USE OF BOTTOM ASH AS FINE AGGREGATE IN CONCRETE: A REVIEW

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ABSTRACT

This work deals with the Bottom ash as a replacement of fine aggregates in concrete and the investigation on the use of bottom ash has been very limited. It gives an overview of the various literature and experimental investigations been carried out by many researchers to study the use of bottom ash as aggregates in concrete. Effect of bottom ash on the properties of concrete such as workability, compressive strength, flexural strength, are discussed elaborately. Bottom ash use in concrete is becoming more important in view of the fact that sources of natural sand as fine aggregates are getting depleting gradually, and it is of most significance that substitute of sand must be examined.

Key words: *Bottom ash, Compressive strength, Flexural strength, Splitting tensile strength, Workability.*

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1. Introduction

Concrete is a complex mix of diversified materials consisting of cement, fine aggregate (FA), coarse aggregate (CA) and water (admixtures, if any) which has emerged as a preeminent construction material for the infrastructural and building needs. Concrete is the most widely used building material in the world and is a material synonymous with strength and longevity. Concrete has moderately high compressive strength, but relatively lower tensile strength, and as such is usually reinforced with materials that are strong in tension (often steel). The density of concrete varies, but is around 2,400 kg/m^3. The elasticity of concrete is constant at low stress levels but starts decreasing at higher stress levels as the matrix cracking develop. Also, Concrete has a very low coefficient of thermal expansion and is subjected to long-duration forces prone to creep. Tests can be made to ensure the properties of concrete correspond to specifications for the application (Shetty, 2013; Kadam and Patil, 2013).

Waste material has gained attention among researchers as a replacement to natural aggregate or cement in concrete making so as to enhance the properties, reduce the wastage and its disposal keeping in view the economical benefits. The impression of using waste materials in concrete is not only in terms of economic factor but the more significant aspect is to protect the environment as more solid wastes are produced day by day. Durability of concrete has been of great interest in research field as the durability problem is largely affecting concrete for a long term performance. Repair work due to weakening of concrete also imposed considerable expense and economic impact and has been a subject of prime concern. To be durable, the concrete mass must have high resistance to access of external damaging agent which would consequently lead to the deterioration of the hardened mass. To have resistance to deterioration, the durability of the concrete should be of primary design concern along with strength design criteria.

One of the wastes that can be used in concrete is bottom ash. It is expected that bottom ash can be used as fine aggregate replacement in making concrete when natural sand is expensive to long carrying distance and has high clay content. Utilization of bottom ash as fine aggregate should be studied to alleviate the environmental problem. Bottom ash is collected at the end of the grate in a Waste-to-Energy plant consists of non-combustible materials, and is the residual part from the incineration of household and similar waste. There can be various forms of bottom ash such as raw bottom ash, coal bottom ash, boiler slag, etc. Raw bottom ash is a granular material that consists of a mixture of inert materials (sand, stone, glass, porcelain, metals, and ash from burnt materials). Coal bottom ash and boiler slag are the coarse, granular, incombustible by-products that are collected from the bottom of furnaces that burn coal for the Generation of steam, the production of electric power or both.

The chemical composition of bottom ash is moreover similar to the fly ash but typically contains greater quantity of carbon. Bottom ash exhibits high shear strength and low compressibility which can be seen through the literatures referred (Aggarwal et. al, 2007; Kumar et. al, 2014). These engineering properties make bottom ash an ideal material in design construction of dam and for other civil engineering applications.

2. Various Properties of Bottom Ash

Information regarding the physical, chemical, and engineering properties of coal combustion residues (bottom ash) is required before these materials can be safely and effectively utilized. The physical and engineering properties, in particular, are important parameters affecting the behavior of coal combustion residues in various engineering applications and the chemical composition is important for addressing the potential environmental impacts associated with coal combustion residues utilization and disposal. Most of the researchers have accentuated that bottom ash has quite alterable physical, chemical, and engineering characteristics (Aggarwal et. al, 2007; Abdus Salaam Cadersa et. al, 2014; Kumar et. al, 2014).

The properties of bottom ash are not only varying from one plant to another, but also from day to day production within a single plant over time. Therefore, these characteristics reported by researchers just can be taken as references and not absolutes. Power plant's operating parameters play an important role in the validation on the characteristics of bottom ash from a given source.

