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Utilization of Various Waste Materials in Concrete a Literature Review

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***Abstract*: In the world construction, one material is used above all is concrete.Concrete is far more produced all over the world than any other man made material. It is incredibly versatile, and is used in almost all major construction projects. The amount and type of waste materials increasing because of increase in population.Many of the non-decaying materials remain present in environment for hundreds and thousands of years. This waste materials cause disposal crises and thereby contributing to the environmental problems.So the use of waste in concrete has been done for safe and economical disposal of waste materials. The use of waste materials not only saves natural resources and dumping spaces but also it maintains a clean environment.Partial replacement of waste materialin concrete is done to achieve the desire properties of concrete such as strength, durability and workability. This paper gives idea about various waste materials used in concrete and their effects on various properties of concrete.**

Keywords-Concrete, Waste materials, Partial replacement.

I. INTRODUCTION

At present no construction activity is possible without using concrete. It is the most common material used in construction worldwide. The main reason behind this is because of its high strength, durability and workability. The total world consumption of concrete per year is about one ton for every living human being. Man consumes no materials except water in such tremendous quantities [1]. Due to privatization and globalization, the construction of important infrastructure projects like Highways, Airports, Nuclear plants, Bridges, Dams etc. in India is increasing year after year. Such developmental activities consume large quantity of precious natural resources. This leads not only faster depletion of natural resources but also increase the cost of construction of structures.

In view of this, people have started searching for suitable other viable alternative materials which could be used either as an additive or as a partial replacement to the conventional ingredients of concrete so that the existing natural resources could be saved to the possible extent, and could be made available for the future generation.In this process, different industrial waste materials such as fly ash, blast furnace slag, quarry dust, tile waste, brick bats, broken glass waste, waste aggregate from demolition of structures, ceramic tiles, electronic waste of discarded old computers, TVs, refrigerators, radios, waste paper mill pulp, iron filling, waste coconut shell, rice husk ash, marble dust powder, hypo sludge, machine crushed animal bones, chicken feather, eggs shell, granite quarry sludge, palm oil fuel ash, copper dust, human hairetc. have been tried as a viable substitute material to the conventional materials in concrete.

II. LITERATURE REVIEW

Dr. Haider K. Ammash, et.al.[2]studiedon the possibilities Waste Glass of size up to 5mm as a fine aggregate in concrete. The waste glass was used as a partial weight replacement of sand with percentages of 10, 20, 30 and 40 %. They found that, waste glass aggregate can be satisfactorily substituted for natural fine aggregate at replacement levels up to 20%.

M. Iqbal Malik, et.al. [3] studied the use of Waste Glass as partial replacement of fine aggregates in concrete. Fine aggregates were replaced by waste glass powder as 10%, 20%, 30% and 40% by weight for M-25 mix. The concrete specimens were tested for compressive strength, splitting tensile strength, durability and density at 28 days of age and the results obtained werecompared with those of normal concrete. They discovered that 20% replacement of fine aggregates by waste glass showed 15% increase in compressive strength at 7 days and 25% increase in compressive strength at 28 days. Fine aggregates can be replaced by waste glass up to 30% by weight showing 9.8% increase in compressive strength at 28 days. With increase in waste glass content, percentage water absorption decreases. With increase in waste glass content, average weight decreases by 5% for mixture with 40% waste glass content thus making waste glass concrete light weight. Splitting tensile strength decreases with increase in waste glass content.

Gunalaan Vasudevan, Seri Ganis KanapathyPillay, [4] studied to investigate the effect of using Waste Glass Powder in concrete. Laboratory work was conducted to determine the performance of control sample and concrete with used waste glass powder. They concluded that concrete with using waste glass powder averagely had higher strength at 14 days but once the concrete reached at 28 days the control mix give more higher value compare to mix that contained waste glass powder but still give high value of the M 30 grade.

G.Murali, et.al. [5]concluded that the concrete with Steel Powder as waste material was found to be good in compression which had the compressive strength of 41.25% more than the conventional concrete. Better split tensile strength was achieved with the addition of the steel powder waste in concrete. The strength has increased upto 40.87% when compared to that of the conventional concrete specimen. In flexure the specimen with soft drink bottle caps as waste material was found to be good. While adding the soft drink bottle caps

the flexural strength increased by 25.88% that of the conventional concrete.

