ARID ZONE JOURNAL OF ENGINEERING, TECHNOLOGY & ENVIRONMENT
AZOJETE June 2021. Vol. 17(2):243-260
Published by the Faculty of Engineering, University of Maiduguri, Maiduguri, Nigeria.
Print ISSN: 1596-2490, Electronic ISSN: 2545-5818
www.azojete.com.ng

ORIGINAL RESEARCH ARTICLE

EFFECT OF ELEVATED TEMPERATURE ON THE DURABILITY AND STRENGTH PROPERTIES OF CONCRETE WITH GROUND RICE HUSK ASH AS A PARTIAL REPLACEMENT TO CEMENT: A REVIEW

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ARTICLE INFORMATION

Submitted 16 December, 2020
Revised 26 February, 2021
Accepted 4 April, 2021

Keywords:
Concrete strength
Durability
Elevated Temperature
Rice Husk ash
Cement replacement

ABSTRACT

Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time. Cement is an important constituent in the concrete composite; however, its cost is relatively very high, this has impacted in the cost of concrete production and by extension on the cost of housing delivery in Nigeria. Rice husk ash is one of the promising pozzolanic materials that can be blended with Portland cement for the production of durable concrete and at the same time a value-added product. the use of the rice husk ash as partial replacement to cement in concrete not only improve the strength of concrete, protection against cracking, spalling, reduce density and porosity of the concrete. It also reduces the emission of carbon monoxide to the environment which is very dangerous to the atmosphere. The elevated temperature is one of the most harmful effects that cause durability problems in construction; this effect can cause permanent damage in construction and reduce the service life. This paper reviews the work presented by various researchers on effect of elevated temperature on the durability and strength properties of concrete using rice husk ash as partial replacement. From the available literature reviewed, there is a possible research gab in investigating the effect of elevated temperature on concrete with rice husk ash as partial replacement to cement, because most of the researchers have focused on conventional concrete, whereas concrete with rice husk ash as replacement to cement have been recommended for use with a replacement value of 10-20%. The degree of its performance of these recommended replacement needs to be investigated

1.0 Introduction

Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time. Portland cement is the commonly used type of cement for production of concrete. Concrete technology deals with study of properties of concrete and its practical applications. In a building construction, concrete is used for the construction of foundations, columns, beams, slabs and other load bearing elements (Naus, 2005).

Concrete is a sustainable construction material which is widely used all over the world as it provides superior fire resistance, gains strength over time, gives an extremely long service life and capable of being moulded into different shapes (Neville, 2011). The major components of concrete are cement paste and inert materials.

Cement is an important constituent in the concrete composite. However, its cost is relatively very high. This has impacted in the cost of concrete production and by extension on the cost of housing delivery in Nigeria. Adabas *et at.* (2012) an option available in mitigating this challenge is in replacing a proportion of cement with cheap and available pozzolanic materials (ground husk ash) from agro wastes. There are different types of binding material is used other than cement such as lime for lime concrete and bitumen for asphalt concrete which is used for road construction. Various types of cements are used for concrete works which have different properties and applications. Some of the types of cement are Ordinary Portland cement, Portland Pozzolana Cement (PPC), rapid hardening cement, Sulphate resistant cement etc.

Typical Portland cement is a mixture of tricalcium silicates ($3CaO.SiO_2$), tricalcium aluminates ($3CaO.Al2O_3$), dicalcium silicates ($2CaO.SiO_2$) and a tetra-calcium aluminoferrite ($4CaO.Al2O3Fe2O_3$) in various proportions together with small amounts of magnesium and iron compounds. Sometimes, Gypsum is added to slow the hardening process (Deepa *et al.,* 2010). The temperature at which cement is been manufactured (~1500°C) and the high energy consumption associating with it pose problem in construction industries. There is also emission of harmful gases which pollute the atmosphere during its production. The production of every ton of Portland cement contributes about one ton of CO_2 in the atmosphere. Small amount of NOX (NO and NO_2) and CH4 gases are also emitted (Singh *et al*., 2007). Besides energy consumption and emission of harmful gases, one positive benefit is that calcium hydroxide, one the hydration products during the hydration of cement is a bonus for construction industry especially when allowed to react with pozzolans.

