition ($CaSO_4$·2H2O).<br>➢ physically bound water loss<br>➢ At 350°C break up of some siliceous aggregates.<br>➢ At 930–960°C calcite decomposition takes place<br>➢ $CaCO_3 \rightarrow CaO+CO^2$, carbon dioxide release |
| 3 | Minimum strength is found for C5(5%RHA+60%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000°C temperature. | ➢ As temperature increases water present in the concrete evaporates and strength reduces. |

## PERCENTAGE CHANGE IN COMPRESSIVE STRENGTH WITH RESPECT TO NORMAL CONCRETE

| TEMP. | NORMAL (N/MM$^2$) | C1(%) | C2(%) | C3(%) | C4(%) | C5(%) | C6(%) |
|---|---|---|---|---|---|---|---|
| Room Temp | 29.41 | 2.82 | 10.94 | -0.306 | 6.49 | -1.63 | 4.08 |
| 200⁰C | 27.32 | 7.28 | 14.64 | 2.19 | 12.08 | -1.35 | 8.05 |
| 400⁰C | 24.1 | 8.92 | 20.75 | 5.02 | 17.51 | -3.49 | 10.75 |
| 600⁰C | 21.69 | 16.69 | 32.27 | 15.08 | 24.53 | -7.05 | 19.50 |
| 800⁰C | 17.41 | 14.36 | 27.46 | 7.01 | 18.84 | -2.53 | 15.16 |
| 1000⁰C | 7.6 | 40.53 | 73.42 | 35.67 | 48.82 | -5.26 | 49.61 |

## GRAPHICAL REPRESENTATION



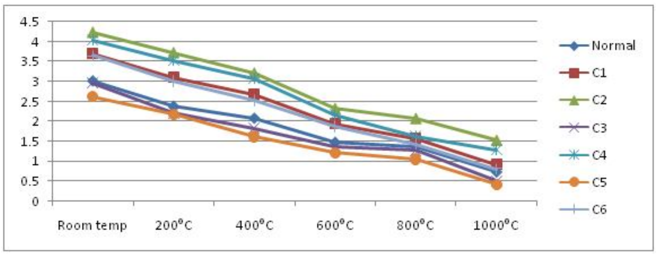

## OBSERVATIONS

1) Maximum percentage increase in strength is 40.53% found for C2(10%RHA+20%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000ºC temperature.
2) Maximum percentage reduction in strength is 5.26% found for C5(5%RHA+60%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000ºC temperature.

## SPLIT TENSILE STRENGTH (N/mm²)

| TEMP. | NORMAL | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|---|
| Room Temp | 3.01 | 3.69 | 4.23 | 2.96 | 4.03 | 2.62 | 3.65 |
| 200°C | 2.38 | 3.09 | 3.72 | 2.22 | 3.53 | 2.18 | 3.01 |
| 400°C | 2.08 | 2.68 | 3.21 | 1.83 | 3.07 | 1.62 | 2.53 |
| 600°C | 1.48 | 1.93 | 2.32 | 1.36 | 2.16 | 1.22 | 1.87 |
| 800°C | 1.37 | 1.57 | 2.07 | 1.28 | 1.62 | 1.06 | 1.43 |
| 1000°C | 0.74 | 0.92 | 1.32 | 0.51 | 1.25 | 0.43 | 0.81 |

## GRAPHICAL REPRESENTATION (Strength in N/mm$^2$vs Temperature in $^0$C)



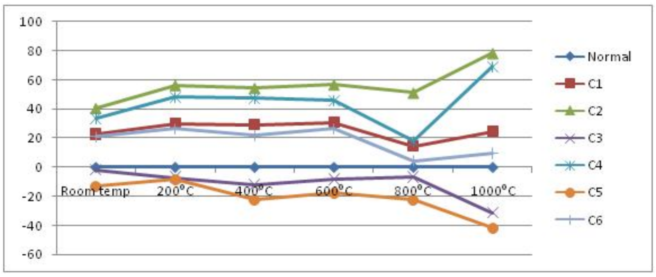

## OBSERVATIONS

1. Maximum strength is found for C2(10%RHA+20%BFS+1%Steel Fiber) over conventional concrete(Normal) at room temperature.
2. As temperature increase strength is going to reduce.
3. Minimum strength is found for C5(5%RHA+60%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000ºC temperature.