Mostafa Jalal [6] investigated the mechanical behavior of concrete reinforced with Recycle Steel Fibers (RSF) recovered from milling and machining process. He observed that the compressive strength of the specimens was significantly increased. By increasing the waste fibers percentage, workability of concrete decreased. In some cases, water must be added so that the workability increases and as a result, the compressive strength decreases a little. By using waste fibers, cracks distribution got much more uniform during failure. The desired amount of fibers from the compressive strength point of view was turned out to be between 2-3 percent.

Dr. G.Vijayakumar et al. [7] conducted and experiment concrete prepared by partial replacement of cement by waste Glass Powder of particle size 75µm. The waste glass powder was replaced by 10%, 20%, 30% and 40% of the binder and the mix design was prepared. Before adding glass powder in the concrete it had to be powdered to desired size. In this studies glass powder ground in ball/pulverize for a period of 30 to 6o minutes resulted in particle sizes less than size 150 µm and sieved in 75 µm.The concrete mix design was proposed by using Indian Standard for control concrete of grade M20. The mixture was prepared with the cement content of 330kg/m3 and water to cement ratio of 0.53.At 28 days the glass powder shows a compressive strength of 41.96N/mm^2, strength at 30% cement replacement.The pH value observed from the alkalinity test showed that the specimen tested found to be more alkaline and hence more resistant towards corrosion.

Ali N. Alzaed [8] observed that Iron Filings are very small pieces of iron that look like a light powder. He used four different percentage of iron filing and was added to concrete mix to measure the variation 0% (control), 10%, 20% and 30% which may be obtained in compression and tensile concrete strengths after 28 days.Ordinary locally-available Portland cement having a specific gravity of 3.15, Locally-available sand having a fineness modulus of 2.54 and a specific gravity of 2.62 was used. Crushed granite coarse aggregate of 20 mm maximum size having a fineness modulus of 7.94 and specific gravity of 2.94 was used. Water conforming to the requirements of water for concreting and curing as per IS: 456–2000. He concluded that compressive strength of concrete was increased by 17% when 30% of iron filling added to the concrete mix. Concrete tensile strength had a minor effect if the percentage of iron filing used more than 10%. Concrete tensile strength increased by 13% when 10% of iron filling added to concrete mix.

KabiruUsmanRogo and SalehAbubakar [9] They studied on the Coconut Shell which can be a substitute for aggregates. The shell of the coconut is mostly used as an ornament and as a source of activated carbon. The powdered shell is also used in the industries of plastics, glues, and abrasive materials. The use of coconut shells can also help the prevention of the environment and also help economically. The coconut shells are obtained from a local coconut field. They were sun dried for 1 month before being crushed manually with particle sizes of the coconut shell range from 5 to 20 mm.They prepared about 72 concrete cubes size 150x150 x150mm with different mixed ratios1:2:4, 1:11/2:3 and 1:3:6 were casted and tested. They concluded that compressive strength inN/mm^2 of coconut shell at 7, 14 21, and 28 days with mix ratios of 1:2:4, 1:1.5:3 and1:3:6 are (8.6, 8.9, 6.4), (9.6, 11.2, 8.7), (13.6, 13.1, 10.7) and (15.1, 16, 5, 11)respectively for gravel (19.1, 18.5, 9.6) (22.5, 23.0, 10.4) (26.7, 24.9, 12.9) and (28.1,30.0, 15) respectively. Since the concrete strength of coconut shell with mix ratio 1:1.5:3attained 16.5N/mm^2 at 28 days it can be used as plain-concrete.Hence cost reduction of48% was obtained.

Mohd Monish et. Al. [10] They investigated that huge quantities of construction and demolition wastes are generated every year in developing countries likeIndia. The disposal of this waste is a very serious problem because it requires huge space for its disposaland very little demolished waste is recycled or reused. The paper deals with the effect of partial replacement ofcoarse aggregate by demolished waste on workability and compressive strength of 7 and 28 days.The concrete mix design was done inaccordance with IS:10262 (1982). The cement content inthe mix design was taken as 380 kg/m^3 which satisfiesminimum requirement of 300 kg/m^3. Three specimenseach having 0%, 10%, 20%, and 30% demolished wasteas coarse aggregate replacement for mix of 1:1.67:3.33were cast and tested after 7 and 28 days in order to have acomparative study. They concluded that up to 30% replacement of coarse aggregate withrecycled aggregate concrete was comparable to conventional concrete.Up to 30% of coarse aggregate replaced by demolished waste gave strength closer to the strength of plain concrete cubes and strength retention is in the range of86.84-94.74% as compared to conventional concrete.

