Studies on the Effect of Bottom Ash on Ceramic Waste Aggregate Concrete

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Abstract - *Natural sand is a standout among the most ordinarily utilized fine aggregate as a part of concrete. Owning to acute shortage of natural sand in many areas and keeping environmental and cost factors into consideration an alternative for the same is pondered. In view of above discussion, an attempt is made to replace the cement and coarse aggregate in concrete with bottom ash and ceramic waste to study the workability and compressive strength at 7,14 and 28 days curing periods. Bottom ash and ceramic waste are used as fine aggregate replacements and coarse aggregate replacements in this study to help reduce the amount of waste that is sent into the environment because of these wastes. It has been estimated that about 30% of the ceramic waste that is made each day is thrown away. This is bad for concrete technology and the environment, so it needs to be replaced. Coal is burned in power plants, and the bottom ash is a byproduct called "bottom ash." Typically, power plants make about 20% of the total ashes. Ash from this fire was put down the drain, in a landfill or near ponds and rivers, which makes the environment dirty. So, the ash is used as a fine aggregate to keep the environment clean.*

Ceramic waste is being used as a part of the coarse aggregate in this project. The maximum amount of ceramic waste that can be used is about 30% of the mass of coarse aggregate. None of the ceramic waste was replaced. The percentages of ceramic waste that was replaced were 0%, 5%, 10%, 15%, 20%, 25%, 25%, and 30%. In concrete, the amount of ceramic waste used as a part of the coarse aggregate increases, which gives it the moderate strength properties. In order to make the concrete stronger, 10 percent of bottom ash is added to it as a replacement for some of the fine aggregate. This makes the concrete more durable. Tests are done to find out how concrete behaves when it's new and when it's hardened. Properties like compressive strength, split tensile strength, flexure strength test, workability at 7, 14, and 28 days of curing were calculated and compared with ceramic waste bottom ash aggregate. This study will lead to a lot of ceramic waste and bottom ash being used in a big way, which will help keep the environment clean and save natural resources.

Key Words: Natural Sand, Fine aggregates, Bottom ash, Ceramic Waste, Coarse aggregates

1. INTRODUCTION

Concrete is a composite material that primarily consists of water, aggregate, and cement. By adding additives and reinforcements to the concrete mixture, the required physical qualities of the final material may be achieved. By combining these elements in certain quantities, a solid mass that can be readily shaped into the appropriate shape may be generated [1-3]. When aggregate is combined with dry Portland cement and water, the combination creates a fluid slurry that is readily poured and shaped. The cement chemically interacts with the water and other components to generate a tough matrix that holds the materials together to make a durable stone-like substance with a wide variety of applications. Frequently, additives such as aspozzolanic or super plasticizers are included into the mixture to enhance the physical qualities of the wet mix or final material. The majority of concrete is poured with imbedded reinforcing components to increase its tensile strength, resulting in reinforced concrete.

1.1 USE OF OTHER WASTE MATERIALS IN CONCRETE MAKING

It has been estimated that about 30 percent of daily production goes as waste in ceramic industry. Ceramic waste which is durable, hard and highly resistant to biological, chemical and physical degradation forces is not recycled so far. The rate of growth in waste has put pressure on the ceramic industries to find a solution for its disposal and to minimize the pollution. Other wastes like quarry dust, rice husk, bottom ash, silica fume, glass, crushed bricks, oil palm shells, crushed red clay ceramics were also used in concrete making [13].

So in this study we are used the waste materials are:

- Ceramic waste
- Bottom ash

1.2 SUSTINABLE CONCRETE TECHNOLOGY

Concrete is the most widely and extensively used material in the world. The fine aggregate used in the production of concrete is becoming highly expensive and scarce day by day. Also the use of river sand as fine aggregate, results in the exploitation of natural resources erosion of river bed, lowering of water table and sinking of bridge piers [2]. The construction industry has shown great gains in the utilization of recycled industrial by- products and wastes, including ceramic waste. If fine aggregate is replaced by bottom ash by specific percentage and in specific size range, it will decrease fine aggregate content and thereby reducing the ill effects of river dredging and thus making concrete manufacturing industry sustainable. Using of these recycled by-products and wastes not only saves the landfill space but also minimizes the demand for fine aggregate.

