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COAL BOTTOM ASH AS SUBSTITUTE TO CONVENTIONAL BUILDING MATERIALS - A REVIEW

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ABSTRACT

The Coal Bottom ash is the by- product of the combustion of process of coal in furnaces in the production of electricity in thermal power plants. There is huge amount of bottom ash generated in India which is used in land fill only. The land filling leads the various type of pollutions for the environment. Composed of coarser and popcorn-like particles. FA has been extensively used in production of Pozzolanic Portland cement and in manufacturing of mortar or concrete as cement replacement. It is an established fact that the use of FA as supplementary cementing material in production of concrete improves its strength and durability properties. This study tried to find the exact methodology to use coal Bottom Ash effectively in the concrete. The various regress analysis done using from different literature study. This paper shows the root map of optimize use coal bottom ash usage in the concrete from the various researcher's aspects. Material testing methods and procedures involved in the regular concrete and coal bottom ash concrete from the researchers. Finally the review shown the clear idea about the optimizing procedure and usage coal bottom ash as an construction material.

Key words: Pozzalonic Properties, Coal Bottom Ash, Compressive strength, Flexural Strength, Material Testing, Construction Industry.

1. INTRODUCTION

In India, coal is used as a major source of power generation, in which bottom ash is the by- product of the combustion of process of coal in furnaces in the production of electricity in thermal power plants. The coal of India has high ash content (30-45%) which leads to the generation of a huge quantity of bottom ash per year, whereas some lignite coals may have an ash content as high as 30%. At present, nearly 150 million tons of coal ash is being generated annually in India, which requires a lot of land area for its disposal and is a major problem from an environmental point of view. Environmentally safe disposal of large quantities of bottom ash is not only tedious and expensive, but also own challenging problems in the form of land usage, capital loss to power plants, health hazards, ecological imbalances and related environmental problems. Thus, there is a dire need to establish strategies to use this industrial bi-product effectively and efficiently. Cachim et al. observed that because of increasing environmental concerns and sustainable issues, the utilization of solid waste materials is the need of the hour. However, it is only in geotechnical engineering applications, such as the construction of embankments/dykes, as back fill material, or as a sub-base material etc., that its large-scale utilization is possible either alone or with soil. On the other hand, the need for industrial wastes such as coal ash produced from power generating plants as a substitute for conventional construction material has increased due to the increased scarcity of stable soil deposits in recent years. The utilization of coal ash not only solves a waste disposal problem but also provides an economically viable construction material. Many other researchers concluded that bottom ash can successfully be used as agranular material to enhance the strength and durability of concrete and to use it as a pozzolanic material. Bottom ash can generally be classified as coarse grained, in terms of the grain size of soils; while bottom ash particles range in size from fine gravel to fine sand, with low percentages of silt clay-sized particles. Physically, bottom ash is typically grey to black in color, is quite angular, and has a porous surface structure (Fig. 1).

Pulverized coal combustion dry bottom ash is a type of coal combustion by-product of burning coal under controlled conditions for the generation of electricity. Bottom ash collected
Fig. 1.1 Bottom ash generated from a thermal power plant

under the furnace bottom is categorized as dry bottom or wet bottom ash. If the ash is in a solid state at the furnace bottom, it is called dry bottom ash, as shown in. Wet bottom ash refers to the molten state of the ash which leaves the furnace as a liquid. Wet bottom ash is more often called boiler slag. Bottom ash is collected at the bottom of the combustion chamber in a water-filled hopper and is removed by means of high-pressure water jets and conveyed by sluiceways to a decanting basin for dewatering, stockpiling, and possibly crushing. Although similar to natural fine aggregate, bottom ash is lighter and more brittle and has a greater resemblance to cement clinker. Coal is the dominating fuel source used in thermal power plants for generation of electricity. At the coal-fired thermal power plants, the raw coal is first pulverized to the shape of flour before it is force-fed to the furnace. During the pulverization process, the clay particles entrapped in the cracks of coal get separated from the coal. Then on combustion of coal in furnace, these clay particles and other noncombustible matter result in production of coal ash. The quantity of coal ash produced at coal-fired thermal power plants varies from 5% to 45% depending on the type and source of coal used as fuel in the furnace. The coal ash produced at coal-fired thermal power plants is classified into two types, i.e., fly ash (FA) and bottom ash. During burning of pulverized coal in the furnace, the finer and lighter particles of ash are carried away by the swirling flue gases. These ash particles are extracted from the flue gases in the electrostatic precipitators before entering into the air. The ash collected from the electrostatic precipitators is called FA. It constitutes about 80% of total coal ash. The coarser and heavier particles of ash settle down at the base of furnace. Also some ash particles accumulate on furnace walls and steam pipes. The clinkers so formed build up and when become too heavy, fall to the base of furnace. These clinkers are grounded to the form of fine aggregate before they are sluiced to the disposal site. The ash collected at the base of furnace is termed as coal bottom ash (CBA) and forms nearly 20% of total coal ash. CBA is generally.
Composed of coarser and popcorn-like particles. FA has been extensively used in production of Pozzolanic Portland cement and in manufacturing of mortar or concrete as cement replacement. It is an established fact that the use of FA as supplementary cementing material in production of concrete

