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The Effect of Elevated Temperatures on The Behavior of Concrete Material

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ABSTRACT

Reinforced concrete systems are commonly used in India on account that this is the handiest & financial device for low-rise buildings. However, for medium to excessive rise homes this form of shape is now not economic because of accelerated dead load, less stiffness, span restriction and dangerous formwork. RCC is in the main used creation fabric in case of low-rise buildings and medium rise buildings in India. Composite creation is taken into consideration as satisfactory choice when we cope with excessive rise buildings due to ductility functions which are very useful in resisting earthquake. So, the Structural engineers are dealing with the venture of striving for the maximum green and reasonably priced layout answer. Also, Wind & Earthquake engineering have to be prolonged to the design of wind & earthquake touchy tall buildings. Currently, steel-concrete composite creation may be very famous because it fastens the construction velocity, most economical and utilizes each the building of steel & concrete. Concrete systems are heavy & own extra self-weight (useless load), decreased stiffness and constraint of span length. So, the primary objective of gift observe is to examine the structural conduct of low, medium & high-rise buildings situated in seismic area-II, with the RCC, metal & composite creation. Frame structure is both manufactured from RCC, steel or steel-concrete composite sections. Their behavior can be analyzed with the aid of using the ETABS software program. Then all the consequences could be in comparison to locate the low-priced building and better structural performance below equivalent static load analysis. The major end got here out is that the composite construction is exceptional in case of high-rise buildings. As the contrast of steel, RCC & Composite frame buildings are done for G+3 Storey buildings, which conclude that composite building Reponses better when subjected to earthquake loads in contrast with RCC & steel.

Keywords: Reinforced Concrete, Elevated Temperature, Concrete Material, ETABS, Frame Buildings, RCC

1. INTRODUCTION

The purpose of this research was to provide an overview of the effects of elevated temperature on the behavior of concrete materials. The effects of elevated temperatures on the properties of ordinary Portland cement concretes and constituent materials are summarized. The effects of elevated temperature on conventional concrete, GGBS concrete and BFS concrete are noted and the performances are compared to conventional concrete strength.Concrete in case of unexpected fire, the concrete properties are changes after fire.The building should design for structure can withstand high temperatures and also mainly for fire exposures. During exposure to high temperatures such as during fire, the mechanical properties of the concrete such as strength, elastic modulus and volumetric stability are significantly reduced. A concrete structure is subjected to high temperatures, it will fail in many of different ways such as colour, compressive strength, elasticity, and concrete density and surface appearance are affected by high temperature.

Temperature effect on concrete: Mechanical characteristics of most materials are greatly influenced by the operating temperature. Stress-strain diagrams are obtained at specific temperatures. High temperature reduces material stiffness and strength, while low temperature increases material stiffness and strengtl Almost all materials creep over time if exposed t elevated temperatures under applied load. At "low temperatures, ductile materials behave like brittl materials, whereas at "high" temperatures, brittl materials behave more like ductile materials. As fire ha been known since ancient times as one of mankind' greatest enemies, we intend to draw attention to fire, a well as to its impact on structural elements. Durin design, in several cases the fact is ignored that a buildin may also be exposed, to the effect of high temperatur when the properties and the bearing capacity of materials also change. Therefore, it is very important to get acquainted with the behaviour of the different materials under high temperature, as a consequence of which a building may also collapse.Concrete has excellent properties in regards of fire resistance compared with other materials and can be used to shield other structural materials such as steel. Concrete must at times resists the effects of artificially induced high temperatures such as might be encountered near furnaces or in atomic reactors, in pavements subjected to jet engine blast, and in areas exposed to fire. Applications of concrete involving extremely high temperaturessuch as landing pads for missiles, are considered expendable, but in most instances, it is desired to avoid deterioration of the concrete's physical properties as much as possible. Fire is one of the natural hazards that attack the building constructions. Subjecting concrete to a higher temperature (e. g., due to accidental fire etc.) leads to severe deterioration and it undergoes a number of transformations and reactions, thereby causing progressive breakdown of cement gel structure, reduced durability, increased tendency of drying shrinkage, structural cracking and associated aggregate colour changes.

Aim: The aim of this project is to provide an overview of the effects of temperature on the Modulus of Elasticity of concrete. Also, to determine modulus of elasticity of concrete under different elevated temperatures by replacing cement with Ground granulated blast furnace slag (GGBS) and Coarse aggregate with Blast furnace slag (BFS).

Objectives: The objective of the experimental investigations are to check the effect of different elevated temperatures on Modulus of elasticity of concrete.

1. To evaluate the effect of elevated temperatures on modulus of elasticity of conventional concrete with a different varying temperature.
2. To investigates the actual behavior of concrete when cement has been replaced by Ground granulated blast furnace slag and Coarse aggregate by Blast furnace slag with a different percentage.
3. To determine the modulus of elasticity of M-25 grade concrete by replacing cement with Ground granulated blast furnace slag (GGBS) and Coarse aggregate with Blast furnace slag by 10, 20 and 30%.