The advantages of developing alternative or supplementary cementing materials as partial replacements for ordinary Portland cement powder are sub-divided into ecological, economic, and engineering categories [4].

1.3 ECOLOGICAL OR ENVIRONMENTAL BENEFITS OF ALTERNATIVE MATERIALS ARE AS FOLLOWS:

(1) The diversion of non-recycled waste from landfills for advantageous applications.

(2) The reduction in the adverse effects of producing cement powder, namely the utilization of nonrenewable natural resources.

(3) These materials reduces the energy required for cement production

(4) They reduce the emissions of greenhouse gasses.

The economic benefits of using alternative materials are best realized in the situations where the cost of the alternative material is cheaper than that of cement powder while providing comparable performance. This cost includes the source of the alternative material, its processing, transportation, and should consider savings through diversion, such as tipping fees and landfill management costs. The engineering or technical benefits of alternative materials are concluded when a specialized use for such material may be developed, such that the use of the alternative material is more favorable than use of concrete made with OPC [6].

A ceramic material may be defined as any inorganic crystalline material, compounded consists of metal and non-metal or metalloid atoms. Ceramic Materials are strong and inert. Ceramic materials are brittle, hard, and solid in pressure, frail in strain and additionally in shearing. They can withstand compound disintegration that happens in an acidic or scathing ‘environment. Ceramics generally can withstand very high temperatures that can go from 1,000 °C to 1,600 °C (1,800 °F to 3,000 °F). Exemptions are there for the inorganic materials which don't have oxygen and in addition silicon carbide.

Table -1: Physical Properties of Cement

Grade of concrete	Experimental	43 GRADE (As per IS:8112:2013)
Minimum specific Surface (blaine's air permeability) m^2/kg	200	225
Initial setting time	110 minutes	30 MINIMUM
Final setting time	216 minutes	600 MAXIMUM
Soundness, expansion (mm)	5mm	10 maximum (Le Chatelier Test)
Normal Consistency	32%	-
Compressive Strength		
7 Days	33Mpa	33Mpa
28 Days	43.5Mpa	43Mpa

Table -2: Sieve Analysis of Fine Aggregates

IS Sieve Size	Weight of Aggregate Retained (gms)	Average (gms)	% of total Weight retained	Cumulative % of total Weight retained	% of Passing	Permissible value as per IS:383-1917 (Zone-2)
10mm	0	0	0	0	100	**100**
4.75mm	92	92	9.2	9.2	90.8	**90-100**
2.36mm	53	53	5.3	14.5	85.5	**75-100**
1.18mm	101	101	10.1	24.6	74.8	**55-90**
600 μm	169	169	16.9	41.5	58.5	**35-59**
300 μm	378	378	37.8	79.3	20.7	**8-30**
150 μm	180	180	18.0	97.3	2.70	**0-10**

Table -3: Sieve Analysis of Coarse Aggregates

Sieve Size (mm)	Weight of Aggregates retainer (gms)	Avg.	% of total Wt. Retained	Cum. % of Wt. retained	% of passing	Permissible values as per IS 383:1917
20	109	109	10.9	10.9	89.1	85-100
10	852	852	85.2	96.1	14.8	0-20
4.75	39	39	3.9	100	0	0-5
PAN	0	0	0	100	0	-

2. MATERIALS AND METHODS

Experimental Study: After proper mixing of ingredients, moulds of size 150mm×150mm×150mm were placed on vibrating machine after proper oiling and securely tighten to correct dimension. Proper care was taken that there is no gaps left from where there is any probability of leakage of concrete paste (slurry). Then the concrete is poured in the moulds in three layers. Each layer is left to vibrate for 8-12 seconds to avoid honey combing and moulds are filled up to the brim. After concreting and compaction upper surfaces made smooth with the help of trowel. The moulds were left undisturbed for 24 hours in the laboratory. A total of 81cubes were casted for the experimental study. All the specimens were casted according to IS 516:1959.