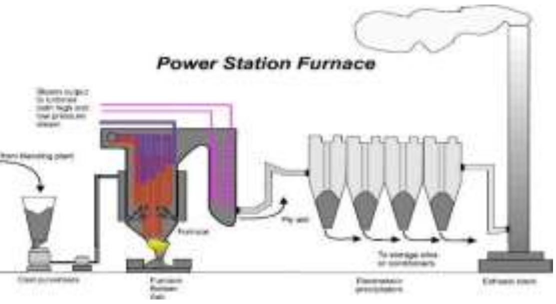

Fig. 1.2: Production of coal bottom ash

improves its strength and durability properties. Whereas, CBA contains coarser and more fused particles compared to FA, as such it shows less pozzolanic activity. Generally, CBA is considered as an inert material and unsuitable for use as supplementary cementing material. Since particle size distribution of CBA is similar to that of sand, it attracts to be used as replacement of sand in several civil engineering applications. CBA can be used in embankments construction, as structural fills, unbound or stabilized granular bases and subbases, as a foundation material, in noise barriers, as a capping layer on landfill sites, and as aggregate in asphalt and concrete.

1.1 Scope and Objective

The main aim of the research work was to determine the impact of coal bottom ash on concrete performance i.e. strength and durability. A variety of tests were performed to check whether small proportion of these materials can enhance the durability and strength properties of concrete. Study the effect of coal bottom ash as a partial replacement or total replacement of natural river sand on the fresh and harden properties of concrete. Improvement in strength of concrete mix due to partial replacement of sand. Achievement of sustainable developments. The aim of this current study is to model concrete mixtures partial replacing natural sand with coal bottom ash for M30 grades of concrete.The objectives of the current research are specified as follows: To do the pre-data analysis through various resources in researcher's aspects. To create the optimal and adoptable Concrete mix design for grades M30 by replacing various percentage of coal bottom ash. To assess the fresh and hardened concrete (Strength, Durability etc..) properties in partial replacement of natural sand by coal bottom ash. Interpretate and compare the overall results of concrete properties of coal bottom ash concrete over with normal concrete.

2. LITERATURE REVIEW

2.1 Construction of Road Base and Subbase

CBA can be used as a granular base material in road construction, if it meets specifications for granular base. Large size or agglomerated popcorn particles are removed from CBA by screening or washing to make it suitable for use as granular base material. Blending with conventional aggregate may also be required. According to published literature, granular base made with CBA having 1.5 times thickness of conventional aggregates achieves a comparable stress level in the underlying subgrade. However, according to study the thickness of CBA should be two times the thickness of conventional aggregates to maintain similar deflection at the surface of the base course layer. When CBA is used in construction of stabilized base, the cementitious materials bind the aggregates and provide bearing strength. In such applications moisture control and proper grading of CBA are maintained.

2.2 Structural fill

CBA has been used in construction of an embankment or as backfill material. For use in these applications, CBA must be free of pyrites and/or “popcorn” like particles and must be noncorrosive. Pyrites are volumetrically unstable and expansive when exposed to water over a long period, therefore pyrites must be removed from CBA prior to use. FA and CBA in combination has been used successfully in highway embankment projects. The collapse behavior of compacted fill decreased with increase in CBA content.

2.3 Asphaltic Concrete Aggregate

CBA is primarily used in cold mix asphalts since lightweight and porous particles present in it make less suitable for hot mix asphalts. Moreover, for use in cold mix application, CBA should be surface dry since moisture can affect the coating of its particles by the emulsified asphalt. However, the field and laboratory investigations indicate comparable performance of hot mix asphalt with up to 15% CBA to control mix. According to study, hot mix asphalt made with 15% CBA as replacement of aggregate displays desirable strength, low temperature, and rutting properties. The upper limit of CBA as aggregate in an asphalt pavement mix is 30%. The laboratory study reveals that CBA is a feasible material for use in hot mix asphalts. The field study also indicates that pavement constructed using asphalt concrete made with CBA as partial replacement of fine aggregate showed adequate performance.