Concrete containing mineral admixtures is used extensively throughout the world for their good performance and for ecological and economic reason. Some of the common cementitious materials that are used as concrete constituents, besides Portland cement are silica fume, fly ash, ground granulated blast furnace slag and rice husk ash. They save energy, conserve resources and have many technical benefits (Arioz, 2007).

Rice is an increasing important crop in Nigeria and relatively easy to produce and grown for sale and for home consumption (Chukwudebelu *et al*., 2015), rice husk is an agricultural remainder derived from the external covering of rice grains during milling procedure and the ground one into powders forms is called the Ground Rice Husk Ash (GRHA) which are shown from figure 1.0 below. It comprises 20% of the 500 million tons of paddy generated in the world (Sivaumat, 2014). When rice husk is burnt, about 20% by weight of the husk is recovered as ash in which more than 75% by weight is silica. Unlike natural pozzolan, the ash is an annually renewable source of silica. Also Rice husk ash is a recent addition in the list of pozzolanic materials. (Ramezanianpour *et al*., 2009), opined that one of the most suitable sources of pozzolanic material among agricultural waste components is rice husk, as it is available in large quantities and contains a relatively large amount of silica.

Rice husk ash is one of the promising pozzolanic materials that can be blended with Portland cement for the production of durable concrete and at the same time a value-added product. Binary blending of Portland cement with rice husk ash does not only improve the early strength of concrete, but also forms a calcium silicate hydrate (CSH) around the cement particles which is highly dense and less porous, and may increase the strength of concrete against cracking (Saraswathy, 2007). Also, addition of rice husk ash (RHA) speeds up setting time, although compared to OPC the water requirement is higher, it has improved compressive strength due to its higher percentage of silica and improved resistance to acid attack compared to OPC which is said to be due to the silica present in the RHA which combines with the calcium hydroxide and reduces the amount susceptible to acid attack (Deepa,2013). Rice husk ash can also replace silica fume in high strength concrete as further described by (Koksal et al., 2012) and silica fume or micro silica is the most commonly used mineral admixture in high strength concrete although the major characteristics of Rice husk ash are its high-water demand and coarseness compared with condensed silica fume. Also, the presence of RHA and cement kiln dust in cement pastes improved the resistance of the mortar to sulfuric acid attack (Hashem, 2013).

RICE HUSK ASH GROUND RICE HUS ASH

Elevated temperature is one of the most harmful effects that cause durability problems in constructions. This effect can cause permanent damages in constructions, reduce the service life and may cause causalities, thus affecting the construction's sustainability (Aydin, 2003). Concrete is well known for its capacity to endure high temperatures and fires owing to its low thermal conductivity and high specific heat (Arioza, 2007). However, it does mean that the fire as well as the high temperatures does not affect the concrete. High strength concrete may exhibit damages such as cracks and spalling's when exposed to high temperatures (Kalifa, 2001).

During exposure to high temperatures such as fire, important changes may occur in its mechanical, physical, and thermal properties according to (Choni, 2001). These suggest that failure of the elements could be multidimensional as observed by (Choni,2001). In addition, elevated temperature reduces the strength of concretes and the degree of strength-loss is dependent on the temperature reached and the exposure duration (Castillo, 1990). Other factors that influence the strength loss according to (Knack, 2010) are aggregate types and the strength of the concrete at room temperature. High Strength Concrete (HSC) according to (Kodur, 1999) provides a high level of structural performance, especially in strength and durability, as compared to Normal Strength Concrete (NSC). As such, (Bui, 2001) defined high strength concrete as that concrete designed to give optimized performance characteristics for a given set of load, usage, and exposure conditions consistent with the requirement cost, service life and durability.