A- Physical Properties

Bottom ashes have angular particles with a very porous surface texture. Bottom ash particles range in size from a fine gravel to a fine sand with very low percentages of silt-clay sized particles. The ash is usually a well graded material, although variations in particle size distribution may be encountered in ash samples taken from the same power plant at different times. Bottom ash is predominantly sand-sized, usually with 50 to 90% passing a 4.75 mm (No. 4) sieve, 10 to 60% passing a 0.42 mm (No. 40) sieve, 0 to 10% passing a 0.075 mm (No. 200) sieve, and a top size usually ranging from 19 mm (3/4 in) to 38.1 mm (1-1/2 in). Table 1 gives the physical properties of bottom ash.

B- Chemical Properties

Bottom ash and boiler slag are made essentially out of silica, alumina, and iron, with smaller percentages of calcium, magnesium, sulfates, and other compounds. The composition of the above particles is controlled principally by the source of the coal and not by the type of furnace. Bottom ash or boiler slag derived from lignite or sub-bituminous coals have a higher percentage of calcium than that from anthracite or bituminous coals. Due to the salt content and, in some cases, the low pH of bottom ash and boiler slag, these materials could display corrosive properties.

When bottom ash or boiler slag is used in an embankment, backfill, sub-base, or even possibly in a base course, the potential for corrosion of metal structures that may come in contact with the material is of high concern and should be investigated prior to use so that it does not pose any problem (Table 2).

Table 1: Physical Properties of Bottom ash

S.No.	Properties of bottom ash	Values
1	Specific gravity	2.12
2	Bulk density (gm/cc)	0.642-0.747
3	Fineness modulus	6.28
4	Maximum dry density (kN/m^3)	7.20
5	Water absorption (%)	14.10
6	Sizes produced (mm)	3.40 -4.75
7	Aggregate impact value (%)	18.25
8	Aggregate crushing strength (%)	19.30
9	Aggregate abrasion value (%)	30.12

Table 2: Chemical Characteristics of Bottom ash

Constituents	Percentage by weight
SiO_2	68.00
Al_2O_3	25.00
$Fe_2O_3 + Fe_3O_4$	2.18
TiO_2	1.45
CaO	1.66
MgO	0.02
SO_4^{2-}	Nil
Loss on ignition	1.69

3. Literature Review

Bottom ash is a by-product of burning coal at thermal power plants. Bottom ash particles are much coarser than the fly ash. It is a coarse, angular material of porous surface texture predominantly sand-sized. This material is composed of silica, alumina, and iron with small amounts of calcium, magnesium, and sulfate Grain size typically ranges from fine sand to gravel in size. Concrete has a very low coefficient of thermal expansion and as it matures concrete shrinks. All concrete structures will crack to some extent, due to shrinkage and tension. Concrete which is subjected to long-duration forces is prone to creep. Tests can be made to ensure the properties of concrete correspond to specifications for the application. The density of concrete varies from experimental conditions point of view, but is generally around 2,400 kg/m^3 (Table 3).

Table 3: Physical properties of bottom ash concrete

Material	Aggregates 10mm	Aggregates 20mm	Sand	Bottom ash
Fineness Modulus	6.76	7.64	3.75	2.7
Specific Gravity	2.75	2.67	2.62	1.92
Water Absorption	0.601	0.601	1.01	10.062

Less work has been done on Bottom ash till date but various experiments have revealed that when bottom ash is used as a replacement of aggregates in concrete, it increases the strength and other properties up to a significant amount. The sub-sections shows the reviewed effect of Bottom ash as partial replacement of fine aggregate on workability, compressive strength, flexural strength and split tensile strength of concrete (Soman et al., 2014; P. Aggarwal et al., 2007; Kadam & Patil, 2013; Abdus et. al, 2014; Kumar et. al, 2014; Aggarwal & Siddique, 2014).

