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A Study on Fresh and Hardened Properties of Concrete with Partial Replacement of Bottom Ash as a Fine Aggregate

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Abstract. To overcome the shortage of natural resources for the production of concrete, many waste materials are used to replace the raw materials of concrete. In this way, bottom ash is one of the major industrial wastes which shall be used as the replacement of materials in concrete production. It shall be used to replace the materials either up to one-third. This review brings out the evaluation of the industrial waste material which can be repeatedly used as a substitution for concrete as fine aggregate. This paper reviewed the use of industrial waste i.e., bottom ash as fine aggregate in the concrete. The parameters discussed were physical, chemical, fresh, and hardened properties of the concrete with partial replacement of bottom ash. By reviewing some of the research papers, concluded that 10-15% replacement of fine aggregates is acceptable for all the properties of concrete. High utilization of natural sources -gives the pathway to produce more industrial wastes which are responsible for the development of new sustainable development.

1. Introduction

The concrete production has a large amount of negative thoughts in the field of environment and globe .Concrete is one of the most used and widely manufactured material in the world. Concrete mainly derieved from fine aggregate, cement and sand [1]. Out of these material cement is the major part of concrete which acts as a unaltered material in the field of construction .Concrete is produced by burning of natural materials like fly ash and slag of industrial by products ,limestone and clay [2].Concrete is one of the major production material in the world due to its cost effectiveness ,long term performance and easy application [3].Concrete is mainly used in the construction of parking garges ,offshore structures railway bridges in large numbers. The reinforcement of concrete structures, in particularly in bridges is one of the key to face difficulties during their service time in front of multinational structural engineers [4] .Such concrete structures as consequence due to ineffective loads and decay corrosion .In addition most of the concrete structures were constructed during the year of 1950s and 1960s which is incompatible with current requirements[5] .In concrete structures the increased in fatigue is normally subjected to millions of repetitive axle load cycles during their passive traffic during their life time that can collapse during low load limits.[6]..The main exposure of the concrete structures is fire poses. The properties of concrete includes durability ,mechanical and physical is the major effect of fire production in concrete. The mechanical characteristics of concrete are most significant during the

fire exposure. The endurance quality of concrete cannot be determined in any situation. The investigation of concrete has been founded that the properties of concrete affect the fire properties of concrete which include additives, industrial wastes, and types of aggregate[7]. The longiviety of concrete is not only for the structures to perform well but also for the mechanical requirements. concrete can be able to avoid more damage to structures and also withstand durability is often gives importance from the engineers. Concrete is a mixture of aggregate, cement and the water. Concrete can be able to withstand equal distribution to reduce the risk of separation of compatibility and the workability as per the building codes and the standards the concrete can be able to withstand heavy loads sufficiently. To attain the strength of concrete curing of 28 days is required. Concrete can be able to produced all degradation process which produced as a result of constituent materials[8].To reduce the disadvantages of concrete nonmetallic reinforcement become feasible which acts substitute for the conventional concrete reinforcement[9].To maintain stable growth and safe functional environment concrete plays an important role in the field of civil engineering.[10].In order to stabilize the stability of concrete to maintain the aim of concrete waste. The main aim of the concrete is to examine the flexural properties of concrete waste[11].

