COMPARISION BETWEEN NORMAL CONCRETE AND CONCRETE CONTAINING RECYCLED PLASTIC AGGREGATES (ELECTRONIC WASTE & HDPE) AS A PARTIAL REPLACEMENT OF NATURAL COARSE AGGREGATES

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ABSTRACT: *Nowadays, the demand of infrastructure is increasing day by day. The fundamental component in the construction of any infrastructure is concrete. Due to the widespread use of concrete as the main building material, the availability of raw materials is being questioned. The relationship between supply and demand for a material is rapidly increasing. Thus, in order to overcome the demand for natural materials such as aggregate, alternatives to this material must be sought. On the other hand, the generation of e-waste (e-waste) is also an emerging problem that poses serious environmental problems. The generation of e-waste is a very serious problem in the world. Electronic waste (E-Waste) was selected in this study to ensure its possible use as an additive in concrete construction. The study used an experimental research design to carry out its work. E-Waste was passed through various stages which turned it into particles around 20mm size. The shredded E-waste was used in concrete at 10%, 20% and 30% by weight of conventional coarse aggregate. Four types of concrete samples were made, including the control. The flexural and compressive strength of the concrete specimens was tested after a curing period of 7 days, 14 days, and 28 days, respectively. The result showed that a concrete sample containing 10% E-waste by weight showed higher compressive strength than other samples. The flexural strength of the concrete samples containing E-Waste aggregate was lower than that of the control concrete. The wider use of these wastes leads to a decrease in the demand for natural resources used in concrete.*

Keywords: Electronic waste, Compressive strength, partially replacement, Tensile strength, Flexural strength.

I. INTRODUCTION

Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens (cures) over time. In the past lime based cement binders were often used, such as lime putty, but sometimes with other hydraulic cements, such as a calcium aluminates cement or with Portland cement to form Portland cement concrete. Many other non-cementitious types of concrete exist with other methods of binding aggregate together including asphalt concrete with a bitumen binder which is frequently used for road surfaces and polymer concretes that use polymers as a binder.

Electronic waste or e-waste describes discarded electrical or electronic devices. Used electronics which are destined for reuse, resale, salvage, recycling, or disposal are also considered as E-waste. Informal processing of electronic waste in developing countries may cause serious health and pollution problems, as these countries have limited regulatory oversight of e-waste processing.

Lifestyle changes and an ever-growing population have led to a significant increase in the amount of plastic waste after consumption. The annual consumption of plastics in the world has increased from about 5 million tons in the 1950s to about 100 million tons recently, and the production of plastic waste is increasing rapidly. Plastic waste is now a major environmental threat to modern civilization. Plastics are composed of a variety of toxic chemicals, which pollute soil, air and water.

The development of alternative recycling systems and the recovery of waste, especially non-containers are returnable. Now a day’s plastic is being used as a combination of concrete and High Density Polyethylene (HDPE) in the building. There are different types of plastic waste aggregates that can be used for specific purposes.

High Density Polyethylene (HDPE) is well suited for a range of blow injection, and rotational Molding applications like IBCs and storage tanks, crates and pallets, pails and lids, automotive components, bottles and caps, toys, and water sports equipment. Additionally, HDPE resins are utilized in extrusion film applications such as grocery, garbage and deep freezer bags (10 to 25 microns). This is just one more way in which the ExxonMobil polyethylene business is helping deliver tomorrow's performance today.

Electronic Waste (E-Waste) is widely used in Japan and is discarded after a single use. E-Waste is commonly used in the manufacture of plastic bottles, food packaging etc. Studies have shown that incorporating plastic aggregate into concrete can achieve the approx. same level of strength as regular concrete and can be used in construction applications.

In recent years, plastic consumption has increased dramatically around the world, producing large amounts of plastic based waste. Plastic waste is now a serious environmental threat to modern lifestyles, despite measures being taken to reduce its consumption. It creates a lot of waste every day, which is very unhealthy. Plastic bottles, tins and other packing plastics such as High Density Polyethylene (HDPE) are used as partial components in this production of interlocking concrete blocks.