3.1 Workability

P. Aggarwal et al. (2007) studied the diverse strength properties for various percentages of replacement of sand with bottom ash, and the results of the work revealed that workability of concrete decreased with the increase in bottom ash content. The study revealed that the workability measured in terms of compaction factor, decreases with the increase of the replacement level of the fine aggregates with the bottom ash (Table 4 and Figure 1)

Table 4: Bottom Ash Concrete mixes and the compaction factor (P. Aggarwal et al. (2007))

Mix Type	M1	M2	M3	M4	M5
C.F	0.90	0.87	0.85	0.84	0.82

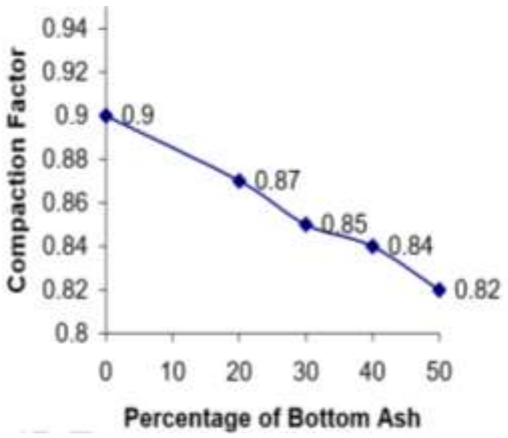

Figure 1: Compaction factor versus Percentage of the bottom ash (P. Aggarwal et al. (2007))

Abdus Salaam Cadersa et. al (2014) found that the workability commonly reduced with the increased Concrete Bottom Ash content. He reported that the workability of the concrete is usually correlated to its slump value. It was observed by the researchers that up to 50% replacement of Coal Bottom ash, the slump is within the designed range 60-180mm (Figure 2). The workability generally decreased with the increased Coal Bottom Ash content. The decrease in workability is attributed to the fact that the Coal Bottom Ash is irregular in shape, vesicular in texture and porous such that friction between particles is high. Thus, with increasing Coal Bottom Ash content, there is an increase in water demand to achieve similar workability as for the control mix. Similar results were found by various other researchers as well in the same field of study.

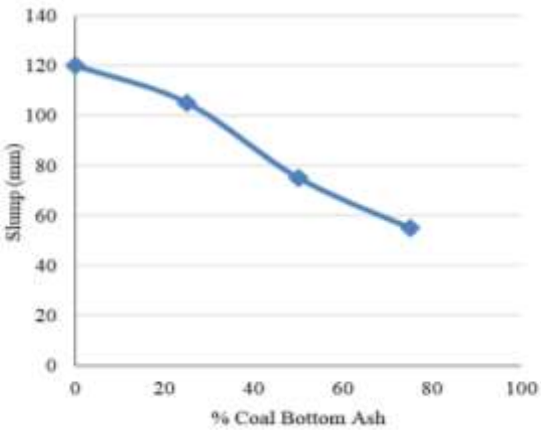

Figure 2: Variation of slump with different CBA percentage replacement (Abdus Salaam Cadersa et. al (2014))

3.2 Compressive strength

Another investigation was carried out by P. Aggarwal et al. (2007) to assess the compressive strength. It was found that the compressive strength of fine aggregates replaced bottom ash concrete specimens were lower than the control concrete specimens at all the ages. The difference in the strength between the Bottom ash concrete specimens and the control concrete specimens became less distinct after 28 days. Compressive strength of fine aggregate replaced bottom ash concrete continues to aggrandize with age for all the bottom ash contents. Mix containing 30% and 40% bottom ash, at 90 days attained the compressive strength equivalent to 108% and 105% of compressive strength of normal concrete at 28 days. The span required to attain the required strength is more for bottom ash concrete.

The extensive work results also revealed the bottom ash concrete gained strength at a slower rate in the initial period and acquired strength at faster rate beyond 28 days, due to pozzolanic action of the bottom ash. Also, at early age bottom ash reacted slowly with calcium hydroxide liberated during hydration of cement and did not contribute significantly to the densification of concrete matrix at early ages. The compressive strength of fine aggregate replaced bottom ash concrete continued to increase with age for all the bottom ash contents (Table 5).

Table 5: Compression behavior of bottom ash concrete with age (P. Aggarwal et al. (2007))

Mix Type	7 days	28 days	56days	90 days
M1	24.75	33.33	35.40	37.18
M2	23.26	30.43	32.15	36.07
M3	22.48	29.55	31.78	36.74
M4	21.70	28.00	30.60	35.26
M5	20.15	26.37	30.44	35.18

M.P. Kadam and Y D Patil (2013) carried out the compressive strength tests of concrete mixes made with and without coal bottom ash of cubes size 150 mm × 150 mm × 150 mm and the results were determined at 7, 28, 56, and 112 days. It was observed that for 10 % and 20 % sand replacement the compressive strength was increased by 4.6 %, 3.99 %, 0.61%, 0.20 % for 7, 28, 56 and 112 days respectively as compared to the controlled concrete specimens. The compressive strength decreased from 30% to 100 % replacement from 2.07 % to 22.30%, 4.97 % to 33.66 %, 1.23 % to 38.99%, and 0.78 % to 36.83 % for 7, 28, 56 and 112 days respectively as compared with the controlled concrete.