P.Krishna Prasanna and M.Kanta Rao [11] They carried out an experimental study byutilizing E- waste particles as coarse aggregates in concrete witha percentage replacement from 0% to 20% i.e. (5%, 10%, 15% and 20%). Similarly, conventional specimens were also prepared for M30grade concrete without using E- waste aggregates. By conducting tests for both the specimens the hardened properties of concretewere studied.The e-waste contents were calculated on weight basis as coarseaggregate in the conventional mix. The fineness modulus of coarse aggregate with various E- waste contents was observed as 6.937.Compressive strength test was conducted to evaluate the strengthdevelopment of concrete containing various E- waste contentsat the age of 7, 14, 28 days respectively. It was also observed that the compressive strength of concrete was found to be optimum when coarse aggregate was replaced by 15% with E-Waste. Beyond it thecompressive strength is decreasing.

Dr. A.M. Pande and S.G.Makarande [12] investigated thatRiceHusk Ash (RHA)which are the waste products of agricultural industry can be use as materials in concrete which not only improves the strength of concrete but also leads to the proper disposal of these materials,resulting in reducing the impact of these materials on environment. The investigation was to make the concrete with targets of 28-day Compressive strength of at least 40 MPa. Proportion of mixtures was selected basing on these targets. The RHA was trialed to replace for cement with various ratios, namely 0, 12.5, 25, and 37.5 % by mass of cement. They concluded that replacement of 12.5 % of cement with rice husk ash in matrix causes reduction in utilization of cement and expenditures.

Also it can improve quality of concrete at the age of 90 days.Results indicated that pozzolanic reactions of rice husk ash in the matrix composite were low in early ages, but by aging the specimens to 90 days, considerable effect have been seen in strength.

Olaoye, R.A. et. Al. [13] Jute, Oil palm and Polypropylenefibers were used as complement in concrete and its suitability,durability and influence on the properties of concrete were assessed by them. The percentages of fiber used were 0.25 and0.5 of cement content by weight. A total of 84 concrete cube specimens were prepared for standard tests whichinclude compression test, slump test and compaction factor test. Concrete cube size of 150 x 150 x 150 mm was used to conduct the compressive test. The specimens weredifferentiated with respect to the type of fiber used and the fiber content by weight of cement. Specimens whichcontain zero percentage of fiber were used as control specimen. A total of 84 test cubes were prepared. They concluded that with the addition of Jute, oil palm andPolypropylene fibers, the compressive strength increases greatly from the 7^{th}- 28^{th} day compared to the control mix.

Youcef Ghernouti et. Al. [14] They have investigated the use ofPlastic Bag Waste as substitution of a variable percentage of sand such as 10, 20, 30 and 40 %.The influence of the waste on the fresh and hardened states properties of the concrete like workability, bulk density, ultrasonic pulse velocity testing, compressive and flexural strength of the different concretes, has been investigated and analyzed in comparison to the control concrete. They found that bulk density has decreased considerably for all concrete's with the content of replacement of sand by plastic waste that also becomes than lighter with 40% of plastic waste. They also observed that a fall in compressive strength at 28 days about 10 and 24 % containing 10 and 20 % of waste respectively.

Abdullah Anwar et. Al. [15] They investigated that Marble Dust Powder is settled by sedimentation and then dumped away, which results in environmental contamination, in addition to forming dust in summer and threatening both agriculture and public wellness. Therefore, utilization of the Marble Dust Powder in various industrial sectors, especially the construction, agriculture, glass and paper industries would help to protect the environment. The study is conducted by them to analyze the compressive strength of concrete when the base materials, i.e. cement is replaced with marble dust powder respectively. The marble dust powder replacement was kept at 0%, 5%, 10%, 15%, 20% and 25%. In all total 18 cubes of OPC and 18 cubes of PPC (150mm × 150mm × 150mm) were examined and results were analyzed after curing 28 days. The result obtained for 28-day compressive strength confirms that the optimal percentage for replacement of cement with marble dust powder is about 10%.This will post less on the production of carbon dioxide and solving the environmental pollution by cement production; thereby enhances the urban surroundings.