II. LITERATURE REVIEW

1. Qifang Xie et al. [1] prepared 75 prism specimens and divided into four groups (three carbonated groups and one uncarbonated group). Specimens were tested under different temperatures (20, 300, 400, 500, 600, and 700° C), exposure times (3, 4, and 6 hours), andcoolingmethods(waterandnaturalcooling).Surfacecharacteristics,weightlossrate, and residual mechanical properties (strength, initial elastic modulus, peak, and ultimate compressive strains) of carbonated concrete specimens after elevated temperatures were investigated and compared with that of the uncarbonated ones. Results show that the weight loss rates of the carbonated concrete specimens are slightly lower than that ofthe uncarbonatedonesandthatthecracksareincreasedwithraisingoftemperatures.Surface colors of carbonated concrete are significantly changed, but they are not sensitive to cooling methods. Surface cracks can be evidently obser2ved on carbonated specimens when temperature reaches 400°C. Residual compressive strength and initial elastic modulus of carbonated concrete after natural cooling are generally larger than those cooled by water. The peak and ultimate compressive strains of both carbonated and uncarbonated concrete specimens increase after heating, but the values of the latter are greater than that of the former. Finally, the constitutive equation to predict the compressive behaviors of carbonated concrete after high temperatures was established and validated bytests.

2. KRISHNA et al.[2]proposed, the behavior of high temperature exposure of three different grades of concrete M20, M45 and M60 are considered. The specimens were subjected to high temperature regime of 100C–900C and were cooled by different methods. The maximum degradation of mechanical properties was observed between temperature regimes of 400C to 600C. High strength concrete was found to be more vulnerablecomparedtonormalstrengthconcrete.Mathematicalmodelsexpressingthe variationofdifferentmechanicalpropertiesofconcretewere developedandexplained.

Tiwary et al.[3] purpose of the experiment was to see how increased temperatures affected residual properties of concrete, including flexural strength, compressive strength,tensilestrength,staticaswellasdynamicelasticmodulus,waterabsorption,massloss,andultrasonicpulsevelocity.Attemperaturesof200^{0}C,400^{0}C,600^{0}C,800^{0}C, and 1000^{0}C, the typical fire exposure behavior of concrete was investigated. The effects of two cooling techniques, annealing and quenching, on the residual properties of concreteafterexposuretohightemperatureswereinvestigatedinthisstudy.Replacement of up to 10% of the cement with marble dust and fine sand with foundry sand when concrete is exposed to temperatures up to 400 ◦C does not influence the behavior of concrete. At temperatures above 400 ◦C, however, the breakdown of concrete, which includes marble dust and foundry sand, causes a rapid deterioration in the residual properties of concrete, primarily for replacement of more than10%.

4. Jayswal et al.[4] proposed that, the effect of temperature on stress strain response under monotonic compressive loading is studied for two blended high strength concrete (HSC, viz., high calcium fly ash blended HSC (FCHSC) and alccofine blended HSC (AL-HSC)) mixes. The experimental studies have been carried out with a 100 mm æ 100 mm æ 100 mm cube specimen and tested at 28 days of curing. For each mix, four sets of specimens, including control specimen and those exposed to elevated temperatures of 80¯C, 140¯C and 160¯C for 6 h were considered for the study. The stress strain behavior of HSC mixes at elevated temperatures exhibits a distinct effect of material composition. The increasing exposure temperatureincreasespeakstressforAL-HSC,whereasitinitiallydecreasesandthenincreases for FC-HSC. The results from the study confirm that elevated temperature contributes to stiffening of the pre-peak region, but the effect on peak stress is influenced by the material composition.Theeffectofelevatedtemperatureonmicrostructuralchangeisevaluatedthrough thermo gravimetric analysis and the results are compared for FC-HSC and AL-HSC. The weightloss(30160¯C)representingcalciumsilicatehydrate(CSH)degradationdecreaseswith increasing exposure temperature for FC-HSC, whereas it remains range bound for AL-HSC. On the other hand, weight loss (400500¯C) representing degradation of calcium hydroxide (CH)remainsrangeboundforFC-HSCwhileitincreaseswithincreasingexposuretemperature forAL-HSC.Theobservedresultssuggestthatincreasingexposuretemperaturecontributesto CSH degradation in FC-HSC, whereas it enhances CH formation for AL-HSC. The study resultsprovideusefulinsightontheeffectofelevatedtemperatureonthestressstrainbehavior of blended HSC with fly ash andalccofine.

5. Lin, et al.[5]This paper presents a comprehensive review of the recent research works on the fire 13 resistance of FRC. In particular, the temperature-dependent mechanical properties of 14 steel fibre reinforced concrete, polypropylene fibre reinforced concrete and hybridfibre
15 reinforced concrete are discussed, including permeability, spalling, compressive 16 strength, tensile strength, elastic modulus, toughness and mass loss. In addition, the 17 currently available predicting equations for FRC residual properties are summarised 18 and compared.

6.Hiraskar, et al.[6] proposed that the 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 alsoreduced water absorption and porosity beyond 28 days in comparison to that of conventional concrete with stone chips used as coarseaggregate.

