Literature Review on Different Plastic Waste Materials Use in Concrete

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***Abstract* –Plastic waste is silent threat to the environment and their disposal is a serious issue for waste managers. Now a day society does not have any alternative to plastic products like plastic bags, plastic bottles, and plastic sheets etc. In spite of all efforts made to limit its use but unfortunately its utility is increasing day by day. To circumvent this issue many efforts were made in the past to reuse the plastic waste but no significant results were achieved. On contrary concrete being the widely used construction material is facing problem due to unavailability of construction material (Cement, sand and coarse aggregate). Various attempts were made through experimentation to check the feasibility of plastic waste to be use partially in concrete with respect to various properties of strength, workability, durability and ductility of concrete. This paper includes review of various studies conducted on utility of waste plastic material used in the concrete. Moreover this paper will draw our focus toward the impingement on the various properties of concrete when partially replacing with waste plastic.**

***Index Terms*— plastic waste, concrete, replace, testing, properties**

I. Introduction

Used Plastic bags, pieces of plastic sheets and bottles of diverse sizes, colors and textures are found flying around freely, scattered in the streets, swimming in the gutters, posing a serious environmental threat. These keep the environment dirty and cause blockages to our sewer system. Several attempts were made to discourage plastic bags and other plastic products but yield no result due to its versatility in daily use. Being cheap and easily available now it look like that we have to live up with it.

Large quantity of plastic waste is produced every year. Recycle process and reused of plastic waste products amount for vast manpower and huge processing cost resultantly very small amount of plastic waste is recycled and used and rest going into landfills, incinerators and dumps. Now the question arise how to effectively minimize the impact of plastic waste with minimum cost? Many researchers have tried for the utilization of plastic waste and few have suggested its utilization in concrete in many forms.

The utilization of waste in the construction industry has two glaring dividends, one, environmental impact is addressed by disposal of the waste and second, the economic impact and this waste has the edge of being available large quantity, everywhere and at low value.

Concrete[3] being the widely used construction material in the world estimated up to 11 billion metric tons every year. Typical concrete ingredients are cement, sand and coarse aggregate which are used universally for producing concrete. Due to the great utility of concrete, with the passing of each day these materials are getting deficient thus demanding for the alternatives. It is off course a matter of serious concern for the civil engineers who are on the search of suitable materials which can fully or partially replace the typical concrete materials.

Keeping in view the disposal issues of plastic waste, its utility in concrete is studied and experimented by various researchers. They have worked on the use of pulverized plastic in concrete as partial replacement of fine aggregate and use of waste plastic in concrete as partial replacement of coarse aggregate. Testing was conducted on the samples casted by using plastic waste in the laboratory to study the variation of concrete properties from normal concrete.

The behavior of concrete is studied under various combination of plastic waste material with regard to effect on various concrete properties. This paper is based on the review of literature which gives the idea of utilizing various plastic waste materials in the concrete.

II. Literature Review

Youcef Ghernouti et al. [1] The study present the partial replacement of fine aggregate in concrete by using plastic fine aggregate obtained from the crushing of waste plastic bags. Plastic bags waste was heated followed by cooling of liquid waste which was then cooled and crushed to obtained plastic sand having finesse modulus of 4.7. Fine aggregate in the mix proportion of concrete was replaced with plastic bag waste sand at 10%, 20%, 30% and 40% whereas other concrete materials remain same for all four mixes. In fresh properties of concrete it was observed from the results of slump test that with increase of waste content workability of

[3] PK Mehta "Concrete Microstructure, properties and Materials" third edition, chapter1, p-3

concrete increases which is favorable for concrete because plastic cannot absorb water therefore excessive water is available. Bulk density decreases with increase of plastic bags waste. In harden state, flexural and compressive strength were tested at 28 days and reductions in both strengths with increasing percentage of plastic bag waste sand in concrete mix. Plastic waste increases the volume of voids in concrete which on other hand reduce the compactness of concrete simultaneously speed of sound in concrete is also decreased. Strength reduction in concrete mix was prime concern; however they recommend 10 to 20% replacement of fine aggregate with plastic aggregate. Use of admixtures to address the strength reduction property of concrete with addition of plastic aggregate is not emphasized.