Factor Affecting the Properties of Concrete at Elevated Temperature

According to Iffat and Bose (2016), few aspects can affect the properties of concrete when exposed to fire such spalling, cracking, density of concrete, moisture content, fire intensity, transverse reinforcement placing, type of aggregates, fibre reinforcement, concrete strength and water-cement ratio. Since the type of aggregate used in concrete is one of the aspects that influence the concrete properties, the selection of aggregate must be a major concern in concrete design when subjected to fire. There are two types of aggregate that commonly used in construction, carbonate aggregate and siliceous aggregate (Abram, 1973). Also, Siliceous aggregate affords higher thermal conductivity and expansion, higher fire resistance, and improved spalling resistance in concrete compared to carbonate aggregate. Furthermore, concrete with compressive strength more than 55Mpa is more responsive to spalling and may have a lower resistance (Yehia and Kashwani, 2003). The spalling of concrete normally occurs at initial stages of fire due to the expansion of water pressure or the effect of thermal expansion in concrete mixes. High strength concrete may have a very lower permeability and water-cement ratio that causes moisture escapes with a slow rate and pressure of pore will be increased. Consequently, this will contribute to a major reduction in load bearing capacity during fire exposure. Concrete density also has a significant impact on concrete properties when exposed to fire. For example, high strength concrete has a dense paste and low water cement ratio which is liable to spalling when exposed to fire. The rate of transmission of high temperature to the concrete core is high that leads to rapid loss of concrete surface (Kodur, 1999).

Furthermore, concrete is the feasible material that can be exposed to high temperatures during the fire or near to the furnaces (Lucccio *et al.*, 2003) whereas exposure to high temperature during the fire can be a potential threat for any construction buildings that can cause a major damage to reinforced concrete structures (Yehia and Kashwani, 2003). Despite that concrete is a non-combustible material, the effect of fire on concrete structure still can change physical, chemical, and mechanical properties of the concrete once it exposed to elevated temperatures. Moreover, it will also cause the strength reduction, volume stability and modulus of elasticity of the concrete (Ndoukouo *et al.*, 2011). Thus, the concrete properties exposure to fire is significant, while considering the load carrying capacity and restoring fire-damaged buildings (Hertz, 2005). It is generally known that concrete is a composite material that made from cement, water and almost 65% to 75% volume of concrete is occupied by aggregates. Currently, the depletion of raw materials in concrete production such as natural aggregates become a serious problem all over the world and it was caused by the rapid industrial development. One of the best solutions to reduce this problem is to utilize recycled waste material and industrial by-product in the concrete production such as palm oil clinker, bottom ash, fly ash, granite powder, rice husk ash, marble and dolomite powder, furnace slag and so on as alternative materials for natural aggregate. According to Iffat and Bose (2016), the exceptional fireproof achievement of concrete is might be due to constituent materials of concrete such as its aggregates. Similarly, Sakr and Hakim (2005), reported that the strength degradation of concrete with the different types of aggregates is not same at high temperatures. According to Hager (2013), the commonly used aggregate is steady up to a temperature range of 200°C to 350°C but when the temperature rises up to 600°C, the physical and chemical changes of the aggregate will occur and contributed to a lower strength of concrete. Since the aggregate is one of the main materials in concrete production, the properties and type of aggregate play a significant role in the behaviour and properties of concrete when it is exposed to the high temperatures (Arioz, 2007). Therefore, the aim of this study is to review available relevant research works on effect of elevated temperature on the durability and strength properties of concrete with rice husk ash as partial replacement for the Cementous material.

2.0 Methodology

Literature review

Generally, the atmospheric temperature of concrete structures is expected to be at room values during construction and during their service life. Current design and construction codes take care of safety of these structures in relation to room temperature values (BS 8110 Part 1). At times the environmental temperature may increase extremely or fluctuate periodically, and often the design strength of the structure is significantly affected (Guo,2011). It has become a big assignment for engineers to be interested in the residual design strength of concrete subjected to high temperatures in order to form data base for performance at these elevated temperatures for practical research applications.

Stress-strain relationship of high strength concrete, HSC, (concrete strength in excess of 70Mpa) has been investigated and reported. The variables considered in the experimental study included concrete strength, type of aggregate, and the addition of steel fibres. (Cheng *et al*., 2014) reported that tests show that plain HSC exhibits brittle properties below 600°C, and ductility above 600°C. HSC with steel fibres exhibits ductility for temperatures over 400°C. The compressive strength of HSC decreases by about a quarter of its room temperature strength within the range of 100-400°C. They also showed that surface concrete cracking is a visible type of damage that has significantly adverse effects on the mechanical properties and durability properties of concrete.