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One of the new waste materials used in the concrete industry is the recycled e plastic. For solving the disposal of large amount of recycled plastic material, the reuse of plastic in concrete industry is considered as the most feasible application. Recycled plastic can be used as coarse aggregate in concrete. However it is important to underline that reusing of wastes is not yet economical advantages, due to high cost of transport in these effect on the total costs of production. Moreover, it is important not to neglect other costs, directly referable to the kind of waste, due, in particular, to the need of measuring gas emission, during firing, and the presence of toxic and polluting elements.

In this research we will investigate the compressive strength, workability, flexural strength and split tensile strength of concrete first with natural aggregates and then by replacing natural aggregates with uncoated HDPE and Electronic waste. This research will describe the suitability of recycled plastics HDPE and E-Wastes as a partial replacement of coarse aggregate in concrete and its benefits. Comparison of normal concrete and concrete containing HDPE and Electronic wastes will be done in terms of workability, compressive strength, flexural strength and split tensile strength.

II. OBJECTIVES

The main objective of this research is to study the suitability of waste plastics (E-Waste) in concrete as partial improvement of coarse aggregates and comparison of the properties of E-Waste concrete with conventional concrete. The detailed objectives are as under

- Detailed literature review related to the effects of addition of waste plastics (E-waste) in concrete.
- Tests for dry density, bulk density, water absorption and specific gravity on E-waste and natural coarse aggregates
- Test for Workability on normal concrete and concrete containing E-waste separately and comparison of the test results of normal concrete and E-Waste concrete according to standard (ASTM C143/C143M)
- Test for compressive strength on normal concrete and E-waste concrete separately and comparison of the test results of normal and E-Waste concrete according to standard (ASTM C39/C39M – 17b)
- Test for flexure strength on small beams containing normal concrete and E-waste concrete separately and comparison of test results of normal concrete and E-Waste concrete according to standard (ASTM C293 CenterPoint Loading)
- Test for split tensile strength on normal concrete, E-Waste concrete separately and comparison of the test results of normal and E-waste concrete according to standard(ASTM C496/C496M – 17)

III. LITERAURE REVIEW

IV. High Density Polyethylene (HDPE)

High Density Polyethylene (HDPE) is a thermoplastic polymer made from petroleum. As one of the most versatile plastic materials around, HDPE plastic is used in a wide variety of applications including plastic bottles, milk jugs, and shampoo bottles, bleach bottles, cutting boards, and piping. Known for its outstanding tensile strength and large strength to density ratio, HDPE plastic has a high impact resistance and melting point. Besides its use for food applications, it can be found in unusual places, including wood plastic composites plastic surgery, specifically skeletal and facial reconstruction, 3-D printing filament and food and beverage containers and in concrete as coarse aggregates.

Considering how much plastic we use in our day to day lives one of the most important factors when deciding on a material is plastic recycling. Fortunately, HDPE plastic is easily recyclable, helping keep non-biodegradable waste out of landfills while helping reduce plastic production by up to 50 percent. If you are looking for a cost effective environmentally responsible material, HDPE may be the plastic for you.

HDPE often replaces heavier materials which help companies and individuals alike pursue sustainable and affordable manufacturing and project goals. Thanks to its high malleability, rigid strength, and corrosion resistance. HDPE is the perfect combination of strength, cost efficiency, and environmental friendliness.

In 2020, **P.O. Awoyera, A. Adesina [1]** worked on case study in construction material that concrete incorporating plastic waste as partial replacement of sand in fine aggregates constituents and found to have good resistance against impact load. The impact of concrete increased was by 39% when 20% of plastic constituents were used.

Ahmad K. Jassim in 2016 **[2]** investigated that High Density Polyethylene waste is mixed with Portland cement to investigate the possibility to produce plastic cement and study the effect of replacing sand by fine polyethylene waste with different percentage on the properties of product. The experiments were done by using the waste of polyethylene packages include bottle and food crates in the range of 10% to 80% by volume as a short reinforcement structure. The results show that there is a possibility to produce plastic cement from polyethylene waste and Portland cement by using 60% and 40% respectively. Plastic cement with waste High Density Polyethylene have up to 60% good workability. By increasing the HDPE ratio, the compressive strength values of concrete mixtures decrease at each curing age. The best compressive strength was found in the mixture has 25%, 30%, and 35% polyethylene. The yield points for them are 971, 915, and 945 N, for immerged 7 days respectively.