The bottom ash can be obtained from the cold-fired plants that can be used as a by- product. During the ignition process the ash is softened as a result the large particles is produced and the displacement in water vessel beneath the surface of the material these large particle obtained is bottom ash.[12].The generation of industrial waste is produced tons of bottom ash in millions. The control technique for municipal and the industrial solid waste is commonly done by using energy recovery with the incineration process. In swedoon the bottom ash gives rise to the production of just about one million tone wastes burned annually. In Switzerland and Norway the production of bottom ash is just about 18 million ton annually[13]. In similar the bottom ash can be used fpr many construction purpose after treatment. In general the treatment process involves dividing the metal pieces which goes along with the natural weathering(ageing) to produce the bottom ash more secure to filter metal by means of sparkle.[14].Bottom ash gives up the possibility of burning up of heavy metals hence suitable pre-processing before it can be applied landfilled or it can be used as a supporting raw material. Although the direct reuse of bottom ash is not achievable and it is durable and maintain the stable cost and economic benefits from using alternative material for bottom ash. The building construction produces an outstanding results for utilization of exactly treated as bottom ash[15]. Depending upon the preparation of the aggregates can be used in the form of bottom ash in the bottom of bottom of the road and in the production concrete is replaced by the natural aggregates because of pozzolanic characteristics[16]. To find the quality of bottom ash we have to concentrated on two mix design foremost one is W/c ratio and second important is stable slump value. It has been observed the exact compressive strength, drying shrinkage, and wc ratio bottom ash is increased with decreases when it mixed with concrete. In other hand in constant slump there is an equivalent amount of compressive strength mixes with concrete. The drying shrinkage enlarge when the increased natural sand is replaced by bottom ash with 30%[5].The bottom ash concrete reveals good dimensional concrete, better water resistance to sulphuric acid and chloride particles with the comparision of traditional concrete[17].[18] observed when the high strength of concrete with chloride content is replaced by fine bottom ash with fine aggregate finally the outcome shows the chloride diffusion is reduced in the presence of high concrete strength in the bottom).

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Figure:1.Bottom Ash

2. Properties of concrete:

In major the properties of concrete can be classified into two major parts they are

Fresh concrete
Hardened concrete

2.1 Properties of fresh concrete

Workability

In fresh concrete the workability is complex property which involve the various needs of strength portability, cooperative, finishability and the placeability. The best method to find suitable workability or consistency of concrete is slump cone test. The appearance of excellent waste of bottom ash in concrete gives rise to grow up the demand of concrete when contrast with standard sand particles. To maintain the standard values of workability in slump cone test the water content was slowely increased when the replacement of sand is increased with waste factory and bottom ash which gives an clear explanation about the demand of water[19].

Density

The thickness of the concrete is reduced with the enlargement of low content due to the presence of bottom ash in the relative density of bottom ash. The analysis shows due to the low content of specific gravity in bottom ash the density of concrete is less. The thickness of the concrete is reduced in hardened state with gradual increase in the bottom ash [20].

2.2 Properties of hardened concrete

The concrete has various properties among them strength are the most important properties. To find strength some of the test are discussed

Compressive strength
Split tensile test
Flexural strength test

Compressive strength test

The compressive strength is decreased when the concrete is mixed with the involvement of bottom ash as the substitution of particular sand. The mixture with restore fine aggregates has little difference when compared to the mix with age of 365 days[21]. The strength variation is observed due to the formation of same properties of bottom ash[22].The development of concrete strength is increased when we added bottom ash. During the 7 days of curing the bottom ash has gained its strength as 5% and 20% which is greater than the control specimen at the level of 10% and 15% correspondingly this is due to the action of pozzolanic reaction of the bottom ash. Due to the

substitution of bottom ash the porosity of concrete is increased. Due to the presence of silica jel in the bottom ash the C-S-H is produced the strength is increased due to the presence of jel[23].

Split Tensile Test

When the sand is replaced with bottom ash in split tensile test has less strength when compared to control concrete specimen in all the ages. Bottom ash produces split tensile strength approximately ranges from 121-126% at 90 days of the normal concrete at 28 days.[24].The substitution of bottom ash in concrete the strength is increased at 7 days and 28 days is the most perfect one.The workability of concrte is reduced when the bottom ash is added as a fine aggregate[25].In 7,and 28 days the split tensile test is increased for 10% to 30% replacement in remaining substitution the split tensile test was decreased[26].In 7 days the split tensile test was increase at the ratio of 0.7%,5.70% and 12.16% for 10,20 and 30% of substitution. For the substitution of 50% there is a dropping of 15.20% at the curing of 7 days. During the replacement of 20 and 30% the strength of the split tensile test in increased in 28 days of curing[27].

Flexural Strength Test

The difference in the strength between bottom ash and normal concrete become less clear after 28 days. The substitution of fine aggregates in the flexural strength the concrete is proceed to extend with all the ages of bottom ash .The adding of 30 % of bottom ash with concrete and sand the strength of the flexural properties is high. It is observed that the flexural strength of concrete is about linearly decreased when the substitution level of bottom ash is increased[20].