A study on the identification and quantification of surface cracking of concrete heated to different temperatures ranging from 105 to 1250°C was carried out, in addition to the quantification of the residual compressive strengths of concrete after high temperature exposure; both initial surface absorption and total porosity were measured. The investigation showed that crack density was determined using a flatbed scanner and then images were treated using paint shop program. The total porosity was obtained using American Society for Testing and Materials (ASTM) methods as reported. Further discussions pointed to the fact that the mechanical properties of concrete were largely affected by temperatures beyond 500°C and were very feeble when temperatures exceeded 1000°C. The surface cracks' density, initial surface absorption and total porosity by boiling methods gave a rapid indication on concrete durability from the report (Toumi *et al*., 2010).

The effect of exposing carbon- fibered reinforced concrete to elevated temperatures on its bond strength with reinforcing steel bars have been investigated by Hassan (2012). He wrote that experimental program consisting of fabricating and testing of 54 pull-out cubic specimens was prepared. From the experiments, the specimens were divided into three groups to study the effect of addition of various amounts of discrete carbon fibre on its residual bond strength and the bond strength- slip response after exposure to temperature levels of 150°C, 250°C, 350°C, 450°C and 550°C in addition to the room temperature. The carbon fibre content considered was 0.0%, 0.75% and 1.0% by weight of cement. In addition to the pull- out specimens, nine cubes having the same pull-out specimens' size (three from each concrete group mix) were tested in compression. It was concluded that the percentage residual bond strength after exposure to temperature level of 550°C for the concrete reinforced with 0.75% carbon fibre by weight of cement (28%) is lower than that for plain concrete and the concrete reinforced with 1.0% carbon fibres (32%). There was no clear conclusion that could be obtained concerning the effect of changing temperature levels on bond- slip response of plain concrete and that reinforced with 0.75% and 1.0% carbon fibres.

An experimental investigation was conducted to evaluate the influence of elevated temperatures on the mechanical properties, phase composition and microstructure of silica flour concrete (Morsy *et al.*, 2010). The 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°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°C.

Also, an investigation presented the results of a study on the effect of polyester fibre reinforcement on the residual compressive strength of normal-strength concretes subjected to sustained elevated temperature by Suresh *et al.* (2014). Two different volume fractions of polyester fibre were adopted in the concrete which was subjected to elevated temperatures of 100°C, 200^0 C, 300^0C, 400^0C, 500^0C, 600^0C, and 800^0C, sustained for 2 hours. This involved a total of 72 specimens containing 0%, 0.5%, and 1% volume fraction of 12 mm polyester. The test results showed that the addition of polyester fibres will contribute to the increase in the compressive strength depending upon the percentage of fibres present in it. Based on this research, it is observed that there is an increasing trend in the residual compressive strength of the normal strength concrete up to sustained elevated temperature of 400^0C due to the addition of polyester fibres at 0.5% volume fraction.

From the eighteenth century onwards, the World's Portland cement consumption increased to 2 million tons from 1.3 billion tons annually. This was accompanied with other environmental issues like largest amount of CO_2 produced during the cement manufacturing process (Rawaid *et al.*, 2012; Meyer, 2009). This leads to the utilization of substitution material for cement. However, the sustainable material would reduce the demand of Portland cement and reduce the production cost of concrete. One of the most assuring materials is Rice Husk Ash (RHA).

Concrete containing agricultural waste is used extensively throughout the world for their good performance and for ecological and economic reason. Some of the common cementitious materials that are used as concrete constituents, besides Portland cement are silica fume, fly ash, ground granulated blast furnace slag and rice husk ash. They save energy, conserve resources and have many technical benefits. Rice husk ash is a recent addition in the list of pozzolanic materials (Ariozo, 2007).