Cement: To prepare mixes, ordinary Portland cement (O.P.C) grade 43 manufactures by shri ultra was used throughout the study. The physical properties of the cement are listed in Table 1. The cement satisfies the requirements of IS 8112:2013.

Fine Aggregates: The fine aggregate which was used was locally available river sand, which passed through 4.75 mm. Result of sieve analysis of fine aggregate is given in Table 2. The specific gravity of fine aggregate is 2.61 and fineness modulus is 2.67. Bulk density of fine aggregates is 1.29.

Coarse aggregate: Crushed stones of size greater than 4.75mm and passing through 20mm sieve conforming to IS 383:1970 were used in the study. Sieve analysis of coarse aggregates is given in Table3. The specific gravity of coarse aggregates is 2.63 and bulk density is 1.5.

Bottom Ash: Bottom ash is the coarser material, which drops into the bottom of the furnace in latest large thermal power plants and constitute about 20% of gross ash content of the coal fed in the boilers. It consists of non-combustible materials, and is the residual part from the incineration of household and similar waste. Raw bottom ash is a granular material that consists of a mix of inert materials such as sand, stone, glass, porcelain, metals and ash from burnt materials. Bottom ash is available from Thermal Power Station, Vijayawada.It is used as partial replacement of Fine aggregate in concrete mix. Fineness and lime reactivity of Bottom Ash was 360m2/kg and 5.2N/mm2 respectively.

Ceramic Waste: The waste generated by the ceramic industries is termed as ceramic waste. Ceramic waste obtained from ceramic electrical insulator industry has a glassy outer skin. Initially the glazed surface was removed manually and it was broken in to 100 mm to 150 mm size by a hammer. Then it was fed into the jaw-crusher to get 20 mm graded aggregate. Specific Gravity obtained was 2.15 whereas water absorption was obtained 0.18%.

Water: Potable water was used for mixing and curing.

Mix Design: Design mix proportion of 1:1.77:2.278 at w/c ratio of 0.35 were used for M50 grade concrete and cement content were 450kg/m3 satisfying all the basic requirement as per IS:10262-2009.

Table -4: Replacement percentage of cement and aggregates by bottom ash and ceramic waste

S.No	Concrete Mix	Mix Content
1.	M0	M50
2.	M1	M50 + 10% bottom ash
3.	M2	M50 + 20% bottom ash
4.	M3	M50 + 30% bottom ash
5.	M4	M50 + 40% bottom ash
6.	M2C1	M50 + 20% bottom ash + 10% ceramic waste
7.	M2C2	M50 + 20% bottom ash + 20% ceramic waste
8.	M2C3	M50 + 20% bottom ash + 30% ceramic waste
9.	M2C4	M50 + 20% bottom ash + 40% ceramic waste

3. RESULTS AND DISCUSSIONS

Fresh property of concrete is determined by Workability of concrete which is one of the main physical parameter which affects the strength and durability as well appearance of the finished concrete and the cost of labor. Workability of concrete is measured with the help of slum test. .The slump flow of M0 was 20mm which is acceptable according to IS 4926:2003. The slump value goes on increasing from M0 to M4 as Bottom ash imparts lateral strength as compared to cement which imparts early strength in concrete. According to IS code all the values are within the limiting range. The compression in slump values for initial mixes is shown in Fig.1. The slump flow goes on increasing from M2C1 to M2C2 and maximum slump was achieved in M2C4 i.e. 40% replacement of cement by Bottom ash and 40% replacement of coarse aggregates by ceramic waste because angular and rough aggregates which results in poor workability are replaced by 40% by ceramic waste which are cubical in shape and smooth in surface. Comparison in slump values for final mixes is shown n Fig.2. The overall comparison is shown in Fig.3.