Raghatate Atul M.[2] The paper is based on experimental results of concrete sample casted with use of plastic bags pieces to study the compressive and split tensile strength. He used concrete mix by using Ordinary Portland Cement, Natural River sand as fine aggregate and crushed granite stones as coarse aggregate, portable water free from impurities and containing varying percentage of waste plastic bags (0%, 0.2%, 0.4%, 0.6% 0.8% and 1.0%). Compressive strength of concrete specimen is affected by the addition of plastic bags and with increasing percentage of plastic bag pieces compressive strength goes on decreasing (20% decrease in compressive strength with 1% of addition of plastic bag pieces). On other hand increase in tensile strength of concrete was observed by adding up to 0.8% of plastic bag pieces in the concrete mix afterward it start decreasing when adding more than 0.8% of plastic bags pieces.

He concluded that utility of plastic bags pieces can be used for possible increase in split tensile strength. This is just a basic study on use of plastic bags in concrete. More emphasis was required by varying the shape and sizes of plastic bags to be use in concrete mixes.

Praveen Mathew et al. [2013][3] They have investigated the suitability of recycled plastic as partial replacement to coarse aggregate in concrete mix to study effect on compressive strength, modulus of elasticity, split tensile strength and flexural strength properties of concrete. Coarse aggregate from plastic was obtained by heating the plastic pieces at required temperature and crushed to required size of aggregate after cooling. Their experimental results shown that plastic aggregate have low crushing (*2.0 as compare to 28 for Natural aggregate*), low specific gravity(*0.9 as compare to 2.74 for Natural aggregate*), and density value(*0.81 as compare to 3.14 for Natural aggregate*), as compare to Natural coarse aggregate. Their test results were based on 20% substitution of natural coarse aggregate with plastic aggregate. Increase in workability was reported when slump test for sample was carried out. Volumetric substitution of natural aggregate with plastic aggregate was selected best in comparison with grade substitution. At 400 centigrade temperature Plastic coarse aggregate shown considerable decrease in strength as compare to normal concrete. An increase of 28% was observed in compressive strength but decrease in split tensile strength and modulus of elasticity was observed. They recommended that with use of suitable admixture @0.4% by weight of cement will improve the bonding between matrix and plastic aggregate; however they demand more research to address the tensile behavior of concrete prepared with 20% plastic aggregate.

R L Ramesh et al.[4] They have used waste plastic of low density poly ethylene as replacement to coarse aggregate to determine its viable application in construction industry and to study the behavior of fresh and harden concrete properties. Different concrete mix were prepared with varying proportions (0%, 20%, 30% & 40%) of recycle plastic aggregate obtained by heat treatment of plastic waste (160-200 centigrade) in plastic granular recycling machine. A concrete mix design with 1: 1.5: 3 proportions was used having 0.5 water/cement ratio having varying proportion of plastic aggregate as replacement of crushed stone. Proper mixing was ensured and homogeneous mixture was prepared. A clear reduction in compressive strength was reported with increase in percentage of replacing plastic aggregate with crushed aggregate at 7, 14 and 28 days of casted cubes (80% strength achieved by replacing waste plastic up to 30%). The research highlights the potential application of plastic aggregate in light weight aggregate. Their research was narrowed down to compressive strength of concrete with no emphasis given to flexural properties of concrete. They suggest future research scope on plastic aggregate with regard to its split tensile strength to ascertain its tensile behavior and its durability aspects for beams and columns.