Zasiah Tafheem et al. 2017-18 [3] investigated the properties of concrete containing High Density Polyethylene (HDPE) plastic that were used as partial replacement of coarse aggregate. The normal consistency of the cement was measured 31.7% as per ASTM C187. It was calculated that splitting tensile strength values for 10% HDPE, and 5% E- WASTE +5% HDPE replaced concrete specimens were decreased by 37%, 7% respectively. The compressive strength values for 10% E-WASTE, 10% HDPE, and 5% E- WASTE + 5% HDPE replaced concrete specimens were decreased by 35%, 48% and 40% respectively while compared to control concrete. Based on the test results, the E- WASTE plastic showed slightly higher compressive strength than HDPE plastic concrete.

Ingabire Dominique et al. [4] determined the melting point and subsequent effects of temperature on High Density Polyethylene (HDPE) as well as determining the mix ratio of the material components that gives the highest compressive strength. To determine the melting point of plastic and subsequent effects of temperature on the mass of HDPE, different samples of the material were heated in a closed drum and their temperatures observed at 30 minutes interval. It was observed that HDPE melts at a temperature of 120-400 degrees Celsius.

Naveen Lasiyal, Lt. Gurkirat Singh Pawar, Meenakshi Dixit in 2016 [5] studied that High Density Polyethylene terephthalate (E- WASTE) were used as partial and complete substitutes for sand in concrete composites. Sand was substituted for 2% to 100% by volume with the same volume of granulated HDPE aggregates for different sizes.

Mohd Mustafa Al Bakri, et al. [6] aimed to study the characterization of HDPE polymer waste aggregate to compare with crushed stone coarse aggregate. The physical analysis of plastics waste coarse aggregates gave the value of 12-17 MPa in compressive strength, 1400-1550 kg/m3 for density concrete, 5-7% in water absorption for aggregate, and suitable as coarse aggregate for concrete. However, the size and shape can be achieved in range 14-20 mm but the aggregate have smooth surface which are considered too severely affect their workability. The compressive and flexural strength of concrete containing the plastics waste a decreasing when the plastics waste increase. The concrete containing plastics waste aggregate of 60:40 % mixing ratio gave the highest strength properties. The connection between plastics waste aggregate and crushed stones will give the higher strength and better properties.

Anju Ram e san, Shemy S Babu, AswathyLal [7] studied High Density Polyethylene (HDPE) as a substitute for natural aggregate. HDPE is the largest of the three polyethylenes by volume of consumption. Compressive strength (after Sulphuric acid curing) increased by 11% for a mix with 30% replacement of natural aggregate by plastic aggregate when compared to control mix. Compressive strength increased by 7% for the mix with 30% replacement of natural aggregate by plastic aggregate when compared to control mix: after sodium Sulphate curing.

Heru Purnomo, Gandjar Pamudji and Madsuri Satim [8] study showed that that compressive strength of all kinds of concrete studied, decreases as water to cement ratio increases. Compressive strength of concrete containing sand coated plastic coarse aggregate is higher than that of concrete with uncoated plastic aggregate. Based on the experiments results represented by the increase of compressive strength and lesser crack appearance on the surface of concrete cylinder specimens, it can be concluded that the sand coating of the surface of plastic coarse aggregate is able to enhance the bond between coarse aggregate and mortar.

M. Mustafa Al Bakri, S. Mohammad Tamizi, A. R. Rafiza, Y. Zarina [9] investigated the HDPE Plastic Waste Aggregate on the Properties of Concrete and study the characterization of HDPE polymer waste aggregate for comparison to crushed stone coarse aggregate. The investigated temperature range was 20 -180 °C. The samples were heated at 15 °C/min up to 180 °C, held at that temperature for five minutes, and cooled at 15 °C/min to 20 °C. Each sample (4-6 mg) was weighed and sealed in the aluminum vessel. The results show that fresh plastic waste coarse aggregate has lower water absorption and a smoother surface texture. Usually plastics do not absorb water, but the heating process modified the aggregate, giving it a higher density. Thus, during the mixing process, less water can be used. The compressive and flexural strengths of concrete containing the plastic waste decreased as the proportion of plastic waste increased. The concrete that contained 60:40 ratio of plastic waste to gravel gave the highest strength properties. The connection between the plastic waste aggregate and crushed stones will give increased strength and better properties.