2.4 Physical properties

The physical properties of CBA mainly depend on the properties of rock detritus present in the fissures of the coal seams. The variability in the rock detritus from one source to another therefore causes variation in the properties of CBA as well. The other factors which also influence the physical properties of CBA are degree of pulverization of coal, firing temperature in the furnace, and type of furnace. CBA is much coarser material than FA. The particles of CBA are generally angular, very irregular in shape with observable pores and have rough, gritty surface texture, and interlocking characteristics. It also contains popcorn-like particles which are crushable even under applied finger pressure. Moreover, it is usually a well-graded material. Particle size distribution of CBA ranges from 1 to 10 mm (Jayaranjan et al., 2014). The physical examination shows that particle size distribution of CBA is nearly comparable to that of sand. But it is a lighter, weak, and more brittle material than river sand. Usually 90% particles of CBA pass through 4.75-mm sieve, 10%_60% particles pass through 600-µm sieve and 0%_15% particles pass through 75-µm sieve. Specific gravity and fineness modulus of CBA varies from 1.2 to 2.47 and from 1.39 to 2.8 depending upon the source and quality of coal, respectively. The CBA with low specific gravity has a porous surface texture, a characteristic “popcorn particle” that can readily degrade under loading or compaction and contains low iron oxide content (Lovell et al. 1991). Whereas, CBA generated from burning of high sulfur and low-rank coals is not very porous and is quite dense (www.caer.uky.edu). Dry unit weight and water absorption of CBA varies from 7.07 to 15.72 kN/m3 and from 5% to 32%, respectively. Table 1.1 shows the wide variation in physical properties of CBA as reported in the published literature. CBA being highly porous material, it can absorb larger amount of mixing water in cement mortar and concrete. But, at the same time, it is not possible to assess the exact amount of water absorbed by CBA during mixing of ingredients of concrete or mortar. As such, correct water/cement ratio of concrete mix containing CBA as replacement of sand cannot be determined.

2.5 Chemical properties

CBA is mainly composed of silica, alumina, and iron with small amounts of calcium, magnesium, sulfate, etc. The chemical composition of CBA is generally governed by the source and quality of the coal burned. CBA generated from burning of lignite or subbituminous coals generally contains significant amounts of calcium and other alkaline elements. This type of ash has cementitious properties in addition to pozzolanic properties and when comes in contact with water, forms an alkaline solution. Whereas, CBA derived from anthracite or bituminous coals is often low in calcium content and high in iron content. The sum value of SiO2, Fe2O3, and Al2O3 component for this type of ash is nearly 90%. This type of ash has pozzolanic properties only and when comes in contact with water, forms acidic solutions. CBA having pH value from 6.5 to 7.5, 7.6 to 8.5, and above 8.5 can be classified as slightly alkaline, moderately alkaline, and highly alkaline, respectively. The basic CBA produces a strong initial alkaline reaction, while acidic CBA produces a strong initial acidic reaction. The chemical compositions of various CBAs are presented in Table 1.2. High loss of ignition in CBA makes it unsuitable for use in mortar and concrete. According to British codes, CBA having loss on ignition lower than 7% can be used in cement mortar and concrete (MTESRT, 2010).

2.6 Pozzolanic Properties

The pozzolanic activity of material is the ability to react with calcium hydroxide. According to the total quantity of calcium hydroxide with which pozzolanic material can combine depends on the nature and content of reactive phase in the pozzolan, SiO2 content of reactive phases, ratio of calcium hydroxide and pozzolan, and duration of curing. The rate of reaction of pozzolanic material with calcium hydroxide depends on the specific surface area of the pozzolan, water/solid ratio, and alkaline content in Portland cement and temperature. The pozzolanic materials are generally high in SiO2 and Al2O3 and low in CaO, with or no reactivity when immersed in water. The pozzolanic activity of material is evaluated by chemical, physical, and mechanical methods. In chemical method, according to International Organization of Standards (ISO) recommendations R 863-1968, pozzolanic material is suspended in saturated lime solution and reduction of calcium ions is measured. In mechanical method, as per European standard EN 450, the strength activity index which is the ratio of compressive strength of mortar bar prepared with 75% Ordinary Portland cement and 25% ash or pozzolanic material by mass, and that of mortar bar prepared with cement alone is determined. According to European standard EN 450, the ash is only allowed to be used as pozzolanic material in concrete if strength activity indexes are more than 0.75 at 28 days and 0.85 at 90 days. The experimental study shows that at 7, 14, 28, and 90 days, compressive strength of CBA mixture (50% CBA, 150% calcium hydroxide, water to solid ratio 50.42) was 1.8, 3.2, 6.4, and 17.3 MPa, and calcium hydroxide consumption was 5%, 15%, 37%, and 60%, respectively. At these ages, the strength activity index of CBA with Ordinary Portland cement was 0.72, 0.764, 0.88 and 0.97, respectively. According to this study pozzolanic activity of CBA starts after 14 days and the consumption of calcium hydroxide is significant after 90 days. Fig. 1.3 shows CBA particles are reacting with calcium hydroxide and are not yet disintegrated.