Zainab Z. Ismail et al. [2007][5] they have conducted comprehensive study based on large number of experiments and tests in order to determine the feasibility of reusing plastic sand as partial replacement of fine aggregate in concrete. They conducted tests on concrete samples for dry/fresh density, slump, compressive and flexural strength and finally toughness indices on room temperature They have collected waste plastic from plastic manufacture plant consist of 80% polyethylene and 20% polystyrene which was crushed (varying length of 0.15-12mm and width of 0.15-4mm). Concrete mix were produce with ordinary Portland cement, fine aggregate (natural sand of 4.74mm maximum size), coarse aggregate (max size below 20mm) and addition of 10%, 15% and 20% of plastic waste as sand replacement. Their test results indicate sharp decrease in slump with increasing the percentage of plastic, this decrease was attributed to the presence of angular and non uniform plastic particles. In spite of low slump however, the mixture was observed with good workability and declared suitable for application. Their tests also revealed the decrease in fresh and dry density with increasing the plastic waste ratio; however increase was reported in dry density with time at all curing ages. Decrease in compressive and flexural strength was observed by increasing the waste plastic ratio which can be related to decrease in adhesive strength between plastic waste particles with cement. However, load-deflection curve of concrete containing plastic waste showed the arrest of propagation of micro cracks which shows its application in places where high toughness is required. The study has shown good workability in spite of low slump but w/c content kept constant in all samples. They should have reduced the water content in order to improve the strength when workability was not an issue.

P. Suganthy et al.[2013][6] This study investigate the application of pulverized fine crushed plastic (produce from melting and crushing of high density polyethylene) as replacement of fine aggregate in concrete with varying known percentages. Their main

focus was on optimum replacement of natural sand by pulverized plastic sand. Five concrete mixes were produced from specified concrete materials having replacement of fine aggregate (sand) by 0, 25, 50, 75 and 100% respectively to study the test graph results of various concrete properties. The results showed increase in water/cement ratio with increase replacement of sand with plastic particles to achieve desired 90mm concrete slump. They have also observed from the results that gradual decrease in strength of concrete specimen for plastic replacement up to 25% but afterward the decrease in strength is rapid which shows suitable replacement up to 25% of sand with plastic pulverized sand. They have also concluded after testing of specimen (having different proportion of plastic replacement) for Ultimate and yield strength that both strength decreases with increase replacement of sand with pulverized plastic particles. Their study lacks detailed testing of properties of concrete because only compressive strength and w/c ratio tests will not be sufficient to study the matrix as a whole to be suitable for construction. No efforts were made to explore the use of admixtures in controlling of compressive strength reduction in a mix containing pulverized plastics.

Khilesh Sarwe.[2014][7] This study presents the results of addition of waste plastics along with steel fibers with an objective to seek maximum use of waste plastic in concrete. Two different categories of mix were casted in cubes (150mm x 150mm x 150mm), one with varying percentages of plastic wastes (0.2%, 0.4%, 0.6%, 0.8% and 1% weight of cement) and another mix of plastics waste/steel fibers (0.2/0.1, 0.4/0.2, 0.6/0.3, 0.8/0.4 and 1/0.5 % by weight of cement) to study the compressive strength at 7 and 28 days strength. The combine mix of plastic waste and steel fibers has shown more strength as compare to concrete mix prep only with plastic waste. He has reached to conclusion that a plastic waste of 0.6% weight of cement when used with steel fiber of 0.3 % (weight of cement) has shown the maximum compressive strength. This study has really focused on addressing the issue of reduced compressive strength with addition of plastic waste. Steel fibers when used along with plastic wastes will affect all the properties of concrete but the researcher only focused on compressive strength property which is insufficient to give clear picture of concrete behavior.