Extensive research activities have been carried out on the ashes of many Agricultural waste materials with the intent of producing concrete and mortar through partial replacement of OPC. In the case of Rice Husk Ash (RHA) - cement composites, it was shown that at w/c ratio of 0.30 and OPC replacement level of 20%, RHA mortar resulted in higher compressive strength compared to the control for both waters cured and uncured cubes. It also improved in durability properties (Abalaka, 2013).

During the pozzolanic reaction, highly reactive pozzolan reacts with calcium hydroxide and produces lower density calcium silicate hydrates; for this reason, GRHA show a higher chloride penetration resistance as compared to natural rice husk ash (Bhanumathi and Mehta, 2004; Ganesan *et al*., 2008; Rukzon and Chindaprasirt, 2008).

The chloride penetration resistance rate of NRHA-10 and GRHA-15 concretes are 19% and 52% more than that of control concrete. Thus, the test results show that the chloride ion penetration resistance is significantly improved by incorporation of RHA in concrete.

The incorporation of RHA in concrete increases the strength, particularly for lower water/binder ratio (Nehdi *et al*., 2003; Giaccio *et al*., 2007; Bui *et al*., 2005) reported that brittle failure was observed in RHA concrete.

The addition of RHA to concrete shows an increase in compressive strength and decrease in water permeability of concrete (Salas *et al*., 2009). It is noticed that the durability of concrete exposed to HCl and H2SO4 attacks, replacement of 20% of Portland cement by rice husk ash led to a positive effect in decreasing the corrosion of concrete (Chatveera and Lertwattanaruk, 2011; Salas, 2009).

Air permeability and chloride ion penetration studies showed that the water/cementitious materials ratio has the influence on decreasing the penetration rate on the RHA replaced concrete. The reduction in chloride ion penetration is mainly due to the pore-refining capacity of RHA in concrete (Sensale, 2010; Ganesan *et al*., 2008).

Similarly, scanning electron microscope is used to examine the natural RHA used, and From SEM study, it is noticed husk ash has many irregular-shaped particles with a sizable fraction showing a porous cellular structure. These particles are functioning as a lubricant or dispersion agent and contribute to the dispersion of OPC particles in a water system, as well as it is used to release the water entrapped between OPC particles, thus improving concrete workability. Natural rice husk ash average particle size is 240×140 µm. Thus, the RHA is finer than cement and it is expected to blend easily not only on pozzolanic material, but also on the microfiber effect (Xu *et al*., 2012).

At the same 20% in another report, compressive strength and porosity of cement mortar showed better result over plain mortar. Still on RHA mortar, two reports gave optimum compressive strengths at 10% and 15% respectively (Rashid, and Ali, 2010). Additionally, the presence of RHA and cement kiln dust in cement pastes improved the resistance of the mortar to sulfuric acid attack (Hashem, 2013).

According to Wang (2017) whose study on the effect of rice husk ash on high temperature on mechanical properties and microstructure of concrete, the result shows that mixing concrete with appropriate amount of RHA can improve its strength. At 8000C the strength is 50% greater than of normal concrete. Thus, rice husk ash can improve the strength and temperature resistance of concrete.

Paraven and Raw (2019) whose study on influence of supplementary cementitious material on strength and durability of concrete using three mineral admixtures of fly ash, silica and limes sludge were used in the preparation of blended concrete. It was evident that the usage of such mineral admixture is having a beneficiary role on the strength as well as the durability properties which shows greater resistance to acid attack compared to controlled mix concrete.

According to Ndububa and Okonto (2016) whose study on the potential used of fonica ash as a pozzolana in concrete, show that at 10% of FHA should not exceeded for optimum strength value.

Furthermore, Nwofor and Sile (2016). Whose study on stability of ground nut ash GSA/OPC on concrete in Nigeria. This shown that certain percentage of cement replace by GSH for 0% to 40% which evident that the result generally shows a decrease in density and compressive strength as the percentage replace out increases.

On partial replacement of cement with burnt rice husk ash for low strength concrete production by Ugwuanyi et al. (2018), the result shows that the highest compressive strength was obtained at 10% replaced of cement with RHA. Using such material reduces cost of cement and density of concrete and produce insulated blocks.