Fig 2.1 CBA particle starting to react with $Ca(OH)_2$

A. K. Mandal et.al., In this work researchers state that, the generation of Bottom Ash (BA) from thermal power plants which are being increased day by day and facing disposal and environmental problems. In spite of that, it is being used as landfills which has no commercial value, but now needs to think on its utilization as useable supplementary materials. The present paper deals with a critical review on BA as an adsorbent, light weight aggregate as well as partial replacement of fine aggregate in concrete. In addition, physical and chemical properties, transportation and disposal mechanism and environmental effects were also discussed by the scholars. Following conclusions drawn by researcher based on the data available from literature survey: In this paper researcher's discussed many properties of coal ashes which can be used with advantage in various geotechnical engineering applications. They have low specific gravity, lower compressibility, higher rate of consolidation, higher frictional strength, higher CBR, negligible swell-shrink potential, water insensitiveness of compaction characteristics and pozzolanic reactivity. The beneficial properties of coal ashes encourage their use as fill materials for low- lying areas as well as construction fill materials on weak compressible soils. Rheological behavior of BA in slurry form indicates that, due to the coarser in size, addition of BA in slurry increases the transportation efficiency. BA has been fruitfully employed for making the lightweight aggregate. The bulk density and 10 % fines value of BA aggregate was increased with an increasing in binder dosage, sintering temperature and time. It is possible to design SCC incorporating FA and BA on various percentages. The SCCs having FA and BA showed all fresh properties within the ranges specified for the mix to be SCC mix. Increase in BA content resulted in decrease in compressive strength and split tensile strength. Ertug Aydin, In this research work authors examines the potential use of coal bottom ash residue, obtained from a brick-producing factory, in cement pastes. The physical, mechanical, and sodium sulfate test results revealed the lightweight nature of the prepared composites, which were suitable for use in brick, tile, paving stone, and controlled low-strength applications. In this research work authors conclude the following points. Compared with the control cement paste (CBA0C100), the remaining composites, which consisted of CBA only or mixtures of CBA and cement or CBA, cement, and lime, had lower IST and FST values. The slump and flow of the composites decreased as the amount of CBA increased. CBA70C30 and CBA70C25L5 featured the highest UCS values among all composites studied. Following 28 days of curing, the UCS and FS