It was also affirmed that 0 to 100 % of coal bottom ash was replaced with sand and optimum percentage of replacement was obtained at 30 % replacement of bottom ash with sand. For controlled concrete, the compressive strength was found to be 27.71, 41.62, and 50.53 and 53.81 N/mm^2 for 7, 28, 56 and 112 days respectively (Figure 3).

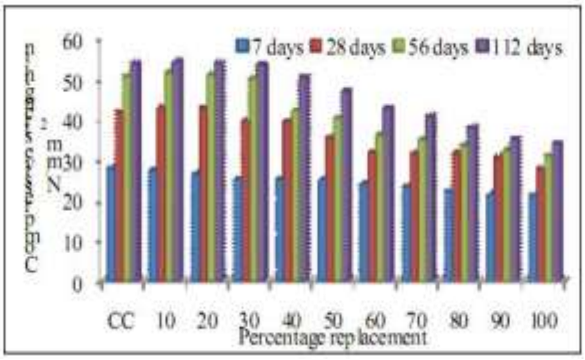

Figure 3: Compressive strength of Bottom ash concrete with age (M.P. Kadam and Y D Patil (2013))

As per the research carried out by Abdus Salaam Cadersa et. al (2014), the compressive strength decreases with increasing bottom ash content and that early gain in strength of bottom ash concrete is lower than normal concrete. They studied the compressive strengths for all mixes which is illustrated in Figure 4. The 28 days compressive strength for the control mix was determined as 23.5 N/mm^2 which is slightly above the target mean strength of 23.2 N/mm^2, while that of M25 and M50 were 21.0 N/mm^2 and 17.1 N/mm^2 respectively. The M75 mix did not even gained the characteristic strength of the concrete. Thus, the result clearly revealed that compressive strength decreases with increasing bottom ash content and that early gain in strength of bottom ash concrete is lower than normal concrete. The decrease in compressive strength may be due to the porous surface structure and high absorptivity of the Coal Bottom ash such that hydration of all cement particles may not have occurred and less paste is possible for bonding. Furthermore, at 28 days, on removing the cubes for the coal bottom ash mixes from the curing tank, some discontinuous fine cracks were observed on the concrete surface. These cracks contribute to the weakening of the concrete. Similar results were obtained by other researchers in the year 1997 who used municipal solid waste incinerator bottom ash as partial coarse aggregates replacement in concrete. The decrease in strength can also be attributed to the fact that Coal bottom ash is a weaker aggregate than normal weight aggregate. Therefore, the greater the proportion of Coal bottom ash in the concrete, the lower is the concrete strength.

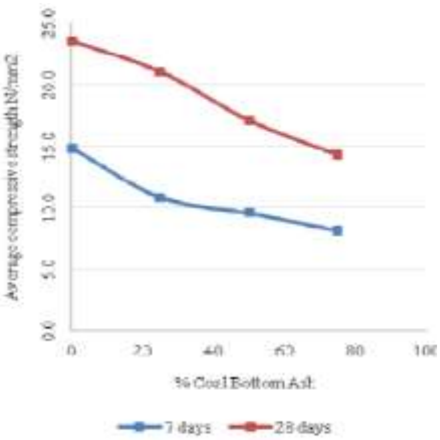

Figure 4: Compressive strength at 7 and 28 days (Abdus Salaam Cadersa et. al (2014))