7.Singh, et al.[7] Present experimental work investigates feasibility of using GBFS as replacement of natural sand and GGBS as replacement of cement in concrete respectively. Concrete cubes have been prepared and their compressive strength is checked for M30 grade of concrete. Thus, it can be concluded that GGBS and GBFS can be used to partially replace cement up to 55% and sand up to 50% in concrete respectively without affecting their compressive strength. Thereby reducing carbon dioxide emission and curtailing cost of concrete by 20.25%.

8.Chaithra, et al.[8] paper deals with the effective utilization of waste material in concrete production as a partial replacement for Cement and sand. The cement has been replaced by GGBS in the range of 30%, 40% and 50% by weight of cement, quarry sand in the range of 40%, 50% and 60% by weight of cement for M40 grade mix. Workability test was carried out on fresh properties of concrete while compressive strength, split tensile strength and flexural strength were carried on hardened concrete. It is found that by the partial replacement of cement with GGBS and sand with Quarry sand helped in improving the strength of the concrete substantially compared to normal mix concrete. Compressive strength test was carried out for 7, 28 and 56 days while flexural and split tensile strength test was carried out at 28 days curing period.

9.Marshall, et al.[9] research that work describes the feasibility of using the GGBS in self compacting concrete production as partial replacement of cement. GGBS can be used as filler and helps to reduce the total voids content in self compacting concrete. Constant level of Fly ash is also used in all set of mix proportion to increase the powder content for achieve the Workability. The cement has been replaced by GGBS accordingly in the range of 0%, 25%, 30%, 35%, and 40% by weight of cement for M-30mix. After iterative trial mixes the water/cement ratio (w/c) was selected as 0.40. Self compacting Concrete mixtures produced, tested and compared in terms of compressive ,split tensile strength and flexural strength with the conventional concrete for 7,14,28 days. It is found that, 25% of GGBS can be replaced and strength obtained is comparable to the conventional concrete.

10.Zhang, et al.[10] study presents, the effects of single factors such as the stress damage and high temperature, as well as a combination of these factors on the neutralization of concrete structures are investigated to evaluate the durability of concrete structures under adverse environmental conditions and promote practical application of concrete with fly ash as fine aggregate (CFA). Rapid carbonation test was conducted to determine the carbonation depths in different carbonation times and evaluate the carbonation resistance of concrete. Results show that the carbonation depth of concrete increases with the increase in the initial stress damage and carbonation time. In addition, compared with ordinary concrete, substituting fine aggregate with fly ash can enhance the carbonation resistance of concrete. High temperature has a noticeable deterioration effect on the neutralization of concrete, and the concrete durability continues to decrease at increasing temperature. The deterioration in the durability of concrete subjected to a combination of high temperature and stress damage is significantly greater than that subjected to a single factor, which significantly reduces the carbonation resistance of concrete, particularly for normal concrete.

III. PROPOSED METHODOLOGY

METHODOLOGY

6.1 GENERAL: The experimental methodology consists of selection of materials, material testing, proportioning, casting of specimens, exposing the specimens to elevated temperature and testing of specimens. The methodology has been briefly described below.

6.2 MATERIALS:

Cement
Fine Aggregate
Coarse Aggregate
Ground Granulated Blast Furnace Slag (GGBFS)
Blast Furnace Slag (BFS)
Water

6.3 BATCHING: To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixes on any site or in any one plant. In batching, quantity of both cement and aggregate shall be determined by mass, admixtures by mass if solid or by volume if liquid. Water shall be measured in volume in a calibrated tank. Volume batching is allowed only where weigh-batching is not practical and provided accurate bulk densities of materials to be actually used in concrete have earlier been established.

Fig. 6.3 Batching of Materials

6.4 MACHINE MIXING OF CONCRETE: For production the homogeneous mass of concrete, the ingredients are mixed. Depending the requirement, quantity, quality, etc. the method of mixing is decided. The mixing should be ensured that the mass become homogenous, uniform in color and consistency. "The concrete shall be mixed by hand, or preferably, in a laboratory batch mixer, in such a manner as to avoid loss of water or other materials, each batch of concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens" – IS516 – 1959.

This is similar processes (Fig.7.2) to hand mixing only the mixing is carried out in rotating drum. When the mixing drum is charged by a power loader, all the mixing water shall be introduced into the drum before the solid materials. The drum shall be loaded with about on half of the coarse aggregate, then with the fine aggregate, then with the cement and finally with the remaining coarse aggregate on top. Finally, the drum is rotated for certain period of time.

Fig. 6.4 Machine Mixing of Material

6.5 POURING AND COMPACTION OF CYLINDER: Pourfresh concrete into the cylindrical moulds in three layers, for cylinder specimen (Fig.6.5), the number of strokes shall not be less than thirty per layer. The strokes shall penetrate into the underlying layer and the bottom layer shall be tamped throughout its depth. Where voids are left by tamping bars, the sides of the moulds shall be tapped to close the voids.

Fig. 6.5 Compaction of Concrete

A concrete with about 4cm slump can be placed and compacted fully in closely spaced reinforced concrete work, whereas for hand compaction, much higher consistency say about 12cm slump may be required. The action of vibration machine (Fig.6.5) is to set particles of fresh concrete in motion, reducing the friction between and affecting a temporary liquefaction of concrete which enables easy settlement.