values of CBA70C25L5 increased by 19.36% and 24.85%, respectively, when compared with those of CBA70C30.
In summary, the current findings indicate that the incorporation of 70% CBA in a pure cement matrix is suitable for preparing alternative cement materials with high performance. Additionally, the addition of 5% lime was also demonstrated to have added benefits on the performance of the final composite material. Haldun Kurama et.al, Scholars worked to determine and evaluate the applicability of an industrial bottom ash (CBA), supplied from Tunc¸bilek Power Station-Turkey, in concrete industry. In the laboratory experiments, the bottom ash was used up to 25% as a partial substitute for the Portland cement. In concrete tests, although the compressive and flexural strengths of specimens cured at 56 days increase with increasing amount of ash replacement up to 15%, the maximum substitution rate of CBA was determined as 10%. When 10% of CBA is replaced by cement, the compressive strength of CBA-concrete increases from 42.65 N/mm2 to 45.1 N/mm2. This relatively lower substitution ratio compared to the common practice of fly ash usage, can be attributed to the different phase distributions and higher unburned carbon contents of CBA. Hongxu Zhou et.al, In this review work researchers critical reviewed a holistic picture of CBA, from the generation, fundamental characteristics, environmental concerns to potential applications, and benefits analysis. Based on the fundamental characteristics, CBA can be considered as a sustainable and renewable resource with great potential to produce value-added materials. High-value applications and current research related to CBA, including construction and ceramic industry, wastewater remediation, soil amelioration, energy catalysis, valuable metals recovery, and material synthesis, are systemically presented and compared. It emphasizes the environmental and economic benefits of the sustainable applications of CBA as well. Particularly, it indicates that CBA is a promising candidate in normal, lightweight, self-compacting, and ultra-high-performance concrete, which shows a reduction in both energy consumption and greenhouse gas emissions during concrete production. Their work provides new insights into the greener and sustainable applications of CBA, and it will offer a practical guide for the sustainable development of the coal industry. Coal bottom ash represents a typical type of coal combustion by product that can be recycled. They said that individual effort from various disciplines may prevent the formulation of clear CBA-reuse guidelines without a comprehensive study. The lack of sufficient investigation makes the CBA an underestimated resource in the environment. In view of the existing defects and deficiencies in the field, specific future research on CBA should focus on the following areas: SiO_2 is the main component of the CBA. The annual global market of silica is estimated at US$6.4 billion, with the leading share of consumption from Asia. Meanwhile, Asia is the largest coal consumption region in the world and generates an enormous amount of CBA. Extensive and in-depth performance investigations are required to develop high value-added CBA based concrete, such as lightweight aggregate concrete, no-fines concrete, ultra-high performance concrete, fiber reinforced concrete, insulation concrete, and acoustic absorbing concrete. These will expand the applications of CBA in the building and construction industries and stimulate the companies' long-term investment for commercial use. The utilization of CBA as a low-cost adsorbent in environmental remediation can deliver cost- effective remediation techniques and fulfil “green and sustainable remediation” principles since CBA has lower or even zero environmental risks compared to other solid wastes (e.g., fly ash and municipal solid waste incineration bottom ash). The management of out-of-date CBA from the landfills or surface impoundments should be encouraged. The local policymakers can launch recycling programs with incentives to reduce CBA stock and ease environmental pressure or co-process with other coal combustion products. Hussein Hamada et.al, In this review work authors studied application of CBA in various concrete types and to increase the understanding of the effect of the CBA on the properties of concrete. The properties explored were fresh, mechanical, durability and microstructural properties of concrete incorporating varying proportions of CBA. This paper reviewed the latest studies, which examined the performance of concrete when CBA was incorporated as fine aggregate at different replacement levels. The performance of concrete containing CBA at various curing ages has been described based on the results of previous studies. These following conclusions were drawn based on the results of previous studies about the CBA- incorporated concrete and its effect on the behavior of concrete. Normal concrete, which contains CBA as fine aggregate, achieved accepted workability compared with the control concrete. A general decreasing pattern in the slump values ↱carried out in concrete has been observed compared with the control. The compressive strength of concrete has been decreased due to the incorporation of a high quantity of CBA as fine aggregate. Moreover, in some cases, a slight improvement in compressive strength was achieved for a less quantity of CBA as fine aggregate replacement. The utilization of cement additives has assisted in increasing the compressive strength at 28 curing days. The compressive strength has been considerably affected by increasing CBA content in the concrete mix. A decrease in the tensile strength of concrete containing CBA as fine aggregate was observed in most cases. The tensile strength has been reduced up to 30% due to the incorporation of CBA as fine aggregate in the concrete mix. The flexural strength of concrete containing CBA as fine aggregate has been enhanced for lower replacement levels of CBA. The use of some cement additives assisted in improving the flexural strength values at different curing ages. The flexural strength has been decreased considerably due to the use of CBA instead of the normal fine aggregate by 25% compared to normal concrete without CBA. Isa Yukse et.al, Researchers investigated in this study that, how the usage of bottom ash (BA), granulated blast furnace slag (GBFS), and combination of both of these materials as fine aggregate in concrete affects the concrete durability. Three series concrete were produced. GBFS, BA and GBFS+BA are replaced the 3–7 mm-sized aggregate. Five test groups were constituted with the replacement percentages as 10%, 20%, 30%, 40% and 50% in each series. These by-products were used as non-ground form in the concrete. In the result researchers conclude that, high-temperature affects the concrete types which contain GBFS or/and BA fine aggregate replacement like reference concrete even if for the 50% replacement. Amount of surface cracks also decrease when these by products are used. They further state that, to replace GBFS and BA with fine aggregate in concrete exposing high temperature. Compressive strength loss due to freezing–thawing effect decreases for low replacement ratio (10–30%). Therefore, durability against freeze–thaw cycles increases for these replacement levels. Compressive strength loss starts to increase after this level that is reference concrete for the maximum level of replacement (50%). Therefore, GBFS or BA replaced