Kumar et. al (2014) revealed that the maximum compressive strength of mix proportion was 32.14 N/mm^2, 34.85 N/mm^2, 36.20 N/mm^{2}and 39.16 N/mm^{2}at 7 days, 14 days, 28 days and 56 days respectively at 40% replacement of bottom ash in concrete while the minimum compressive strength was found 23.56 N/mm^2, 28.18N/mm^2, 30.40 N/mm^2 and 32.87 N/mm^2 at 7 days, 14 days, 28 days and 56 days respectively when no replacement of bottom ash in concrete. After 40% replacement of bottom ash in the concrete it was found that the compressive strength was decreasing. The experimental procedures carried out demonstrated that the compressive strength of the specimen was calculated by dividing the maximum compressive load taken by the specimen by its cross-sectional area. Values of compressive strength at different percentage of replacement at different age are given below (Table 6):

Table 6: Compression strength of bottom ash concrete (Kumar et. al (2014))

Days	0% BA (N/mm^2)	10% BA (N/mm^2)	20% BA (N/mm^2)	30% BA (N/mm^2)	40% BA (N/mm^2)	50% BA (N/mm^2)
7	23.56	26.67	28.12	31.67	32.14	28.34
14	28.18	30.98	32.14	33.52	34.85	30.42
28	30.40	32.40	33.40	35.17	36.20	32.25
56	32.87	35.28	36.70	38.23	39.16	33.42

3.3 Flexural Strength

The flexural strength property was assessed by various researchers in their experimental investigations and the results were found in accordance. P. Aggarwal et al. (2007) in their detailed experimental investigation carried out the flexural strength of sand replaced with bottom ash in the concrete specimens and the flexural strength of the bottom ash concrete specimens were lower than control concrete specimens at all the ages. The strength difference between bottom ash concrete specimens and control concrete specimens became less distinct after 28 days. Flexural strength of fine aggregate replaced bottom ash concrete continued to increase with age for all the bottom ash contents. The results of the study have been discussed in Table 7.

Table 7: Flexural Strength of Bottom ash Concrete varying with age (P. Aggarwal et al. (2007))

Flexural strength (F_t) N/mm^2 or MPa				
Mix Type	**7 days**	**28 days**	**56days**	**90 days**
M1	2.48	3.32	3.64	4.40
M2	2.40	3.20	3.52	3.92
M3	2.28	2.92	3.56	3.76
M4	2.20	2.52	3.44	3.80
M5	2.04	2.40	3.44	3.76

According to Kumar et. al (2014), the maximum flexural strength of concrete was found 7.94 N/mm^2, 8.80 N/mm^2, 9.04 N/mm^2 and 9.24 N/mm^2 at 7 days, 14 days, 28 days and 56 days respectively at 40% replacement of bottom ash in concrete while minimum flexural strength of concrete was found 2.20 N/mm2, 3.10 N/mm2, 3.40 N/mm2 and 4.27 N/mm2 is at 7 days, 14 days, 28 days and 56 days respectively when there is no replacement of bottom ash in concrete. After 40% replacement of bottom ash in the concrete it was found that the flexural strength was decreasing. They carried out the experimental investigation for the Flexural test on beams of 150×150×700 cubic mm size. The load was applied without shock and was increased until the specimen failed, and the maximum load applied which is on the meter to the prism during the test was recorded. The appearances of the fractured faces of concrete failure were noted. Three-point load method was used to measure the flexural strength of bottom ash aggregate concrete. The results were summarized in the Figure 5 as shown below:

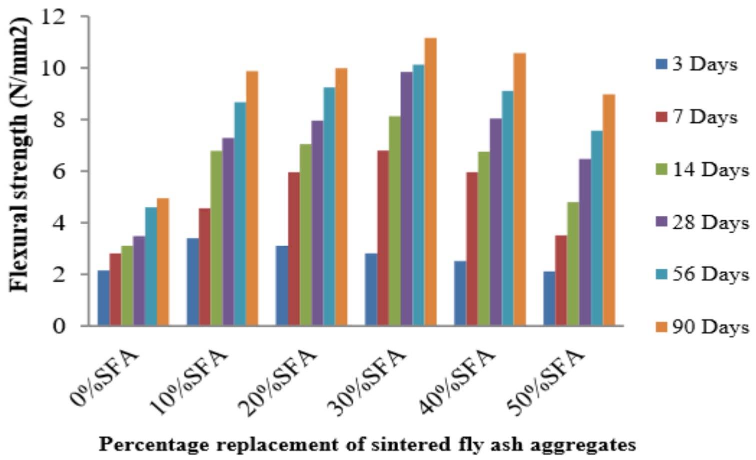

Figure 5: Flexural strength variation with ages (Kumar et. al (2014))

As reported by Kadam and Patil (2013), the flexural strength was increased for 10 %, 30 % replacement and after that it was decreased. They studied the effect of coal bottom ash on flexural strength and showed that bottom ash concrete gained flexural strength with the age which was comparable but less than that of the controlled concrete. Figure 6 shows the variation in flexural strength for different replacement with respect to controlled concrete for 7 days, 28 days, 56 days and 112 days respectively.