## PERCENTAGE CHANGE IN SPLIT TENSILE STRENGTH WITH RESPECT TO NORMAL CONCRETE

| TEMP. | NORMAL | C1(%) | C2(%) | C3(%) | C4(%) | C5(%) | C6(%) |
|---|---|---|---|---|---|---|---|
| Room Temp | 3.01 | 22.59 | 40.53 | -1.66 | 33.89 | -12.96 | 21.26 |
| 200⁰C | 2.38 | 29.83 | 56.30 | -6.72 | 48.32 | -8.40 | 26.47 |
| 400⁰C | 2.08 | 28.85 | 54.33 | -12.02 | 47.60 | -22.12 | 21.63 |
| 600⁰C | 1.48 | 30.41 | 56.76 | -8.11 | 45.95 | -17.57 | 26.35 |
| 800⁰C | 1.37 | 14.59 | 51.09 | -6.57 | 18.24 | -22.63 | 4.38 |
| 1000⁰C | 0.74 | 24.32 | 78.38 | -31.08 | 68.91 | -41.89 | 9.46 |

## GRAPHICAL REPRESENTATION



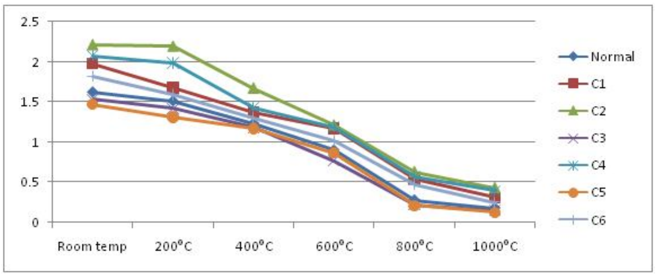

## OBSERVATIONS

1) Maximum percentage increase in strength is 78.38% found for C2(10%RHA+20%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000°C temperature.
2) Maximum percentage reduction in strength is 41.89% found for C5(5%RHA+60%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000°C temperature.

## FLEXURAL STRENGTH (N/mm²)

| TEMP. | NORMAL | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|---|
| Room Temp | 1.62 | 1.97 | 2.21 | 1.53 | 2.07 | 1.47 | 1.82 |
| 200°C | 1.51 | 1.67 | 2.19 | 1.42 | 1.98 | 1.31 | 1.59 |
| 400°C | 1.23 | 1.37 | 1.67 | 1.18 | 1.43 | 1.17 | 1.3 |
| 600°C | 0.9 | 1.17 | 1.21 | 0.77 | 1.19 | 0.87 | 1.02 |
| 800°C | 0.28 | 0.53 | 0.63 | 0.22 | 0.57 | 0.21 | 0.47 |
| 1000°C | 0.18 | 0.31 | 0.43 | 0.15 | 0.28 | 0.13 | 0.25 |

## GRAPHICAL REPRESENTATION (Strength in N/mm²vs Temperature in °C)



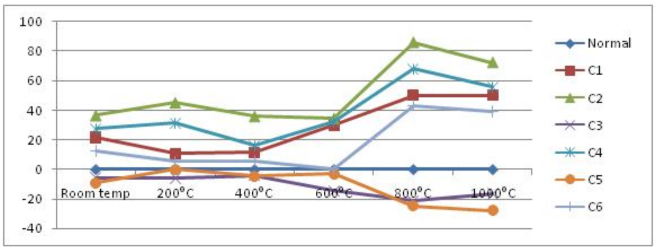

## OBSERVATIONS

1. Maximum strength is found for C2(10%RHA+20%BFS+1%Steel Fiber) over conventional concrete(Normal) at room temperature.
2. As temperature increase strength is going to reduce.
3. Minimum strength is found for C5(5%RHA+60%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000°C temperature.

## PERCENTAGE CHANGE IN FLEXURAL STRENGTH WITH RESPECT TO NORMAL CONCRETE

| TEMP. | NORMAL | C1(%) | C2(%) | C3(%) | C4(%) | C5(%) | C6(%) |
|---|---|---|---|---|---|---|---|
| Room Temp | 1.62 | 21.60 | 36.42 | -5.56 | 27.78 | -9.26 | 12.35 |
| 200°C | 1.51 | 10.60 | 45.09 | -5.96 | 31.18 | -.13.25 | 5.29 |
| 400°C | 1.23 | 11.38 | 35.77 | -4.07 | 16.26 | -4.88 | 5.69 |
| 600°C | 0.9 | 30.00 | 34.44 | -14.44 | 32.22 | -3.33 | 13..33 |
| 800°C | 0.28 | 50.00 | 85.71 | -21.43 | 67.85 | -25.00 | 42.86 |
| 1000°C | 0.18 | 50.00 | 72.22 | -16.67 | 55.56 | -27.78 | 38.89 |

## GRAPHICAL REPRESENTATION




## OBSERVATIONS

1) Maximum percentage increase in strength is 72.22% found for C2(10%RHA+20%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000°C temperature.
2) Maximum percentage reduction in strength is 27.78% found for C5(5%RHA+60%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000°C temperature.