Neslyn Lopez, EmillaCollado, Lois Alexandra Diacos, and Harold Dave Morente [10] studied that the effect of High-density Polyethylene as partial replacement of coarse aggregates on the physical and mechanical properties of Acrylic Polymer Pervious Concrete (ACPPC). Two different coarse aggregate sizes were evaluated which are ½” and ¾” with varying ratios of 10%, 20%, and 30%. It was determined that the partial replacement of recycled HDPE caused an increase in the porosity and permeability of the ACPPC. However, it decreased the ACPPC’s compressive and flexural strength. Only the ½” 10% HDPE modified Pervious Concrete with 15% Acrylic Additive (PCHA) achieved a compressive strength that is within the range of the acceptable compressive strength for pervious concrete. This study used the crushed aggregate with and without partial replacement of HDPE aggregates which are cut into ½” and ¾” sizes and cement with 15% by cement weight of acrylic polymer as binder mixed with water to produce permeable concrete samples. It can be stated that the addition of HDPE aggregates in the mixture, increases the permeability and porosity of a pervious concrete. The higher percentage replacement results to higher value of porosity and permeability.

Tanveer Asif Zerdi et al. [11] Investigated the Compressive Strength in Recycled Plastics Granules (HDPE) Concrete by Replacement with Coarse Aggregates. In this research work recycled plastic granules were used as a partial replacement to natural coarse aggregate (NCA) of concrete. Intended percentages of recycled plastic granules were in varying percentages from 0% to 30% with an increment of 10%. (0%, 10%, 20%, 30%). The compressive strength of each sample was determined and compared with conventional concrete mix. Waste scrap plastics, articles of High-Density Polythene (HDPE), materials were collected from landfills and other locations of nearby locality. These were cleaned and dried. The waste plastics articles were shaped and cut to required size. The compressive strength of modified concrete with recycled plastic coarse aggregates High Density Polythene (RPCA-HDPE) was compared with conventional concrete and it was observed that the compressive strength in comparison to conventional concrete was achieved up to 79.55%, 85.61%, and 76.47% for mix of waste plastic of 10%, 20%, and 30% respectively.

Anju Ramesan, Shemy S. Babu, Aswathy Lal [12] compared Performance of Light-Weight Concrete with Plastic Aggregate. The results showed that the addition of plastic aggregate to the concrete mixture improved the properties of the resultant mix. Cubes, cylinders and beams were casted for varying percentage replacement (5, 10, 15, 20, 25, 30, 35, and 40) of natural aggregate by plastic aggregate. Plastic aggregate there was a gradual increase in 7-day, 14 day and 28-day compressive strength of cube. An increase in strength was observed till 30% replacement of natural aggregate with plastic aggregate and on further replacement strength was found to be decreasing. Plastic aggregate is a lightweight material with specific gravity 0.94. The workability of concrete was increased by 50% for a mix containing 40% plastic aggregate. Compressive strength and splitting tensile strength of concrete increased till 30% replacement of natural aggregate with plastic aggregate (HDPE).

Parvesh Kumar, Gaurav Kumar in 2013 **[13]** studied the Effect of Recycled Plastic Aggregates (HDPE) on Concrete. Recycled plastic can be used as coarse aggregate in concrete.

However it is important to underline that re-using of wastes is not yet economically advantageous due to the high costs of transport and its effect on the total costs of production. Moreover, it is important not to neglect other costs. (HDPE) Plastics can be used to replace some of the aggregates in a concrete mixture. This contributes to reducing the unit weight of the concrete. This is useful in applications requiring nonbearing lightweight concrete, such as concrete panels used in facades. For a given w/c, the use of plastics in the mix lowers the density, compressive strength and tensile strength of concrete. The effect of water-cement ratio of strength development is not prominent in the case of plastic concrete. It is because the plastic aggregates reduce the bond strength of concrete. Therefore, the failure of concrete occurs due to failure of bond between the cement paste and plastic aggregates. Introduction of plastics in concrete tends to make concrete ductile, hence increasing the ability of concrete to significantly deform before failure. This characteristic makes the concrete useful in situations where it will be subjected to harsh weather such as expansion and contraction or freeze and thaw.