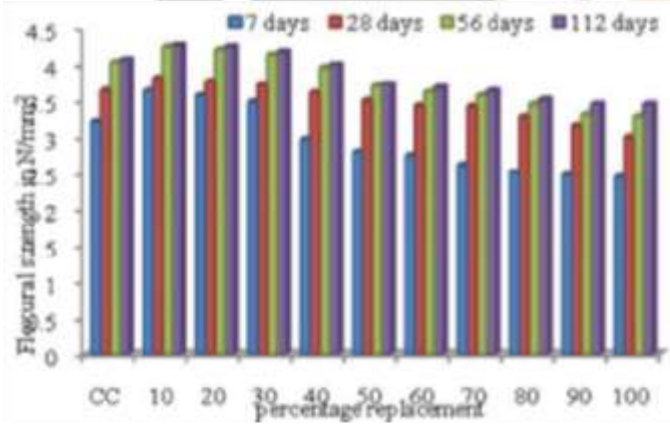

Figure 6: Effect of coal bottom ash on flexural strength of concrete with age (Kadam & Patil (2013))

3.4 Split Tensile Strength

Experiments carried out by Kadam and Patil (2013) revealed that the split tensile strength increased at 7, 28, 56 and 112 days for 10% to 30% replacement and after that it was decreased for remaining replacement. The specimen of size 150 mm in diameter and length of 300 mm was casted and tested under the digital CTM of capacity 300 ton and was kept under CTM at the center with play wood of thickness 5 mm at top and bottom and load was applied with pace rate 1.3 KN/seconds and ultimate loading was noted. The spilt tensile strength was calculated according to IS: 5816-1970 and IS: 516 – 1959 codes. The split tensile strength for controlled concrete was found 3.01, 4.34, 5.22 and 5.42 for 7, 28, 56 and 112 days. It was observed that for 10 % to 20 % sand replacement the spilt tensile strength was increased from 14.29, 2.29, 1.73, 0.00 % for 10 % replacement at 7, 28, 56 and 112 days respectively with controlled concrete. The split tensile strength for 20 % replacement was increased by 8.97 %, and 1.67 % at 7, 28 days and decrease for 56 and 112 days compared with controlled concrete. It was found that the split tensile strength decreased from 30 % to 100 % replacement by 1.67 to 40.57 %, 0.46 to 39.86 %, 0.76 to 46.55 % and 3.51 to 45.20 % for 7, 28, 56 and 112 days with respect to controlled concrete. Splitting tensile strength of concrete decreased with the increased in bottom ash as fine aggregates in place of natural sand which is clearly shown in Figure 7.

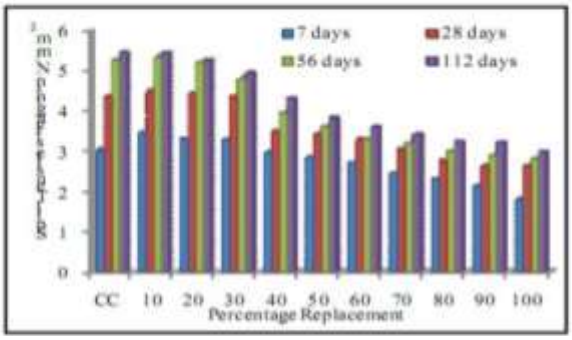

Figure 7: Split tensile strength of coal bottom ash concrete with age (Kadam and Patil (2013))

It was experimentally reported by Aggarwal and Siddique (2014) that the splitting tensile strength for mix with bottom ash content was more than the control mix at all ages (7, 14, 28, 56 and 90 days). Inclusions of same proportion of bottom ash tend to decrease the strength. Thus, not much difference in strength was observed from 10 % to 50 % replacement of sand with equal percentage of waste foundry sand and bottom ash. Also the strength was obtained at replacement of 30 % (15% waste foundry sand and 15 % bottom ash) in the replaced mixes, was adjudged as optimum mix.