concretes have better durability than reference concrete. A 20% replacement level is ideal level for the best performance. All concrete types, which by-products are used as fine aggregate single or mutual, are durable against abrasion. BA, used as fine aggregate, increases the degree of porosity of concrete. GBFS also increases porosity but this increment occurs less than BA. For normal concretes, 20% replacement is an optimum ratio with regard to the test results obtained in this study. L.B. Andrade et.al1, Scholars worked on the incorporation of coal bottom ash from thermoelectric power stations as a substitute material for natural sand in the production of concrete. For the composition of the concrete mix proportions, two different dosage schemes were carried out in order to test the influence of the natural water content in the bottom ash at the time of concrete production: one considering the natural water content, without discounting the water – CRT3; and the other discounting the natural water content, considering all (bottom ash + natural moisture) as solid material, with the aim of obtaining the same compressive strength in relation to the reference sample – CRT4. The different types of concrete were produced with the substitution of natural sand in the following percentages: 0%, 25%, 50%, 75% and 100%. Researchers conclude that from this research: The concrete type influenced the results obtained for compressive strength. The bottom ash concrete of type 3 gave satisfactory results with mixtures containing a maximum of 50%. On the other hand, the mixtures of type 4, regardless of the amount of bottom ash, resulted in concrete with a greater strength than the reference mix. Regarding the strain, the lowest compressive strength gave more dispersed results, regardless of age. L.B. Andrade et.al, In this research work scholars investigates the influence of the use of coal bottom ash as a replacement for natural fine aggregates on the properties of concrete in the fresh state. Tests for water loss through bleeding, and the determination of the setting times and plastic shrinkage, were carried out in order to evaluate the material in the presence of bottom ash. The concrete mixes were prepared according to two forms of bottom ash addition: (a) equivalent volume replacement, correcting bottom ash quantities according to the moisture content – CRT3; (b) non-equivalent volume replacement, without replacement of bottom ash according to the moisture content of the aggregate – CRT4.