## THE LIST OF CHANGES TAKING PLACE IN CONCRETE DURING HEATING

| TEMPERATURE RANGE | CHANGES |
|---|---|
| 20–200°C | slow capillary water loss and reduction in cohesive forces as water expands;<br>80–150°C ettringite dehydration;<br>C-S-H gel dehydration;<br>150–170°C gypsum decomposition ($CaSO_4$·2H2O);<br>physically bound water loss |
| 300–400°C | approx. 350°C break up of some siliceous aggregates (flint);<br>374°C critical temperature of water; |
| 400–600°C | 460–540°C portlandite decomposition<br>$Ca(OH)^+ \rightarrow CaO + H_2O$;<br>573°C quartz phase change $\beta - \alpha$ in aggregates and sands; |
| 600–800°C | second phase of the C-S-H decomposition, formation of $\beta$-$C_2S$; |
| 800–1000°C | 840°C dolomite decomposition; 930–960°C calcite decomposition<br>$CaCO_3 \rightarrow CaO+CO^+$, carbon dioxide release;<br>ceramic binding initiation which replaces hydraulic bonds; |

## VIII. CONCLUSION

Based on the limited experimental work carried out in this particular study, the following conclusions may be drawn out,

- After elevated temperatures test and analysis it was found that with the increasing temperature the compressive strength, tensile strength and flexural strength of concrete gets reduced.

- Effect of fire can be observed on the surface of concrete in the form of deep cracks.
- Above $600^0$C temperature concrete is not functioning at its full structural Capacity.
- At elevated temperature the concrete becomes more & more brittle and the loss of strength is more than 30%.
- At 600°C temperature whitish colour and at 800°C temperature dark brown colour appears on the surface of cubes.
- At 1000°C temperature hair cracks developed on specimen.
- Maximum compressive strength is found for C2(10%RHA+20%BFS+1%Steel Fiber) over conventional concrete(Normal) at room temperature.
- Minimum compressive strength is found for C5(5%RHA+60%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000ºC temperature.
- Maximum percentage increase in compressive strength is 40.53% found for C2(10%RHA+20%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000ºC temperature.
- Maximum percentage reduction in compressive strength is 5.26% found for C5(5%RHA+60%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000ºC temperature.
- Maximum tensile strength is found for C2(10%RHA+20%BFS+1%Steel Fiber) over conventional concrete(Normal) at room temperature.
- Minimum compressive strength is found for C5(5%RHA+60%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000ºC temperature.
- Maximum percentage increase in tensile strength is 78.38% found for C2(10%RHA+20%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000ºC temperature.
- Maximum percentage reduction in tensile strength is 41.89% found for C5(5%RHA+60%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000ºC temperature.
- Maximum percentage increase in flexural strength is 72.22% found for C2(10%RHA+20%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000ºC temperature.
- Maximum percentage reduction in flexural strength is 27.78% found for C5(5%RHA+60%BFS+1%Steel Fiber) over conventional concrete(Normal) at 1000ºC temperature.

## IX. FUTURE SCOPE

The behaviour of concrete in fire is not well characterized at present, and further research is required in almost every aspect of this field. The response of concrete materials to heating is fundamentally complex. For example, degradation in the physical properties of concrete varies strongly depending on the details of the concrete mix, including the moisture content, and relevant environmental parameters, such as the maximum fire temperature and fire duration. These changes are generally irreversible. Systematic studies are required on the effects of different heating conditions on concrete.

1. In this project coarse aggregate replace with blast furnace slag, we will also replace sand with blast furnace slag with or without using steel fibre.
2. We use rice husk ash as partial replacement of cement by 5% and 10%. We also check for 15% and 20% replacement.
3. According to test result replacement of 20% blast furnace slag gives more strength at elevated temperature than 40% blast furnace slag replacement, we will also check between 20% and 40% for every 5% interval.

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