3. Physical characteristics of commercial waste as fine aggregate

Physical characteristics of construction waste includes particle size distribution, thickness specific gravity absorption and fine substances helps to realize its ability and the workability when the concrete is replaced by fine aggregate.

Some of the physical charecteristics are:

Specific Gravity
Water Absorption
Bulk Density
Shape and Appearance
Particle Size Distribution

3.1 Specific gravity

Different investigators have been observed that the specific gravity of some of the industrial waste substances are discussed below. The bottom ash has the SG lies between 1.39 and 2.33[35] when compared to the specific gravity is in between 1.93,1.39 and 1.87[36].The specific gravity of unused manufactured sand was investigated to be 2.18.It has been clearly investigates that the specific gravity of waste manufacturing sand ranges from 2.39-2.79.[37]The specific gravity of steel slag is 3.15[38].

3.2 Water absorption:

It is studied that the absorption of water in BA is 5.4% and 6.1 % respectively[42].The water absorption present in the waste manufacturing sand is1.2%.[29]The absorption of water in copper slag is 0.17%[43].The absorption of water in GGBS was found to be 10.0%[15].The presence of water content in steel salg is 0.80%[13]

3.3 Bulk density

The bulk density of bottom ash is 660 kg/ m3[28] when it is differentiated to the loose density of BA is 620 kg/m3[31].The compacted bulk density of manufacturing sand is 1890 Kg/m3[39] while the loose density of the manufacturing sand is 1690 Kg/m3.[37].The density of copper slag

varies from 1900 kg/m3 to 2150 kg/m.[40]. The unit weight of copper slag is 2395 Kg/m3 and the packing thickness of copper slag is 1475 kg/m3[41]

3.4 Shape and appearance

Bottom ash have the rough quality and sharp, uneven and porous material it is well placed sand – sized material. The bottom ash has black to grey colour .The liquid content of the bottom ash ranged from 70 to 80 % of the ash in the presence of dry weight[28].Generally manufacturing sub-rakish sand in the form of spherical in shape. Foundry sand are grey or dark while chemical manufacturing sand are grey in colour[29] . IFS slag is dark in Colour, it is granular and vitreous and it carry toxic metal[30].The copper slag is powdered and dark in nature, shiny particles .The particle size distribution is same as normal sand[31].

3.5 Particle size distribution

The distribution of grain size in bottom size is replaced with 55% material then it ranges in between 1.12 and 0.16 [32]. The particle size distribution of copper slag is just about 75% particles ranges in between 0.3 and 1.18 [33].Particle size distribution is similar in foundry sand is ranges from 85-95% of the material lies between 0.6mm to 0.15mm and greater or smaller than 5-20% of manufacturing sand is lesser than 0.75mm[34].

4.Chemical characteristics of bottom ash as a fine aggregate

The chemical characteristics of bottom ash is identified based upon the process of burning and the types of coal used. The BA is generally composed of aluminium ,iron and silica dueto the presence of small amount of Sulphate, magnesium and calcium.[35].

5.Behaviour of bottom ash

Bottom ash is produced by the incineration process of municipal solid waste management it includes combustible ash, unburned carbon and the noncombustible inorganics based on the characteristics of waste and the classification of incinerators. In common the bottom ash is produced with the mixture of boiler ash is treated with slag. After the completion of incineration process the bottom ash is produced through the furnace bottom and it need to be water-cooled before it produced.[44].

6.Conclusion

Utilization of various industrial waste as fine aggregate replacement was discussed. All the concrete characteristics like hard and freshened, physical were explained and compared among them. The large amount of industrial wastes are used as a partial replacement of fine aggregate like bottom ash, steel slag, copper slag, waste foundry and fly ash.

Physical properties like shape and appearance, particle size distribution ,specific gravity, water absorption all the industrial wastes are nearly to the characteristics of sand excluding particle size distribution of manufacturing sand.

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