Adewumi John Babafemi et al. [14] reviewed the Engineering Properties of Concrete with Waste Recycled Plastic. The investigation showed an insignificant difference in the air contents of the various concrete mixes containing plastic aggregates up to 20% of fine aggregates. However, in comparison to the control mix (without the inclusion of any plastic aggregates), about 110%, 167%, and 387% higher air content were found in concrete when fine aggregate was replaced by 30%, 50%, and 100% plastic aggregate, respectively. The use of recycled plastic aggregates in civil engineering applications, such as pavement and infrastructure, can be an alternative to disposing of them in landfill sites. Recycled plastic aggregates can also be used for producing concrete bricks (for general applications), blocks (for riverbank protection), façade elements, non-structural concrete panels, and temporary shelters.

Edmund T.S.J et al. [15] (2015) used High-Density Polyethylene (HDPE) types of plastic to full or partial replace the fine aggregates in the concrete. The compressive strength of all concrete involving plastic as partial substitution was most likely to be significantly lower than the ordinary or controlled concrete. It is much clearer when the percentage of plastic content as partial substitution increases the lower the strength of the concrete gets. Same conclusion can be made for the slump test result where higher percentage of plastic lower the slump test, which was caused by the irregular shape, angularity as well as the surface smoothness of the plastic used as the substitution.

V. Electronic Waste (E-Waste)

Shinu & Need hidasan (2019) **[16]** proposed in this paper, Electronic waste or E-waste considered as the most dangerous among the wastes generated in the modern digital world. Due to the unending growth of these electronic wastes the drinking waters are getting polluted and our ecosystem is getting worst affected all around the world. The present environmental problems can be minimized to a certain extent by utilizing these electronic waste materials in the construction industry.

Prashant & Kumar (2019) [17] discussed that concrete is a common building material, due to its plastic mould ability and its solidity being strong and highly compressible content. About 70% of the concrete volume consists of aggregates, which not only provide the concrete mix with weight, but also carry on substantial loads. Aggregate characteristics play a significant part in determining the attributes of the substance manufactured from it. It mentions an experimental test to research the effectiveness of e-waste to remove the coarse aggregates partly. The electrical or electronic disposals discarded are e-waste. M30 blend was formulated with 10, 15 and 20 percent of the substitute rates checked. Slump tests and compressive force tests shall be performed and recorded in this paper for each replacement stage. One efficient approach to reduce E-waste is by the usage of electrical waste in concrete, which will then rest on locations and cause environmental problems.

Sabău& Vargas (2019) [18] suggested in this article, has greatly increased the amount of waste produced by human operation by the exponential rise in population growth levels in the world and the present consumer lifestyle. Especially because of its difficult degradation process, e-plastic waste causes significant environmental damage. This paper aims to identify the feasibility of partial replacement of gross mineral aggregates with e-plastic material from concrete. Tests on concrete mixes of 40, 50% and 60% of plastic e- waste were carried out for fresh and hardened properties in a control mix without e-plastic waste designed to achieve a pumping strength of 21 MPa.

Proposed in this paper by **Xavier, Parappattu** (2016) **[19]**, the disposal of used plastics is a major challenge facing the world of our time. Plastics are seen more and more every day. It is very harmful to the atmosphere owing to the poor biodegradability of plastics. Partial replacement in the M30 grade of concrete comprising steel and polypropylene fasters by recycled plastic granules, 8% and 12%, is done in the study. The steel fibers were applied by concrete volume at 0.5 %, 1% and 1.5%. The research found different percentages of steel and polypropylene, 70:30, 75:25 and 80:20. After 7 days and 28 days of water therapy, the compressive, broken tensile and bend intensity are calculated.

Manjunath (2016) [20] proposed for this e-waste paper demonstrates a specific solution to environmental and economic issues in the usage of e-plastic waste goods. By utilizing E plastic waste, the overall costs are high and infrastructure and roads have strong energy. It reduces waste management costs and saves electricity.

Ahirwar et al. (2016) [21] the primary object of the research was to examine the improvement in mechanical properties of concrete by adding electronic wastes into the concrete. The usage of electrical waste aggregates contributes to low weight concrete construction. In this study report, the coarse compound is partly substituted for E-waste from 0 to 30%; 10 percent, 20 and 30 percent of fly ash are also applied to this mixture with the partial substitution of cement. The usage of this technological waste in concrete is thus recommended to reduce the need for standard coarse and fine aggregates and thereby to conserve the natural capital.