According to Ketkula (2018). study on “ground nut hush ash as partial replacement of cement in mortal”. The GHA was used as partial replacement of OPC, the level of replacement of 0%, 2%, 4%,.10% were used for this, using such material the density of the sandcrete block were reduce and water absorption decreases, therefore it is recommended for further research on permeability and durability analysis.

Addition of amorphous silica is accompanied by improving interface transition area leads to concrete with more packing density. A series of investigations carried to evaluate RHA concrete considering hardened properties, favourable percentage of RHA replacement, curing time, electrical resistivity, compressive strength and influencing parameters followed by increase in the percentage of RHA replacement in the mix. (Kartini et al., 2012). Kartini et al. (2012) research showed, increased replacement of RHA to OPC may be resulted in less charge passed values, which reduces along with increase in curing period. So, more replacement of RHA leads to less percentage of chloride ions penetration”.

Structural elements fabricated from reinforced concrete, because of their typical size, have a high thermal inertia that results in relatively slow rates of temperature increase through the cross section. As a result, the steel reinforcement temperatures are kept sufficiently low to

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avoid significant softening. In addition, due to the monolithic nature of construction, the existence of alternate load paths, and compartmentation of fires (conventional civil engineering construction), reinforced concrete structures generally perform well under elevated-temperature conditions that could result from a fire. However, under certain scenarios (rapid heat build-up), spalling of the concrete could occur to expose the steel reinforcement to the effects of elevated temperature (Harmathy, 1970).

Rice husk ash is one of the promising pozzolanic materials that can be blended with Portland cement to produce durable concrete and at the same time a value-added product. Binary blending of Portland cement with rice husk ash does not only improve the early strength of concrete, but also forms a calcium silicate hydrate (CSH) gel around the cement particles which is highly dense and less porous, and may increase the strength of concrete against cracking (Saraswathy and Ha-Won, 2007).

Rice husk has recently been recognized as pozzolana; it is a siliceous/ aluminous material which in itself has little or no cementitious value, but which will in finely divided form and in the presence of moisture, chemically reacts with calcium hydroxide liberated during the hydration of Portland cement to produce stable, insoluble cementitious compound which contributes to its strength and permeability (Sima, 1974).

Koksal *et al*. (2012) used four different composite mixtures with varying amount of expanded vermiculite exposed to high temperatures of 300, 600, 900 and 1100oC for 6hrs, the physical and mechanical properties including unit weight, porosity, water absorption, residual compressive strength, residual splitting tensile strength and also ultrasonic pulse velocity were determined after air cooling, micro-structures were investigated by scanning through electron microscopy and disclosed that light-weight concrete with vermiculite shows a good performance at elevated temperatures.

Extensive research activities have been carried out on the ashes of many Agro-allied waste materials with the intent of producing concrete and mortar through partial replacement of OPC. In the case of Rice Husk Ash (RHA) - cement composites, it was shown that at w/c ratio of 0.30 and OPC replacement level of 20%, RHA mortar resulted in higher compressive strength compared to the control for both water cured and uncured cubes. It also improved in durability properties (Abalaka, 2013).

At the same 20% in another report, compressive strength and porosity of cement mortar showed better result over plain mortar. Still on RHA mortar, two reports gave optimum compressive strengths at 10% and 15% respectively (Rashid and Ali, 2010).

Using different percentages of rice husk (RHA). The initial and final setting times increases with increase in rice husk ash content. The reaction between cement and water is exothermic. The liberation of heat and evaporation of moisture causes the stiffening of the paste and slower heat induced evaporation of water from the cement/RHA paste due to its lower cement content Ikpong (1993).

According to Rawaid *et al*., (2012), the production of cement is costly, consumed higher energy and emits huge amount of greenhouse gases, bring serious pollution and environmental degradation, developed and some developing nation using RHA rice husk ash as cement in concrete production.

Mehta and Folliard (1996) found that the mortars containing RHA possess excellent acid and sulphate resistance properties compared to those that did not contain RHA. Similarly, RHA can be used as a high-performance pozzolan to improve the mechanical and durability properties of conventional.

3.0 Result of critical review

Table 1 provides the critical review summary for tins study.