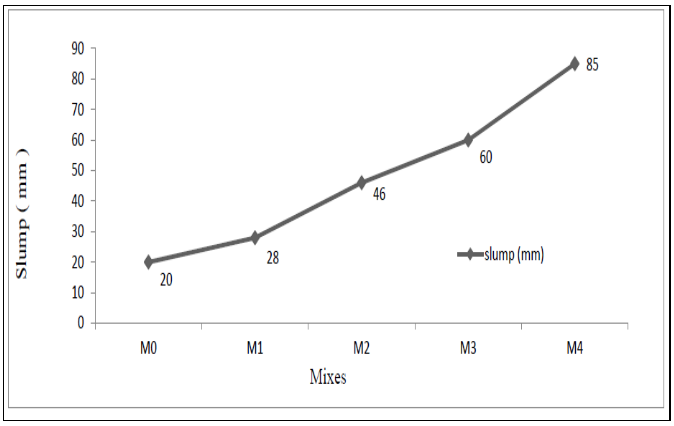

Fig -1: Comparison in slump values of initial mixes

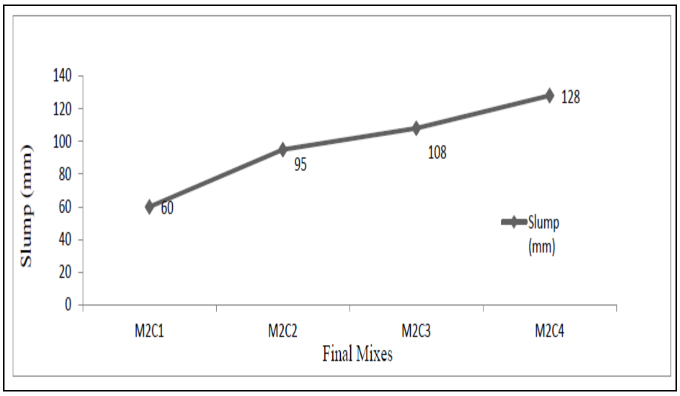

Fig -2: Comparison in slump values of initial mixes

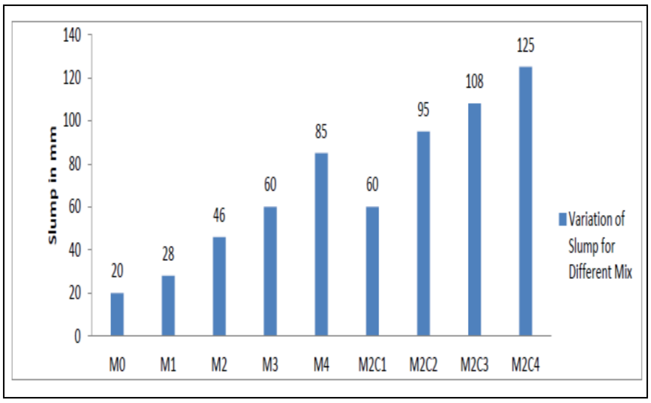

Fig -3: Comparison in slump values of initial mixes

After the completion of curing period of 7days, 14days and 28days cubes were tested for their compressive strength with the help of C.T.M, conforming to IS 516:1959. Cubes were tested immediately after removal from the curing tank. Cubes were placed on the platform of C.T.M. and the load was applied and gradually increased until the specimen is no more able to bear the load and graph shows a decreasing reading. The total load applied at the failure is noted down and this load divided by the area of the specimen gives the compressive strength of the specimen. Averages of at least three specimens were taken for each day and results were recoded.