6.6 CURING OF CONCRETE SPECIMENS:

The test specimen shall be stored in a place free from vibrations in moist air of least at temperature 27° ± 2° C in an atmosphere of at least 90% relative humidity for 24 hrs. From the time of addition of water to dry ingredients. After this period the specimen shall be marked and removed from mould, unless required for test within 24 hours, immediately submerged in clean and fresh water.

The cylindrical specimens are allowed for 28 days of curing. The water in which specimen are submerged shall be renewed every seven day. The specimen shall not be allowed to become dry at any time until they have been tested.

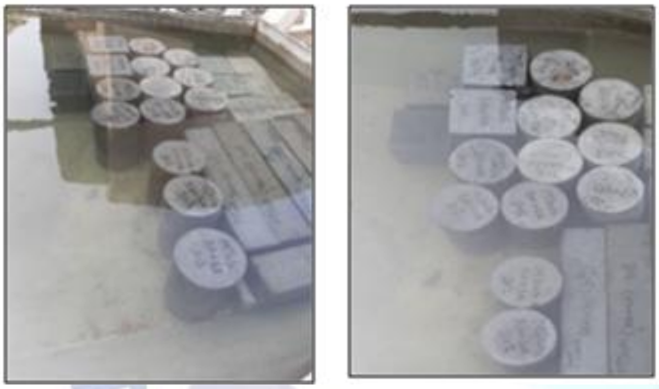

Fig.6.6 Curing of Cylindrical Specimens

6.7 SPECIMEN PREPARATION AND EXPOSURE TO ELEVATED TEMPERATURE:

The cylinder of size 150 mm diameter and 300 mm length were cast and cured in water for 28 days. After 28 days of curing, specimen was taken out, air dried, exposed to 200 ºC, 400 ºC, 600 ºC, 800 ºC, temperature and retained for 1.5 hours in an electric muffle furnace, after exposure to designated temperature the specimen was allowed to cool to the room temperature. After cooling to room temperature for 15 minutes, Specimen should be weighted before and after exposing to different temperatures to evaluate the weight loss due to temperatures, after that the compressometer test was carried out. In order to assess the Modulus of Elasticity of concrete.

Fig. 6.7 Specimens Before Exposure and After Exposure

6.8 TEST ON EXPOSED CONCRETE

COMPRESSOMETER TEST:

Standard test method forstatic modulus of elasticity of concrete in compression.

(This standard is issued under the fixed designation ASTM C469/C469M).

This test method covers determination of (1) modulus of elasticity (Young's) and (2) Poisson's ratio of molded concrete cylinders when under longitudinal compressive stress. This test method provides a stress to strain ratio value and a ratio of lateral to longitudinal strain for hardened concrete at whatever age and curing conditions may be designated.

PROCEDURE:

i) Maintain the ambient temperature and humidity as constant as possible throughout the test. Record any unusual fluctuation in temperature or humidity in the report.

ii) Place the specimen, with the strain-measuring equipment attached, on the lower platen or bearing block of the testing machine. Carefully align the axis of the specimen with the centre of thrust of the spherically-seated upper bearing block. Note the reading on the strain indicators.

iii) Apply the load continuously at a constant rate within the range 250 ± 50 kPa/s [35 ± 7 psi/s].

iv) Record, without interruption of loading, the applied load and longitudinal strain (Longitudinal strain is defined as the total longitudinal deformation divided by the effective gauge length) in case of Modulus of Elasticity. If Poisson's ratio is to be determined, record the transverse strain at the same points.

v). If a stress-strain curve is to be determined, take readings at two or more intermediate points without interruption of loading; or use an instrument that makes a continuous record

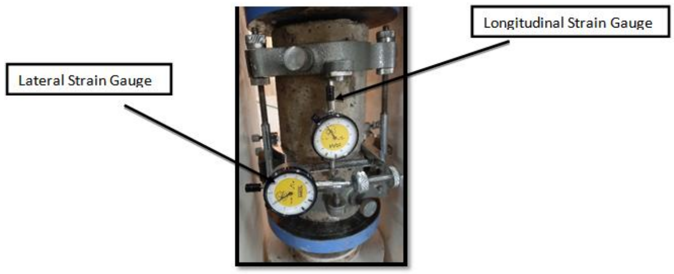

Fig.6.8 Experimental setup of Compress meter test

IV. RESULTS AND DISCUSSION

7.1 Overview: This chapter ensures all the results including quality of materials that was used in concrete. It will present information of different types of tests and their ingredients. The test results used to determine the concrete mix design of M25 grade of concrete. The results such as impact value test, crushing value, specific gravity, sieve analysis, compressometer test of harden concrete. Furthermore, it will offer quality of materials, methods used to test those materials and results of various test used in mix design of concrete. Also, it will present the Modulus of Elasticity of Conventional concrete and how it will change due to different exposure conditions and their comparison between GGBS based concrete and BFS based concrete. Finally, the comparison of weight loss of concrete due the exposure of temperatures.