According to the study by researchers following conclusions was drawn: The high porosity of the bottom ash means that the w/c ratio of the concrete cannot be taken as exact. The water absorbed internally by the bottom ash is released to the concrete over time. The presence of bottom ash increased the quantity of water loss by bleeding. Delays in the initial and final setting time in relation to the reference concrete were observed for the CRT3 type concretes due to the higher quantity of bottom ash and lower quantity of cement. The results for the plastic shrinkage test confirmed the influence of the high water content in the CRT3 concretes and of the increase in the consumption of the CRT4 cement. Mahdi Rafieizonooz et.al, Researchers major aim of this study was to investigate use of coal bottom ash and fly ash in concrete to replace sand with bottom ash waste and cement with fly ash. Concrete specimens were prepared incorporating 0, 20, 50, 75 and 100% of bottom ash replacing sand and 20% of coal fly ash by mass, as a substitute for Ordinary Portland cement. Fresh and hardened state properties of the experimental specimens were determined. After the experimental research work concluded by following: CBA shows low-density, high-water absorption, irregular and spherical shaped and complicated texture. On the other hand, due to suitable particle size distribution of CBA it can be concluded that it is possible to utilize CBA as a fine aggregate substitute for natural sand. The workability of fly ash-bottom ash concrete was reduced due to the utilization of CBA as total or partial substitute of fine aggregate in concrete. The phenomenon of compressive strength development of fly ash-bottom ash concrete with curing period was almost similar to that of control concrete. At curing age of 7 d there was considerable reduction in compressive strength in all fly ash bottom ash concrete mixtures compared with that of control concrete. With progress in curing period, considerable increase in compressive strength of fly ash-bottom ash concrete mixtures was noticed. It can be concluded with some certainty that notable increase in compressive strength of fly ash-bottom ash concrete mixtures after 28 d curing period, was because of pozzolanic activity of CBA and CFA. Increase in curing age resulted in flexural strength of fly ash bottom ash mixes to rise at a higher rate than of control concrete. Flexural strength of these mixtures got better at 91 d maturing and 180 d on use of CBA as partial or total replacement of fine aggregate. At the age of 180 d mixtures of FBC3 and FBC4 achieved 5.51% and 3.05% higher flexural strength as compared to the control concrete respectively. The same trend of flexural strength was observed for the splitting tensile durability of the experimental mixtures in all curing ages.Concrete mixtures incorporating CBA as fine aggregate for partial or total replacement of natural sand, displayed better dimensional stability. Malkit Singh et.al, The objective of researchers to explore the possibility of utilization of coal bottom ash as partial replacement of fine aggregate (sand) in concrete. Experimental tests were performed to evaluate the properties of fresh and hardened concrete containing coal bottom ash. The properties such as unit weight, compressive strength, and splitting tensile strength, modulus of elasticity and microstructure of concrete incorporating coal bottom ash in partial or full replacement of river sand were examined and compared with those of conventional concrete. They state that in there concluding remark results indicate that coal bottom ash was a suitable material to be used as fine aggregate either in partial or full replacement of river sand in production of structural concrete of grade between M20 and M30. Based on the analysis of test results and discussion following concluding remarks was drawn. The workability of bottom ash concrete decreased on use of coal bottom ash in partial or full replacement of river sand in concrete. With the use of coal bottom ash in concrete, water loss from bleeding decreased at all the replacement levels. At the early age, compressive strength reduced marginally on the inclusion of coal bottom ash in concrete. However, 28 days compressive strength of concrete was not found to be significantly affected by replacing river sand with coal bottom ash. After 28 days of curing age, compressive strength of bottom ash concrete mixtures improved and surpassed the compressive strength of the control concrete mixture. Splitting tensile strength of concrete improved at all the curing ages on use of coal bottom ash as fine aggregate in partial or full replacement of river sand. At early curing age of 7 days, splitting tensile strength and compressive strength ratio increased with the increase in levels of sand replacement with coal bottom ash in concrete. Modulus of elasticity of concrete mixture containing coal bottom ash as fine aggregate in partial or full replacement of river sand was lower than that of control concrete. Malkit Singh et.al, In this research work, scholars explore the possibility of coal bottom ash use as sand replacement in concrete manufacturing. Two types of control concrete mixtures to develop 28 d compressive strength of 38 MPa designated as concrete 'A' and 34 MPa designated as concrete 'B' were made with river sands having different fineness of modulus. In both grades of concrete mixtures, sand was replaced with coal bottom ash at 20, 30, 40, 50, 75 and 100% levels. From the study conducted by researchers following conclusions were drawn: Considering workability and strength properties, authors recommend that use of coal bottom ash up to 30% without superplasticizer and up to 50% with superplasticizer in structural concrete. At fixed water cement ratio, the workability and bleeding of concrete decreased on incorporation of coal bottom ash as replacement of both types of river sands. 28 d compressive strength of bottom ash concretes was comparable, For higher than 50% additions of coal bottom ash in concrete 'B', 28 d compressive strength decreased significantly. Bottom ash concrete mixtures of concrete 'A' displayed higher 28 d splitting tensile strength than that of control concrete mixture. Splitting tensile strength of bottom ash concrete mixtures of concrete 'B' incorporating up to 50% coal bottom ash as replacement of sand was comparable to that of control concrete mixture at all ages. After 90 d of curing age, bottom ash concrete mixtures of concrete 'B' containing 75 and 100% coal bottom ash achieved splitting tensile strength almost equal to that of control concrete mixture. Bottom ash concrete mixtures of concrete 'A' displayed lower modulus of elasticity as compared to control concrete mixture. Navdeep Singh, et.al, In the present investigation researchers on reviewing some of the fresh, mechanical and durability properties of Normally Vibrated Concrete (NVC) and Self-Compacting Concrete (SCC) made with incorporation of CBA as replacement of fine aggregates. The utilization of Coal Bottom Ash (CBA) in concrete industry is one of the best feasible