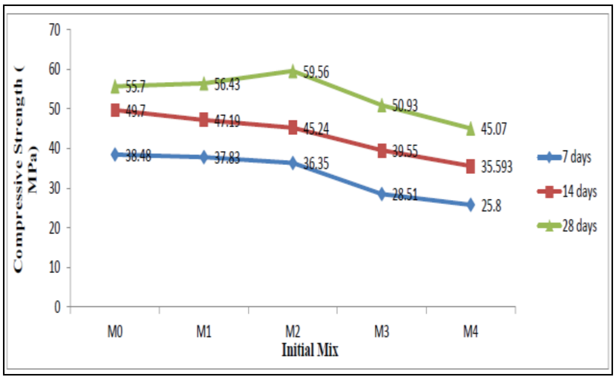

Fig -4: Comparison in slump values of initial mixes

From the Fig.4 it can be observed that the 7days and 14days compressive strength of mixes goes on decreasing from M0 to M4 on replacement of cement by bottom ash. As increase in percentage level of bottom ash in mix the percentage decrease for 7 days compressive strength was found to be 1.69% to 32.95% for M1to M4 respectively while for 28 days curing period the increase in percentage in compressive strength was observed to be 1.31% and 6.93% for M1 and M2 respectively while percentage starts decreasing as we go to M3 and M4 from 8.56% to 19.04% respectively. This is due to pozzolan and self-cementing property of Bottom ash which in case of water hardens and gets stronger over time.

From Fig. 5 it can be observed that there is increase in percentage in compressive strength, moving from M0 to M2C1. The increase in percentage is 13.61% after 28 days of curing. In case of other mixes the strength goes on decreasing from 2.388% to 25.40% in M2C2 and M2C4 respectively. The compressive strength goes on decreasing because of the fact that ceramic waste has smooth surface and cuboidal shape which results in less bonding of materials.

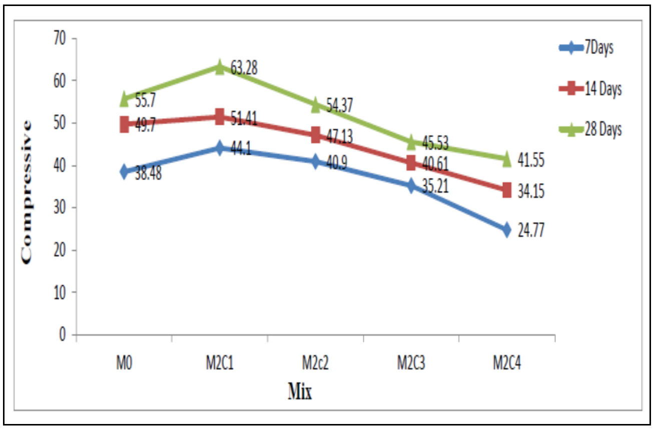

Fig -5: Comparison in slump values of initial mixes

On the other hand compressive strength goes on increasing from M0 to M2C1 because the replacement of coarse aggregate was just only 10% and maximum ceramics were indulge in filling the voids present in the coarse aggregates which results in great bonding of materials and hence results in high compressive strength. Moving from normal M50 grade concrete the weight of concrete goes on decreasing on replacement of cement by bottom ash and coarse aggregates by ceramic waste because bottom ash is light in weight as compared to cement and ceramic is also light in weight as compared to coarse aggregates which results in light weight cubes. The specific gravity of ceramic waste is less as compared to specific gravity of coarse aggregate while specific gravity of bottom ash is less as compared to specific gravity of cement. The comparison in weight of cubes in all mixes is shown below in Fig. 6.

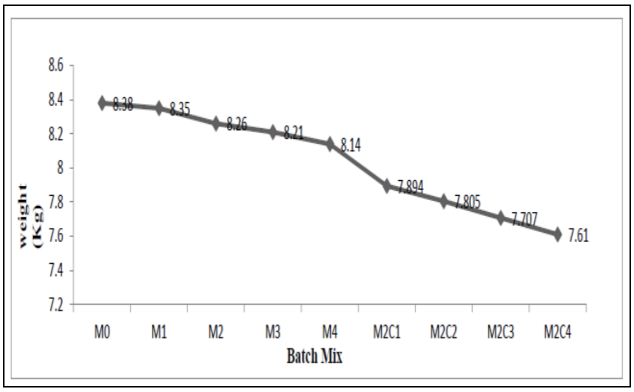

Fig -6: Variation of weight after 28 days for all mixes

Figure 6 shows that there was gradual decrease in weight of each cube as we go from M0 to M2C4. The decrease in percentage of unit weight varies from 0.35% to 9.2% per cube from M1 to M2C4 respectively. The maximum compressive strength was attained in M2C1 composition which results in 5.8% decrease in weight per cube as compared to normal mix. The compressive strength was 13.61% more compared to M0, hence it can be used in light weight structures.