A Bhogayata et al. [2012] [8] they have studied the environment friendly disposal of shredded plastic bags in concrete mix to be use in construction industry which have dire need for alternative material to be use in lieu of conventional materials. Different test results were analyzed after testing on 48 x concrete cubes(150mm x 150mm x150mm) prepared from varying percentage of polyethylene fibers (0.3, 0.6, and 0.9 to 1.2% of volume of concrete) with conventional concrete material to prepare mixes. Two type of plastic bag fibers were used, one cut manually (60mm x 3mm) and another shredded into a very fine random palettes. Cubes were tested for 7&28 days compressive strength and compaction. They concluded that good workability was shown by the mix added with shredded fibers due to its uniform and higher aspect ratio evenly sprayed in the mix. Addition of plastics up to 0.6% is considered suitable after which reduction in compressive strength and compaction is seen affected. They observed that strength loss was less in concrete having shredded fibers of plastic as compare to hand cut macro fibers. Their research focus was only on comparative study of compressive strength but no work was carries out on other concrete properties like tensile strength, modulus of elasticity and density of concrete.

M. Elzafraney et al. [2005][9] this study has incorporated use of recycled plastic aggregate in concrete material for a building to work out its performance with regards to thermal attributes and efficient energy performance in comparison with normal aggregate concrete. The plastic content concrete was prepared from refined high recycled plastics to meet various requirement of building construction like strength, workability and finish ability etc. Both buildings were subject to long and short term monitoring in order to determine their energy efficiencies and level of comfort. It was observed that recycled plastic concrete building having good insulation used 8% less energy in comparison of normal concrete; however saving in energy was more profound in cold climate in building with lower insulation. They recommended that efficiency of energy can further be increase if recycle plastic of high thermal capacity is used. They have suggested the use of recycle plastic aggregate concrete being economical and light weights are having high resistance to heat. The author should also incorporate the comparison of both buildings with regards to durability and strength.

Pramod S. Patil.et al [10] This study presents the use of plastic recycled aggregate as replacement of coarse aggregate for production of concrete. They used forty eight specimen and six beams/cylinders casted from variable plastic percentages (0, 10, 20, 30, 40 and 50%) used as replacement of coarse aggregate in concrete mixes. They have conducted various tests and observed decrease in density of concrete with increase percentage of replacement of aggregate with recycle plastic concrete. They also reported decrease in compressive strength for 7 and 28 days with increase in percentage of replacement of coarse aggregate with recycle plastic aggregate. They have recommended feasibility of replacing 20 % will satisfy the permissible limits of strength. Again these researchers limited their research to only compressive strength property and no work was carried out to study the other important properties of concrete. Their research also lacks use of various admixtures in concrete to cater for the loss in strength.

III. CONCLUSIONS

A. The researchers have represented different forms of plastic waste which can be use in production of concrete. They proposed the replacement of various concrete ingredients with suitable plastic waste material. Their proposals were based on results obtained from experimentation of various casted concrete samples.
B. Most of the researchers have restricted their work to analyze the specific concrete property which does not reflect the true behavior of concrete containing plastics. Concrete is a composite material in which all the properties have direct or indirect relation.
C. The main focus of researchers was on the compressive strength of concrete containing plastics and very less attention was given to other properties of concrete.

D. All the researchers used the typical concrete ingredients with plastic waste and no attention was given to admixtures and use of fly ash etc which can alter the properties of concrete.
E. A plastic with low specific gravity have great potentials in light weight concrete but was not comprehensively covered by any of the researcher.
F. The area of research on use of plastics in concrete has no information on binding property of plastic in the concrete mix.
G. The effect on ductility of concrete containing plastics is another ignored area on behalf of all researchers.
H. Based on above literature work we reached to a conclusion that Plastic waste can be successfully use in concrete. Reduction in density and compressive strength was reported by all researchers. The area of focus of all the researchers was limited to compressive strength and a wide gap is left for further research on other properties of concrete produce by using plastic wasted. Plastic waste material requires detail investigation on behavior of its various types in concrete.

IV. ACKNOWLEDGMENT

We are very thankful to the entire researchers who have done excellent work for drawing attention towards possible disposal of plastic waste in concrete. Their efforts will really helps in saving environment from plastic waste.

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