7.2 Compressometer Test on Harden Concrete: The mechanical properties of the tested specimens were investigated by monitoring the stress–strain relationship, mode of failure, compressive strength, ultimate strain, and modulus of elasticity as following

7.2.1. Stress-Strain Relationship: The stress–strain relationships of concrete are often used to find the Modulus of Elasticity. Therefore, it is crucial to evaluate the temperature effect on these relationships to explore the thermal resistance of concrete structural members. Thebehavior of the stress–strain relationships of concrete under compression is inevitably changed due to the damage caused by temperature. The stress-strain relationship of concrete is evaluated for different mixtures. The different mixes are conventional concrete mix, GGBS based concrete and BFS based concrete. The GGBS concrete mix made up by replacing 10 % of GGBS with cement and BFS mix made up by replacing 10 % of BFS with coarse aggregate. With the increase in exposure to temperature, the peak stresses decreased and caused reductions in the area under the curve. The stress-strain relationship of all concrete mixes is shown in fig. 7.2.1 (a), (b) and (c).

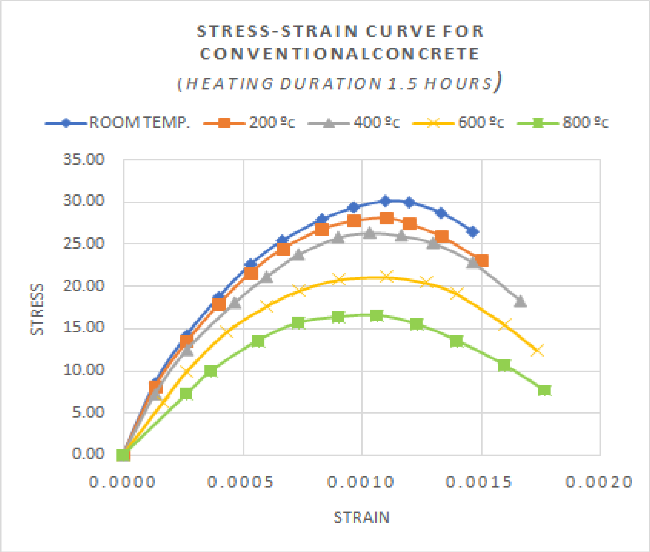

Fig.7.2.1. a. stress-strain relation of conventional concrete

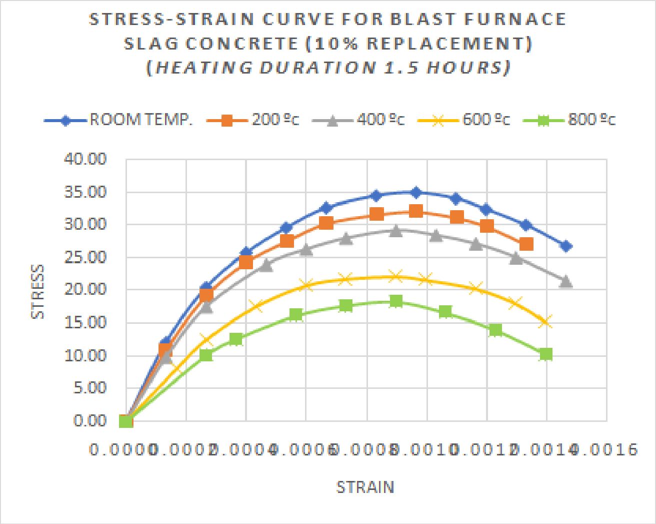

Fig.7.2.1. b. stress-strain relation of BFS concrete

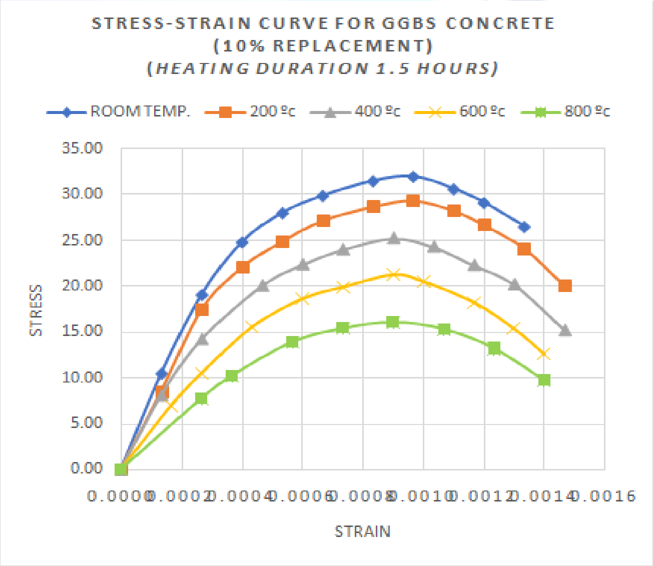

Fig.7.2.1. c. stress-strain relation of GGBS concrete

The exposure to different temperature conditions altered the mode of failure of the tested specimens as shown in Figure Three failure modes were captured for the tested cylinders. Well-formed cones and vertical cracks were the modes of failure adopted by the frozen concrete cylinders.