JayrajVinodsinh Solanki and Jayeshkumar Pitroda [16]An experimental investigation with the use of industrial waste Fly Ash and Hypo Sludge is carried out to know the strength of concrete and optimum percentage of the partial replacement of waste required. 150 mm × 150 mm × 150 mm concrete cubes are casted by using M20 grade concrete. Specimens with ordinary Portland cement (OPC) and OPC replaced with hypo sludge and fly ash at 10%, 20%, 30% and 40% levels. After curing, the specimens tested for compressive strength using a calibrated compression testing machine of 2,000 KN capacities.They conclude that compressive strength of the concrete after 7 days decreases when the percentage of replacement of fly ash increases and with replacement of 10 % hypo sludge compressive strength increases after 7 days. Compressive strength of the concrete after 28 days increases when the percentage of replacement of fly ash increases up to 30% and with replacements of 20 % hypo sludge compressive strength increases after 28 days.

Javed Ahmad Bhat et. Al [17] An exploratory study on the suitability of the Machine Crushed Animal Bones (CAB) as partial or full replacement fornormal coarse aggregates in concrete works has been carried out by them. Physical and mechanical properties of machine crushedanimal bones and locally available normal aggregate have been determined and compared. A large number of concretecubes of size 150×150×50 mm with different percentages by weight of normal aggregate to crushed animal bones as coarseaggregate were cast, tested and their physical and mechanicalproperties were determined. They concluded thatlightweight concrete using CAB aggregate can beachieved by replacing normal aggregate by CABaggregate approximately 50% or more.The average unit weights corresponding to 50%, 75%,and 100% of CAB aggregate inclusion in concrete are19.60 KN/m^3, 17.65 KN/m^3, and 16.55 KN/m^3respectively, for nominal concrete mix 1:1.5:3.Compressive strength of CAB concrete (lightweight)is low as compared to normal concrete.

Menandro N. Acda [18]He observed thatChicken feathers are waste products of the poultryindustry. Billions of kilograms of waste feathers aregenerated each year by poultry processing plants, creatinga serious solid waste problem.The paper deals with theuse of waste chicken feather (barbs and rachis) as reinforcementin cement-bonded composites. He concludes that mix workability decreased significantly as the proportion by weight of feathers or ground feathers increased from 5% to 20. Workability of the mix decreased by 15% to20% with fiber or ground feather content due to the tendency of short fibers to form clumps and cling to one another. He resulted that waste chicken feather canbe used as reinforcement in cement bonded composites butonly up to about 10% feather content.

AmarnathYerramala [19] He observed the use of poultry waste in concrete through incorporating Egg Shell Powder (ESP) in concrete. Different ESP concretes were developed by replacing 5-15% of ESP for cement. He studied that Calcium rich egg shell is a poultry waste with chemical composition nearly same as that of limestone. Use of eggshell waste instead of natural lime to replace cement in concrete can have benefits like minimizing use of cement, conserving natural lime and utilizing waste material.He conclude that compressive strength was higher than controlconcrete for 5 % ESP (eggshell powder) replacement at 7 and 28 days of curing ages. ESP replacements greater than 10 %had lower strength than control concrete. Addition of fly ash improved compressive strength of ESP concrete. Split tensile strengths of ESP concretes were comparable with control concrete up to 10 % ESP replacement.

Soman K and Dr. K. A. Abubaker[20]They found that Granite Quarry Sludge is the waste from rock processing in quarries and crusher units and it is disposed by filling in barren land causing serious environmental issues. This paper deals with an experimentalinvestigation on strength properties of concrete made with 2.5%to 20% replacement of cement by quarry dust of less than 75micron particle size. The tests were carried out to find the compressive strength, splitting tensile strength and flexural strength on specimens.Based on this experimental study, they conclude that compressive strength remains unchanged for a replacement of granite sludge up to 7.5% of cement.The tensile strength and flexural strength are also not affected for replacement of cement by quarry dust up to 7.5%.

Deepak T.J. et. Al. [21]They studied that Palm Oil Fuel Ash is the byproduct of burnt palm oil husk and palm oil shell in the boiler of palm oil mill. The paper deals with the experimental work done on the behavior of Palm Oil Fuel Ash (POFA) in concrete. Specimens containing 5, 15, 25, 35 and 45% POFA were prepared at constant water-cement ratios of 0.5 with super plasticizer content of 0.5% with cement. Workability in terms of slump and strength properties were studied, and compared with control specimen.They determined that the ultimate compressive strength of concrete could be improved by using up to 25 % of POFA to replace Portland cement in the concrete mix. Compressive strength of POFA shows its optimum compressive strength when the cement is replaced with 15% POFA giving a higher compressive strength than OPC. The flexural strength of POFA is slightly higher than that of OPC by replacing cement with 15% POFA.