Pursuant to Aggarwal et. al (2007), the splitting tensile strength of fine aggregates replaced bottom ash concrete specimens were inferior than control concrete specimens at all the ages. Bottom ash concrete procures splitting tensile strength in the range of 121-126% at 90 days of splitting tensile strength of normal concrete at 28 days. The results of splitting tensile strength of concrete mixes with and without bottom ash measured at 7,28,56,90 days are given in Table 8. Figure 8 shows the variation of splitting tensile strength with age for different bottom ash percentages. It was clearly observed that the splitting tensile strength of concrete decreased with the increase in the percentage of fine aggregates replacement with the bottom ash, but the splitting tensile strength increased with the age of curing. The rate of increase of splitting tensile strength decreased with the age. The splitting tensile strength gain is more at 20% replacement of fine aggregates with bottom ash. At higher percentages the strength gain decreased and it has been found to be minimum at 50% replacement level.

Table 8: Splitting tensile behavior of bottom ash concrete with age (Aggarwal et. al (2007))

Splitting Tensile Strength, N/mm^2				
Mix type	**7days**	**28 days**	**56 days**	**90 days**
M1	2.19	2.62	3.01	3.40
M2	2.05	2.52	2.83	3.30
M3	1.98	2.37	2.72	3.26
M4	1.80	2.26	2.69	3.22
M5	1.70	2.23	2.69	3.18

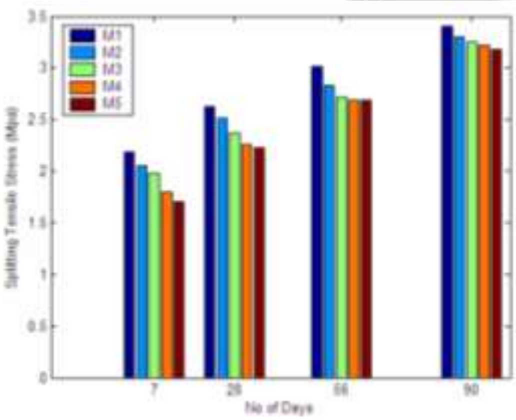

Figure 8: Split tensile strength of coal bottom ash for various mixes (Aggarwal et. al (2007))

4. Advantages and Disadvantages of Bottom ash used in Construction Industry

The various advantages of using bottom ash in the construction industry is discussed below:

- The sustainable utilization of bottom ash improves production efficiency, reduces production costs and diminish waste product disposal problems.
- It eliminates the need to mine virgin materials and conserves limited land and material resources.
- Clean in both production and CO_2 emissions.
- Waste stabilization and solidification
- Used as raw alternative material, replacing earth or sand or aggregates
- When used in concrete, bottom ash is used as replacement of fine aggregate in which concrete has advantageous properties like improved workability, resistance to chemical attack.
- Growing medium in horticulture (usually after sieving)

Some of the factors due to which, utilization of bottom ash is not increasing at desired rate leading to various disadvantages is as follows:

- Lack of awareness of the bottom ash properties.
- High transportation cost.
- Non-availability of the material.
- Lack of proper co-ordination.
- Easy availability of top soil.
- Variations in the quality of bottom ash.

5. Applications of Bottom Ash in Civil Engineering Industry

According to the literatures reviewed to have knowledge about the use of bottom ash in the major areas of construction industry as building material and other civil engineering sectors, the following applications have come to notice. The areas mentioned below have tremendous scope of large scale use of Bottom ash.

- Building bricks and block.
- Drainage media and Sound insulating walls.
- Rock stabilization or filling of cavities, stabilization of soft soils.
- Construction material for highway and pavement.
- Pressure grouting in concrete highways and for other purposes viz, tunnel lining.
- Road construction: Mineral filler in asphalt roads to minimize void content and increase the stability of bituminous wearing course during road construction
- Light weight synthetic aggregate in block and concrete.
- Growing media for plants.
- Mine reclamation
- In concrete, bottom ash is used as replacement of fine aggregate in which concrete has advantageous properties like improved workability, resistance to chemical attack.