Fig. 7.2.1. d. Cracks of Concrete Cylinders

7.2.2 Reduction in Modulus of Elasticity: Modulus of elasticity is dependent mainly on the W/C ratio in the mixture, the age of concrete, and temperature. The variation in the elastic modulus due to temperature is illustrated in Figure. The modulus of elasticity decreased as the temperature increased. At elevated temperature, the disintegration of hydrated cement products and breakage of bonds in the microstructure of cement paste reduced the elastic modulus and the extent of this reduction depended on the moisture loss, high temperature, and type of aggregate. The Reduction in modulus of elasticity of concrete is shown as follows

The following figures summarizes results from several researchers on the temperature dependence of the concrete modulus of elasticity (normalized to reference room temperature modulus). Results for Conventional concrete, BFS concrete and GGBS concrete is presented in Fig. 7.2.2 (a), (b) and (c). The results of modulus of elasticity of concrete recorded for the heating periods of concrete is 1.5 hrs and cooling it for 15 minutes then it will be tested.Results show that the elastic modulus for all the mixes of concrete decreased monotonically with increasing temperature.

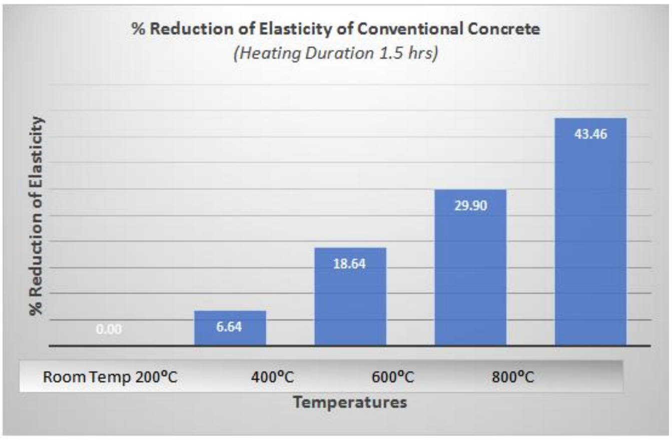

Fig. 7.2.2. a. % Reduction of Modulus of Elasticity of Conventional Concrete

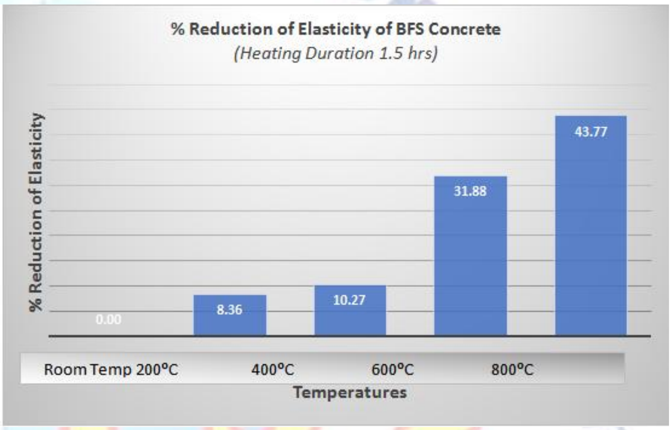

Fig. 7.2.2. b. % Reduction of Modulus of Elasticity of BFS Concrete

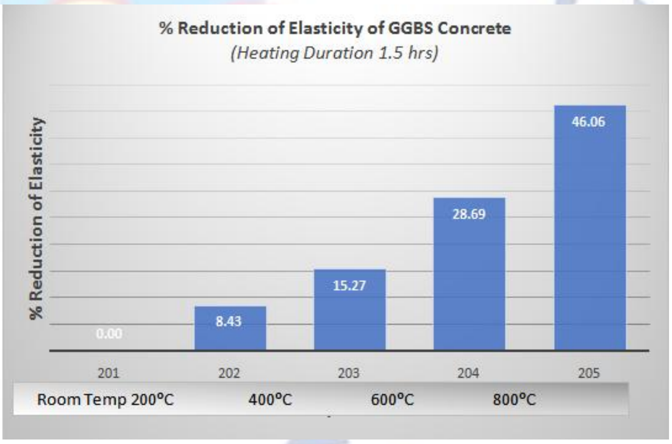

Fig. 7.2.2. c. % Reduction of Modulus of Elasticity of GGBS Concrete

7.2.3 Comparison of Reduction in Modulus of Elasticity: Concrete's modulus of elasticity—a measure of its stiffness or resistance to deformation—is used extensively in the analysis of reinforced concrete structures to determine the stresses developed in simple elements and the stresses, moments, and deflections in more complicated structures. Because concrete's stress-strain curve is nonlinear, the modulus of elasticity is determined either by the initial tangent modulus, secant modulus, or tangent modulus method. Figure 7.2.3 provides the comparison of reduction in modulus of elasticity after considering temperature effects and experimental results of all the mixes. The following fig. shows reduction in conventional concrete, BFS based concrete and GGBS based concrete with respect to different elevated temperatures.