According to **Dawande et al. (2016) [22]** workability is increased when percentage of e-waste present in concrete increases and that the workability of fly ash with e-waste concrete is even more than that of conventional concrete with e-waste. They also observed that compressive strength and flexural strength of concrete decreases as the percentage of e-waste is increased.

Akram et al. (2015) [23] published a paper "E-waste management by utilization of E-plastics in concrete mixture as coarse aggregate replacement" they focused mainly Coarse aggregate replacement, Durability, E-waste, management, Strength. This research reflects on the usage of plastic e-waste in concrete and explores the possibility of the partial substitute of coarse aggregates using shredded e-plastic particles.

In this article, India faces a big challenge to dispose of waste in sites all over the world, **Zarbade et al. (2015) [24]** this research paper provides an overview of post-effects of the usage of reclaimed complete waste, e-waste, and cocoon shells as additional content in cement blends for use by host companies to maintain the highest mechanical consistency in the corresponding cement. Concrete blends comprising different surplus material and critical qualities were set, such as friction intensity and water preservation or water absorption, and a control mixture remained resolved and contrasted.

Siddhique et al. (2015) [25] gave an overview on the use of E-waste as a substitute/replacement of aggregate in concrete. The effect of E-waste on the properties of concrete such as compressive strength, split tensile strength and durability were presented.

Suchithra et al. (2015) [26] have conducted an experimental investigation on partial replacement of E-waste in the range of 0%, 5%, 10%, 15% and 20% with coarse aggregate on M20 grade mix. They have also conducted test for the effects of sulphate and chloride attack. Thus, the addition of E-Waste shows increase in compressive strength up to 15% replacement. But the split tensile strength is almost insignificant whereas gain in flexural tensile strength have occurred even up to 15% replacements. Durability study does not affect the strength of concrete and the optimal mix is more durable than the control mix. Thus, the author concluded that it is possible to use E-waste in concrete as environment friendly manner.

T. Subramani [2015] [27] this research is expected to locate the compelling approaches to reuse the hard-plastic waste particles as coarse aggregate. From this examination it has been reasoned that the plastic waste isn't appropriate to use as a fine aggregate, it is utilized to replace as a coarse aggregate. In any case, the quality perceptibly diminished when the plastic substance was over 20%

Krishna Prasanna (2014) [28] presents the results of an experimental study to investigate the performance of concrete prepared with E-waste. A was made by preparing specimens using E-waste particles as coarse aggregate in concrete replaced at levels of 0, 5, 10, 15 and 20%.

Lakshmi et al. (2010) [29] along with her team, was studying the usage of E- waste materials for replacing the coarse aggregate. The experiment was done by choosing percentage replacement ranging from 0%, 4%, 8%, 12%, 16%, 20%, 25% in Concrete Grade M20. The Compressive, the Tensile & Flexural Strengths were found with and without replacing the aggregate with E-waste in Concrete. After the casting, the blocks showed a good gain in strength. The Ultrasonic Pulse tests on mechanical Properties were also executed. At last, they concluded that till 20% replacement of E-Waste was good and increasing the E-waste replacement deteriorated the performance. Hence, E-Waste can also be disposed in form of construction materials.

Singh and Malviya (2009) [30] publish a paper called "Experimental Analysis of Part of Partial Replacement of Aggregate by electronic waste for flexible flooring." In India, most of the highways are bituminous surface pavements. Symptoms of distressed including splitting, rutting and so on are gradually attributed to the intense traffic, filling cars and major shifts in everyday and seasonal pavement temperature in earlier stages. Work has shown that modifications can be used to boost the rheological properties of bitumen and bituminous blends and render them more appropriate for road building.

Manikandan et al [31] along with his team focused on the improper disposal of e-waste. In our Country (India), primary source of Electronic waste generated was from public & private sector which are 70% from the total waste being generated. The annually estimated generation of E-waste was around 400000 tons. It is found that most of the e-waste generated is from cities like Bombay, Delhi, Bengaluru, and Madras was estimated approx.10000, 9000, 8000 and 6,000 Tones Respectively. only 4% of total waste generated is recycled per annum, it's a disappointment. So, they made efforts for usage of E-waste components as for partially replacing the coarse(10-12) mm Aggregate. The major conclusions drawn by them are: Density of Electronic Waste as Replacement of Coarse or Fine Aggregate in concrete is less when compared to Existing Normal or Conventional concrete as resulting in the lightweight blocks emerge which also reduced the cost of concrete blocks. Up to 15% replacement is allowable as it increased compressive strength and durability compared to conventional concrete?