Sumit A. Balwaik and S. P. Raut [22] They investigated the use of Paper-Mill Pulp in concrete as an alternative to landfill disposal. The cement has been replaced by wastepaper sludge accordingly in the range of 5% to 20%by weight for M-20 and M-30 mix. By using adequate amount of the waste paper pulp and water, concrete mixtures were produced and compared in terms of slump and strength with the conventional concrete. The concrete specimens were tested in three series of test as compression test, splitting tensile test and flexural test.Based on the results they conclude that the slump increased up to 5% replacement ofcement, above 5% the slump decreased as thepaper pulp content in the concrete mixtureswas increased. The compressive, splitting tensileand flexural strength increased up to 10%addition of waste paper pulp and furtherincreased in waste paper pulp reduces thestrengths gradually. The most suitable mix proportion is the 5 to 10% replacement of waste paper pulp to cement.

Dr.A.S.Kanagalakshmi et. Al. [23] They observed the potential use of both agricultural and industrial wastes namely RHA (Rice Husk Ash) and CD (Copper Dust) as raw material in production of concrete. They perform an experimental investigation on replacement of copper dust and rice husk in cement concrete. They studied that it enhances the mechanical properties of concrete subjected to split tensile test and compressive strength test. Based upon the quantities of ingredient of the mixes, the quantities of RHA, CD for 20%, 30% and 40% replaced. They conclude that that concrete with 20% RHA and 40% CD had shown high compressive strength. Hence up to 20% RHA replacement would not adversely affect the strength and mechanical properties. The addition of RHA and copper dust to a concrete mix improved the mechanical properties of concrete with respect to compressive strength and it is nearly about upto 25%. Split tensile strength had shown an increase with increase in replacement levels of copper dust upto 40% with fine aggregate.

Jamshidi A. et. Al. [24] They found that disposal of human sewage has become a necessity for societies. The construction of treatment plants has caused problems with huge contents of Dry Sludge. They also found that each person produce 35 to 85 grams of solid sludge per day.To evaluate the effects of dry sludge on concrete performance, its physical and mechanical properties were studied. Concrete specimens were prepared with water to cement ratios of 0.45 and 0.55, and with sludge contents of 0, 5, 10, 20 and 30 percent. It was observed that the dry sludge of waste water treatment plant of has a satisfying compatibility to concrete materials, due to high contents of SiO_2. Utilization of 10% of dry sludge in concrete caused 8% decrease in compressive strength. They proposed that concretes containing more than 10% of dry sludge can be used as non-constructional concretes such as paving and flooring concretes.

Jain D. and Kothari A. [25] They investigated that Human hair is strong in tensionand it can be used as a fiber reinforcement material. Hair Fiber (HF) an alternate non-degradable matter is available in abundance and at a very cheap cost. It also creates environmental problem for its decompositions. They studied the effect of human hair on plain cement concrete on the basis of its compressive, crushing, flexural strength. Experiments were conducted on concrete beams and cubes with various percentages of human hair fiber i.e. 0%, 1%, 1.5%, 2%, 2.5% and 3% by weight of cement.They concluded that increase in 22% of compressive strength and 8.6% in flexural with 1.5% hair replaced for M15 grade of concrete.

III. CONCLUSION

From the research discussed it is clear that these various wastes are suitable in the construction industry especially in concrete making.Industrial and agricultural waste materials such as fly ash, blast furnace slag, quarry dust, tile waste, broken glass waste, waste aggregate from demolition of structures, ceramic tiles, E-waste, waste paper mill pulp, iron filling, waste coconut shell, rice husk ash, marble dust powder, hypo sludge, machine crushed animal bones, chicken feather, eggs shell, granite quarry sludge, palm oil fuel ash, copper dust, human hair etc.are used in varying proportion as a partial replacement of concrete ingredients. Researchers have indicated their potential forusage in both structural and non-structural concrete. They were found to be performing better than normal concrete, in properties such as workability, durability, permeability and compressive strength. As disposal of wastes, by-products is a major problem in today'sworld due to limited landfill space as well as its escalating prices for disposal, utilization of these wastes in concrete will not only provide economy but also help in reducing disposal problems.

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