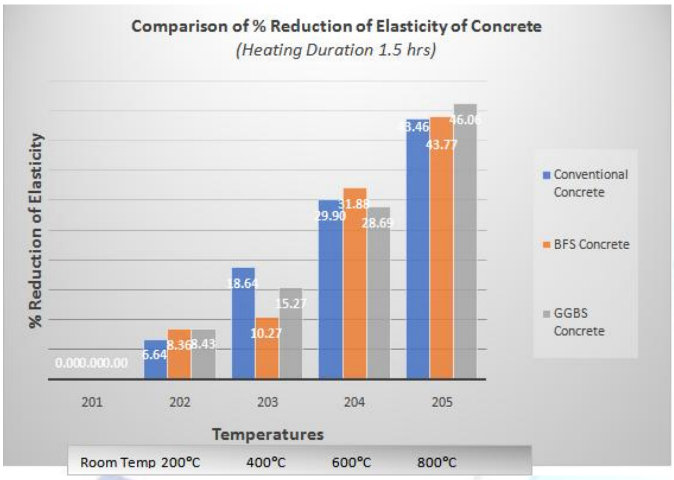

Fig.7.2.3 Comparison of % Reduction of Elasticity of Concrete

The reduction of modulus of elasticity in conventional Concrete is 0%, 6.64%, 18.64%, 29.90% and 43.46% for room temperature, 200ºC, 400ºC, 600ºC and 800ºC respectively. For BFS concrete is 0%, 8.36%, 10.27%, 31.88% and 43.77% for room temperature, 200ºC, 400ºC, 600ºC and 800ºC respectively. Also, for GGBS concrete is 0%, 8.43%, 15.27%,28.69% and 46.06% for room temperature, 200ºC, 400ºC, 600ºC and 800ºC respectively.

7.2.4. Weight Loss of Concrete Due to Temperatures:

The effects of heating on the weights of the concrete specimens were determined using Eq. (a). The specimen weights were determined at normal temperature using the electronic digital balance. Afterwards, the specimens were exposed to varying temperatures and reweighed. The difference between the two weight readings was recorded.

$$\text{Weight loss \%} = \frac{Wn - Wh}{Wn} \quad \text{(a)}$$

where *Wn*is the specimen weight at normal temperature and *Wh*is the specimen weight after heating.

According to the heated specimen results, the Conventional concrete specimens lost 2.84%, 4.87%, 8.42% and 9.76% of their weights when heated at 200 °C, 400°C, 600°C, and 800° respectively compared with their weights at normal temperature as shown in Fig. 7.2.4.a.

The observed weight loss is due to the moisture movement from the concrete surface to the surrounding environment; changes in the stiffness and mechanical properties of the concrete result in weight loss, especially at 800 °C. Hug weight loss difference was observed in the concrete containing GGBS, when heated to 800 °C compared with those of control specimens. Weight decrease was observed when the specimen was subjected to different elevated temperature. When concrete is subjected to elevated temperatures, the incompatibility of thermal deformations of the constituents of concrete initiates cracking. Internal stress is caused by a microstructure change due to dehydration and steam pressure buildup in the pores.