options to minimize the environmental concerns raised due to its presence. Coal bottom ash has a potential to be used as concrete material in place of fine aggregates. Following conclusions were drawn by the researchers from the observed behavior of NVC and SCC with incorporation of CBA: The concretes (NVC and SCC) made with incorporation of CBA in place of fine aggregates satisfies the required workability conditions in accordance with relevant standards/guidelines. Compressive strength of NVC and SCC has been reduced with incorporation of higher content of CBA. However, a small increase has been found for lower replacement of fine aggregates with CBA in some of the cases. The tensile strength has been decreased up to 30% replacement of fine aggregates with CBA for SCC at 28 days of curing. Also, the tensile strength for NVC has been enhanced up to 20% replacement of fine aggregates with CBA across all curing ages. The flexural strength has been improved for lower replacement levels of CBA in place of fine aggregates in NVC and SCC whereas the same has not been true for higher CBA contents. The maximum reduction in flexural strength has been restricted to 25% at curing period of 28 days compared to control NVC and SCC respectively. Normally vibrated concrete made with lower replacements of fine aggregates with CBA (up to 10%), the capillary water absorption has been reduced and further addition of CBA has increased the same. Nitin Ankur et.al, Researchers carried out the investigations on fresh, mechanical, and durability properties of the mortar and concrete mixes with CBA as a replacement of fine aggregates and cement. Most of the investigations carried out on the use of CBA encourage the idea of utilizing it as a green material in the manufacturing of mortar and concrete. Following conclusions were drawn by the researchers from their study. CBA particles have more water absorption than the natural river sand that leads to higher water demand. At a lower percentage of the CBA as NFA replacement (up to 10%), the compressive strength of the concrete mixes increases or is almost comparable to the control mixes without CBA. However, at higher replacement levels, the compressive strength has decreased. CBA on using as a PC replacement at lower replacement levels reduces the compressive strength and flexural strength during the initial curing ages. However, with the increase in the age of the concrete, the mixes attained higher strength than their respective control mixes. Durability performance of the CBA blended mortar and concrete where CBA is used as PC replacement is encouraging up to a certain replacement level (10%). Rajib Kumar Majhi et.al, Researchers state that in this work, utilization of coal waste materials in concrete is an eco- friendly choice. Researchers objective of the experimental investigation was to explore the effects of fly ash and bottom ash on the properties of concrete by replacing them partially with natural fine aggregate and cement, respectively, on an individual basis as well as on combined basis. Concrete specimens were prepared by replacing 0%, 20%, 30%, 40% and 50% of sand by coal bottom ash and 0%, 20%, 30%, 40% and 50% cement by coal fly ash. From the experimental investigations, researchers conclude that, CBA possesses low density and high-water absorption capacity. The compressive strength of concrete decreases at all ages due to addition of CFA or CBA or both CFA and CBA. Split tensile and flexural strength also reduce with the increase in CFA or CBA or both contents. The addition of superplasticizer to the concrete mix with 20% CFA and 30% CBA further enhances the compressive, split tensile and flexural strength. Density of concrete decreases with the increase in the content of CFA or CBA or both CFA and CBA. Sajedeh Sadat Ghazizadeh Hashemi et.al,Coal Bottom Ash (CBA) is one of the widely-produced residues of coal incineration in thermal power plants. The annual extraction of such a huge amount of waste needs a massive transfer field, which constitutes a threat to the environment. However, the utilization of such residue as a fine aggregate in concrete can be an environmentally-friendly opportunity. Hence, the main purpose of this paper is to evaluate the microstructure and mechanical properties of the usage of BA as a fine aggregate replacement in mortar mixtures. It is observed that BA has a reactive fraction with pozzolanic characteristics. This provides stronger mortar when a medium volume of the material (up to 40%) is substituted. In addition, the CBA based mixture can be classified as lightweight concrete. The compressive strength value of the specimen using 40% CBA at 56 days was 55 MPa, which reached the same strength limit of control mortar mixture. In this research, the feasibility of utilizing BA as fine aggregate with different water-cement ratios for different percentages of silica sand replacement in mortar mixture was evaluated using microstructural analysis and investigation of the mechanical properties. The results show that there is a reactive fraction in BA with pozzolanic characteristics. As a result, the compressive strength of the Portland cement based mortar improves when the silica sand replacement with BA is limited to below 40% of the total fine aggregate. However, a high-volume BA replacement has a contrary outcome on the compressive strength of the final matrix. This reduction is attributed to the porous structure of BA, which causes absorption of the mixing water as well as an increase in the total pore volume of the mortar. However, 100% BA can be used as lightweight concrete. Moreover, incorporation of superplasticizer enhances the mechanical properties of the BA mortar mixture where water to cement ratio is above 0.3, while it is inefficient where the water of the system is scarce.

3. Conclusion

This paper review concludes that the coal bottom ash can be utilized as fine aggregate in concrete, which reduces the environmental impact, scarcity of natural sand and cost of construction. In this research work, the effect of coal bottom ash as partial replacement of sand on properties of fresh concrete, strength properties of concrete has been studied. The properties of concrete studied include workability, compressive strength, splitting tensile strength. Test results indicate that coal bottom ash is a suitable material to be used as fine aggregates in partial replacement of river sand in production of concrete.

More the replacement of sand with coal bottom ash in concrete, greater was the effect. For compressive strength compare with control mix, As compressive strength, Split tensile strength, Flexural Strength, Workability and other properties increases when natural sand replaced by coal bottom ash. Then after again increases in replacement compressive strength lowers compared with its maximum replacement. Beyond that proportion, there is no improvement in the strength achievement. The sustainable utilization of bottom ash improves production efficiency, reduces production costs and waste product disposal problems.

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