6. Conclusions

Bottom ash has tremendous uses apart from some of the disadvantages as the coin has always two sides. The key advantages include high suitability in building products, clean in both production and CO_2 emission and waste stabilization while the main disadvantage is the lack of awareness and non-availability of bottom ash. Based on the results of various literatures reviewed, it was concluded that the compressive strength decreased with the increase in bottom ash content and that early gain in strength of bottom ash concrete was lower than normal concrete. The workability of concrete decreased with the increase in bottom ash content due to the increase in water demand. Workability of the concrete was correlated to its slump value.

Also, the optimum percentage of replacement of Bottom ash with sand was obtained at 30 %.

Flexural strength of fine aggregates replaced bottom ash concrete specimens was found to be lesser than normal concrete specimens at all the ages. Bottom ash concrete gained flexural strength with the age that was comparable but less than that of the controlled concrete.

Compressive strength, Flexural strength of fine aggregates replaced bottom ash concrete specimens was lesser than normal concrete specimens at all the ages. The strength difference between bottom ash concrete specimens and control concrete specimens became less distinct after 28 days. Splitting tensile strength of concrete

decreases with the increase in the percentage of fine aggregates replacement with the bottom ash, but the splitting tensile strength increases with the age of curing.
Thus, to increase the speed of construction, enhance green construction environment we can use lightweight concrete. Uses and applications of bottom ash as fine aggregate can reduce the cost of construction materials and also it is useful in environmental protection. Bottom ash used as fine aggregates replacement enables the large utilization of waste product. Even a small quantity of bottom ash used in mass concreting work results in reduction in cost and efficient as well as eco-friendly disposal of bottom ash. Bottom ash has been a resource that has been wasted. This material has worthy property to make it suitable for construction. Though its replacement for sand in concrete in high percentage does not show improvement in strength significantly, its replacement in lesser quantities for a big construction marks it significance. Large quantities of bottom ash have been dumped into land. Such a material can be used in replacement of sand in concrete to make it useful in a better way. This decreases land pollution and makes it eco-friendly. This type of replacement in heavy budget makes it economical. Bottom ash can is effectively used along with plasticizers in considerable amount to improve the strength of concrete. Bottom ash has a property of absorbing moisture even after construction. So there is chance of dampness in the structure. This makes the need to use a waterproofing coat over the structure. The cause of respiratory related diseases is prominent in such an environment.

References

- Abdus Salaam Cadersa, Jaylina Rana, Toolseeram Ramjeawon "Assessing the Durability of Coal Bottom Ash as Aggregate Replacement in Low Strength Concrete", Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS), (ISSN: 2141-7016) 5(5): 344-349 (2014).
- IS 10262-1982 Recommended Guidelines for concrete mix design, BIS, New Delhi.
- IS 516- 1959 Method of Tests for Strength of Concrete, BIS, New Delhi.
- IS 5816 – 1970 Methods of test for splitting tensile strength of concrete cylinders, BIS, New Delhi.
- IS 8112:189, Specification for 43 grades OPC, reaffirmed 1997. Properties of High-calcium Dry Bottom Ash Concrete, ACI Materials Journal, 90-101, (1997).
- Soman K. , Divya Sasi, Abubaker K.A. "Strength properties of concrete with partial replacement of sand by bottom ash ". International Journal of Innovative Research in Advanced Engineering, (IJIRAE), ISSN: 2349-2163, (2014).
- Kumar D. , Gupta A., Sri Rama ,"Uses of Bottom ash in the Replacement of fine aggregate for Making Concrete" International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 - 5161 (2014).
- M.P.Kadam ,Y.D. Patil."Effect of coal Bottom ash as sand Replacement on The Properties of Concrete with different W/S Ratio " International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 - 5161.(2013)
- M.S.Shetty. Concrete Technology, theory and practice. S.Chand & co Publishing Company, New Delhi (2013).
- Majidzadeh, K., EI-Mitiny, R. N., and Bokowski, G.Power Plant Bottom Ash in black base and bituminous surfacing. Vol.2, Users Mannual, Federal Highway Administration, Report No. FHWA/RD-78-148, Washinton, D.C (1977).
- P. Aggarwal, Y. Aggarwal, SM Gupta. "Effect of bottom ash as replacement of bottom ash as replacement of fine aggregates in concrete."Asian Journal of Civil Engineering, 8(1), 49-62 (2007).
- Yogesh, Aggarwal, Rafat Siddique. "Microstructure and properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates.", construction building material 5, 210-223, (2014).