5. CONCLUSION

• Based on the work it has been concluded that at 20% replacement of cement by bottom ash maximum compressive strength was achieved with reference to standard design mix the compressive strength at 28 days was 6..93% more. The compressive strength goes on increasing from 10% to 20% and above 20% replacement level compressive strength goes on decreasing due to low cement content.

• Workability of concrete goes on increasing from 10% to 40% replacement of cement by bottom ash. Maximum workability was attained at 40%.

• Replacement of cement by bottom ash also reduces the bleeding of concrete and hence results in improved surface finish.

• At 20% replacement of cement by bottom ash, the maximum compressive strength is achieved when crushed 10% coarse aggregates were replaced by crushed ceramic waste. But after that it is decreasing for 20% replacement and so on.

• Specific Gravity of ceramic waste is 2.15, which is 18.25% lower when compared to the specific gravity of coarse aggregate which is 2.63.So ceramic waste satisfied limit of specific gravity as per IS Code. Therefore, the usage of ceramic waste can reduce the dead weight of the structure up to 18.25%.

• In combination, maximum compressive strength was obtained for the mix having 20% replacement of cement by bottom ash and 10% replacement of coarse aggregate by ceramic waste which is 13.6% more with reference to standard design mix at 28 days.

• By using the mix M2C2 the mass of cube reduces from 8.38 kg to 7.894kg, which can result in light weight structure as compared to normal concrete.

• The slump value goes on increasing with increase in quantity of Bottom ash in M2 the slump value was 130% more than that of M0 and this increase in percentage is up to 325% for M4.

• On replacing coarse aggregates by ceramic waste the slump value goes on increasing from M2C1 to M2C4.The slump value in case of M2C1, for which maximum slump value was obtained was 200%more than that of M0 and this increase in percentage is up to 525% for M2C4.

• Cost of construction can be minimized with usage of bottom ash which is cheaply available. To realm the saving of environment pollution by cement production, bottom ash and by the ceramic waste was the main objective as being a civil engineer.

REFERENCES

[1] P. R. Wankhede and V. A.Fulari, "Effect of Bottom ash on Properties of Concrete," International Journal of Emerging Technology and Advanced Engineering, 2014.

[2] S. UPADHYAYA and R. CHANDAK, "EFFECTS OF FLYASH ON COMPRESSIVE STRENGTH OF M20 MIX DESIGN CONCRETE," International Journal of Advancements in Research & Technology, 2014.

[3] İ. B. TOPÇU and M. CANBAZ, "UTILIZATION OF CRUSHED TILE AS AGGREGATE IN CONCRETE,"Iranian Journal of Science & Technology, 2007.

[4] G. SHARMA, S. K. MEHLA, T. BHATNAGAR and A. BAJAJ, "POSSIBLE USE OF BOTTOM ASH IN CERAMIC INDUSTRIES: AN INNOVATIVE METHOD TO REDUCE ENVIRONMENTAL POLLUTION," International Conference on Ceramics, 2013.

[5] L. Prajapati, I. N. Patel and V. V. Agrawal, "Analysis Of The Strength And Durability Of The Concrete With Partially Replaced By The Ceramic Slurry Waste Powder," International Journal of Emerging Technology and Advanced Engineering, 2014.

[6] A. J. Patel, S. P. Patel, D. Prajapati and H. Patel, "Literature Review on Different Waste Materials Use in Concrete,"JETIR, 2014.

[7] F. Pacheco-Torgal and S. Jalali, "Compressive strength and durability properties of ceramic wastes based concrete,"RILEM, 2010.

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