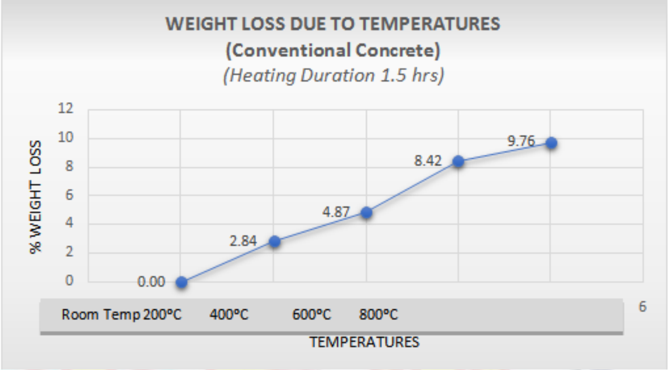

Fig.7.2.4. a. Weight Loss of Conventional Concrete Due to Temperature

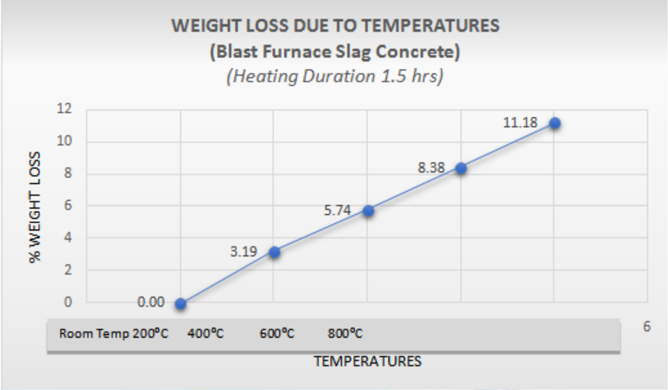

Fig.7.2.4. b. Weight Loss of BFS Concrete Due to Temperature

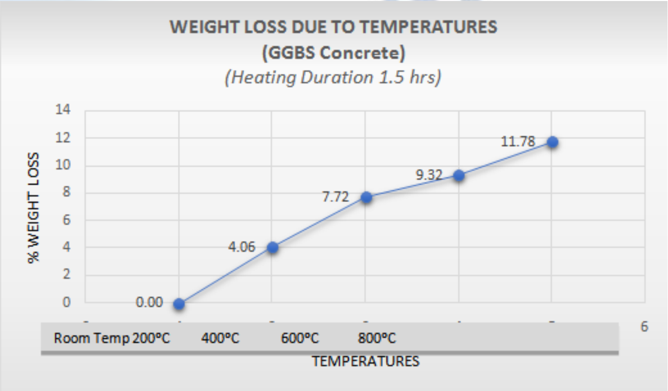

Fig.7.2.4. c. Weight Loss of GGBS Concrete Due to Temperature

Concrete's thermal properties are more complex than for most materials because not only is the concrete a composite material whose constituents have different properties, but its properties also depend on moisture and porosity. Exposure of concrete to elevated temperature affects its mechanical and physical properties.

7.2.5. Comparison of Weight Loss of Concrete: Theweight losses in conventional concrete are 2.84%, 4.87%, 8.42% and 9.76% at 200ºC, 400ºC, 600ºC and 800ºC respectively. The weight loss of concrete containing BFS are 3.19%, 5.74%, 8.38% and 11.18% at 200ºC, 400ºC, 600ºC and 800ºC respectively. Also, for concrete containing GGBS are 4.06%, 7.72%, 9.32% and 11.78% at 200ºC, 400ºC, 600ºC and 800ºC respectively. Weight loss after exposure to high temperatures was due to the differences in the physical and mechanical properties of the materials comprising the concrete mixes. High temperatures can also cause the evaporation of water in the C-S-H gel structure, which is an important factor contributing to weight loss.

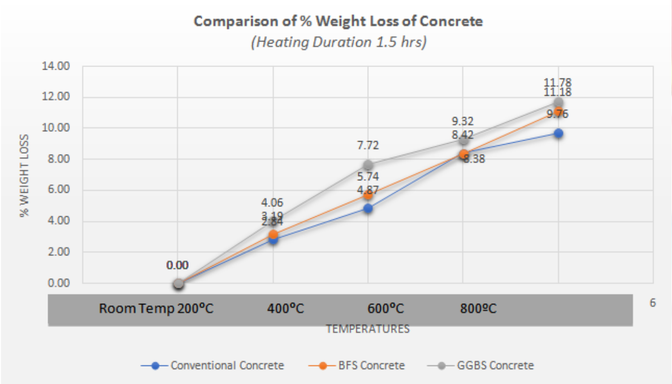

Fig. 7.2.5 Comparison of weight loss of concrete

The High initial rate of hydration due to increased temperature retards the subsequent hydration and produces a non-uniform distribution of the products of hydration. Its reason is that at high initial rate of hydration, there is insufficient time available for the diffusion of the products of hydration away from the cement particle and for a uniform precipitation in the interstitial space. All this results in concentration of the products in the vicinity of the hydrating particles which causes subsequent retardation in hydration and effects strength.

V. CONCLUSION

In this study, an overview of the temperature effect on concrete is experimentally provided. Concrete cylinders were prepared, cured, and stored under different temperature conditions to be tested under compressometer test. The stress–strain curve, mode of failure, ultimate stress, ultimate strain, and modulus of elasticity of concrete were evaluated at age of 28 days. The experimental results were used to validate previous constitutive models and to develop new models to predict the mechanical properties of concrete under the effect of temperature.

i) The substitution of 10% of GGBS with cement and 10% of Blast furnace slag with coarse aggregate shows increase in compressive stress at normal temperature.

ii) The tangential slope of stress-strain relationship of concrete decreased through all the mixes as the temperature increased.

iii) The modulus of elasticity of concrete reduced as temperature increased. For conventional concrete Modulus of elasticity reduces to 6.64%, 18.64%, 29.90% and 43.46% at 200ºC, 400ºC, 600ºC and 800ºC respectively, For BFS concrete 8.36%, 10.27%, 31.88% and 43.77% at 200ºC, 400ºC, 600ºC and 800ºC. Also, for GGBS concrete is 8.43%, 15.27%,28.69% and 46.06% at 200ºC, 400ºC, 600ºC and 800ºC respectively.

iv) Weight loss rate of concrete specimens increased by increases in temperature, theweight losses in conventional concrete are 2.84%, 4.87%, 8.42% and 9.76% at 200ºC, 400ºC, 600ºC and 800ºC respectively. The weight loss of concrete containing BFS are 3.19%, 5.74%, 8.38% and 11.18% at 200ºC, 400ºC, 600ºC and 800ºC respectively. Also, for concrete containing GGBS are 4.06%, 7.72%, 9.32% and 11.78% at 200ºC, 400ºC, 600ºC and 800ºC respectively.

v) Surface cracks of concrete specimen observed in all the exposure condition, the vertical surface cracking of concrete at 800ºC shown in fig. 7.6.1. d.

vi) The changes in colour of concrete specimens observed at a high exposure of temperature, it is shown in fig. 7.6.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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