Table 1: Critical review summary

S/N	Author(s)	Studies carried out	Study findings	Critics
1	Deepa (2013)	Mechanical Properties of Rice Husk Ash (RHA) in High Strength Concrete	His analysis shows that rice husk ash in concrete increases the mechanical properties of concrete such as compressive strength, setting time and protection against acidic attracts.	Failed to investigate the effect of elevated temperature in concrete with rice husk ash
2	Castillo (1990)	Effect of elevated temperature on high strength concrete.	His result shows a decrease in strength of the concrete with increase in temperature.	Study is confined to temperature effect on conventional concrete.
3	Ndoukou *et al* (2011)	Factors affecting the properties of concrete at elevated temperature.	His analysis shows strength reduction, volume stability and modulus elasticity in concrete at elevated temperature.	Study is focused on the durability properties of plain concrete at elevated temperature
4	Iffat and Bose (2016)	Review on Concrete Structures in Fire (effect of agricultural waste as fireproof in concrete using fly ash and Rice)	The studied materials are effective in fire proofing in concrete between from 100°C to 350°C.	Analysis is on two agricultural (fly ash and rice husk) waste as fireproof.

5	Cheng *et al.* (2014)	Effect of elevated temperature on concrete HSC above 70mpa	Result show that the plain HSC exhibits brittleness below 600°C and ductility above 600°C	The research focused only on concrete above 70 Mpa but with no rice hush ash.
6	Toumi *et al.* (2010)	Identification and quantification of surface cracking heated to different temperature	It affects the mechanical properties of the concrete at above 500°C	Studied cracks caused by heat effect in plain concrete without admixture
7	Hassan (2012)	The effect of exposing carbon-fibre reinforced concrete to elevated temperature on it bond strength with reinforcing steel bars from 150°Cto 550°C	The bond is lower at 550°C for the concrete reinforced with 0.75% of carbon to plain concrete	He examined the effect of exposing carbon-fibred reinforced concrete at elevated temperature.
8	Morsey et al. (2010)	Effect of elevated temperature on the mechanical properties of concrete containing Silica flour as partial replacement to cement	His result show that the addition of silica flour increases the performance of produced blend concrete from 100°C to 400°C	His studies focused on using silica flour as admixture in the concrete elevated up to 400°c
9	Suresh *et al.* (2014)	Effect of polyester fibre reinforcement on 0%, 0.5% AND 1% on the residual compressive strength of normal concrete subjected to 100°C to 800°C	The analysis shows that, addition of polyester fibre increases the compressive strength of the concrete up to 400°C at 0.5% volume fraction	Failed to investigate the effect of elevated temperature in concrete with rice husk ash
10	Abaka (2013)	Effect of rice husk ash on the strength and durability properties of concrete as partial replacement to cement.	It improved the strength and durability properties of the concrete from 10-20% proportion.	Failed to investigate the effect of elevated temperature in concrete with rice husk ash

11	Kartini *et al.* (2012)	Compares pozzolanic reaction between Ground rice husk ash (GRHA) and natural rice husk ash (NRHA) with calcium hydrate.	Result shows that, the GRHA show higher chloride penetration resistance as compared to NRHA in concrete.	Failed to investigate the effect of elevated temperature in concrete with rice husk ash
12	Nehdi *et al.* (2003)	Effect of rice husk ash in concrete as partial replacement of cement in different proportion	Result shows that the addition of rice husk ash in concrete increases the concrete strength; brittle failure was observed in RHA concrete.	Failed to investigate the effect of elevated temperature in concrete with rice husk ash
13	Salas *et al.* (2009)	The effect of rice husk ash as partial replacement to cement in concrete expose to HCL and H_2SO_4 in different proportion	It shows that the durability of the concrete attacked by HCL and H_2SO_4 replace 20% of OPC by RHA led positive effect in decreasing the corrosion of concrete	Effect of elevated temperature is not studied.
14	Sensal (2010)	Strength development of concrete with rice husk ash	Investigation shows that the water/cementitious material ratio have an influence on decreasing penetration of chloride ion on the RHA replaced concrete.	The effect of elevated temperature not investigated.
15	Xu *et al.* (2012)	Microstructure and reactivity of RHA using scanning electron microscope	Result shows an improvement in concrete workability	Failed to investigate the effect of elevated temperature in concrete with rice husk ash

16	Praveen and Prasad (2019)	Influence of supplementary cementitious materials on strength and durability of concrete using three mineral admixture of fly ash, silica and sludge	It was evident that the usage of such mineral admixture is having a beneficiary role on the strength and durability properties compare to control mix concrete.	The effect of elevated temperature in concrete with rice husk ash is not investigated
18	Ndububa and Okonto (2016)	The potential of using fonica ash as pozzolana in concrete as partial replacement to ordinary Portland cement	Result shows that optimum strength value is obtained at 10% of fonica ash replacement.	The effect of elevated temperature in concrete with rice husk ash is not investigated
19	Nwofor and Sile (2016)	Stability of groundnut husk ash as partial replacements to cement on concrete in Nigeria	The result shows a decrease in density and compressive strength as the percentage increases	
20	Ugwuanyi et al. (2018)	Partial replacement to cement with burn rice husk ash for low strength concrete production	The result shows that the highest compressive strength was obtained at 10% replacement of cement with rice husk ash RHA, such replacement reduce cost and density	Failed to investigate the effect of elevated temperature in the concrete containing rice husk ash
21	Ketkula (2018)	The effect of ground nut husk ash as partial replacement to cement in mortal	Its analysis shows that the density of the sancrete block reduce, water absorption decrease as the percentage of replacement increases and recommended for further research	The effect of elevated temperature on the mix concrete is neglected

22	Wang (2017)	Effect of rice husk in mechanical properties and microstructure of concrete	The result show that mixing concrete with RHA can improve its compressive strength	Failed to investigate the effect of elevated temperature in concrete with rice husk ash
23	Karim *et al.* (2012)	Strength of mortal and concrete as influenced by Rice Husk Ash (a review)	The outcome shows that the strength of the concrete at 20-30% replacement was increased as compared to OPC concrete.	Failed to investigate the effect of the elevated temperature in the mortal and concrete
24	Nehdi *et al.* (2003)	Effect of rice husk ash in concrete as partial replacement of cement in different proportion	Result shows that the addition of rice husk ash in concrete increases the concrete strength; brittle failure was observed in RHA concrete.	Failed to investigate the effect of elevated temperature in concrete with rice husk ash
25	Chatveera (2011)	The effect of rice husk ash as partial replacement to cement in concrete expose to HCL and H_2SO_4 in different proportion	It shows that the durability of the concrete attacked by HCL and H_2SO_4 replace 20% of OPC by RHA led positive effect in decreasing the corrosion of concrete	Effect of elevated temperature is not studied.

4.0 Conclusion

Concrete is one of the common construction materials in our country and is the feasible material that can be exposed to high temperature due to fire or near a furnace. Whereas exposure to high temperature can lead to damage of reinforce concrete structures despite not been a combustible material. The effect of elevated temperature may bring about physical, chemical and mechanical changes in concrete properties. The strength and durability of concrete depends upon its aggregate; the silicious aggregate afford high thermal conductivity and high expansion, high fire resistance; improve spalling resistance compared to the carbonate aggregate. The compressive strength of concrete decreases as temperature increases due to high dehydration of the calcium hydroxide in the binder as well as generating more water vapour thereby leading to strength reduction. Furthermore, loss of moisture reduces the weight as temperature increases. The addition of rice husk ash to concrete shows an increase in compressive strength of the concrete and decrease in water permeability of concrete under ambient condition, i.e. the durability of the concrete increase by replacement of 20% of the OPC by RHA which bring positive effects. Furthermore, the siliceous aggregate properties afford high thermal conductivity and improve elevated temperature resistance compared to the carbonate aggregate

However, there is a possible research gab in investigating the effect of elevated temperature on concrete with rice husk ash as partial replacement to cement, because most of the researchers have focused on conventional concrete, whereas concrete with rice husk ash as replacement to cement have been recommended for use of 10-20%. The degree of its performance of these recommended replacement needs to be investigated.

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