Sagar R. Raut [32] along with his team Roshani S. Dhapudkar, Monali G. Mandaokar focused on the replacing the coarse aggregate by electronic waste & also tried to replace fine aggregates by e-waste. They have mainly focused on the replacement of aggregates but not included fly-ash for partially replacing the cement. The major conclusions that were drawn by them were: 15% of partial replacing of aggregates gave the best results for Testing of Compression. Electronic Waste can be used as a possible partial replacement for the Coarse Aggregates. Tensile Strength (Split) was max. At 15 percent partially replacing the coarse aggregate by electronic waste. This Study show the Optimum percentage of replacement.

Pramod S. Patil.et al [33] 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 a replacement of coarse aggregate in concrete mixes. They have conducted various tests and observed a decrease in density of concrete with increase percentage of replacement of aggregate with recycling plastic concrete. They also reported a decrease in compressive strength for 7 and 28 days with the increase in the percentage of replacement of coarse aggregate with recycling 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 the use of various admixtures in concrete to cater for the loss of strength.

VI. EXPERIMENTAL PROGRAM

An experimental program was planned and implemented to achieve the objectives of research study. The focus will be on preparation of test specimens, specification of test specimen normal concrete along with cylinders which were used to strengthen these cylinders for compressive strength and split tensile test and beam for flexural test and methodology to perform test concrete cylinder specimens.

VII. PREPARATION OF TEST SPECIMENS

Concrete were prepared from the materials according to the specified ratio 1:1.5:3 derived from the mix design and cast were done in the concrete lab.

First the coarse aggregate place on mixing tray and then placed fine aggregate as sand above the aggregate at the end cement was placed on it. After this, all ingredients were mixed to each other by thrice times and then add the water according to w/c ratio. The water to cement ratio 0.45 were used in the mix design. Before poured the concrete, cylinder were oiled from inner side. To achieve the strength of cylinder better poured the concrete in the cubes in 3 layers and each layer were compacted by 25 strokes of rod.

144 specimens of cylinder were casted in lab which include 72 sample of compressive strength and 72 cylinders of tensile strength in which we used E- waste & HDPE at different ratio of 0%, 10%, 20% and 30% accordingly.

12 specimens of beam were casted in lab for the flexural strength of beam in which we used different ratio of E- waste & HDPE for the test of 28 days.

VIII. Concrete Mixing

This section describes the proportioning of concrete mixtures, the procedures used to produce the concrete mixtures, and the molding and preparation of concrete specimens for testing.

The mixing procedure began after all materials were gathered by first using a cement and water mixture to prepare the mixer. The cement and water mixture was used to coat the sides and blades of the mixer drum and prevent the loss of a mixture’s materials to the mixer surfaces.

The cement and water mixture was poured from the mixing tray. All aggregates were then added to the mixing tray. The water was added to the aggregates. This amount was subjective, with the goal of providing enough water for aggregates to approach a saturated condition. The aggregates were then mixed for approximately 3-5 minutes so that they were well blended. After mixing the all component check the slump of the concrete. The slump range is 1-3 inch.

If the minimum slump limitation was achieved, the mixing

Figure. 1 Concrete Mixing

process proceeded. If the minimum slump was not achieved, additional mixing water was added and the mixture was mixed for an additional 2-3 minutes prior to a second slump test.

The slump and air content were measured again to ensure acceptable levels of each had been obtained, and then the density was measure. No mixture in this study required additional mixing periods beyond the second admixture mixing period. After the density had been measured, the mixed concrete was transported from the mixer to the sample molding area.

Samples were prepared in accordance with AASHTO T R 39, “Making and Curing”.

Concrete Test Specimens were prepared in a Laboratory. There are total 144 cylinders were cast in lab in which 72 cylinder are caste for the compressive strength test and 72 cylinders are caste for the Split tensile strength. Cylinders are caste different ratio of E- waste. The different ratios are 0% 10% 20% and 30% for

Figure. 2 Prepared Samples

curing days of 7, 14 and 28 days.

For the test of the Flexural strength total 12 beams are caste with the different ratio of E- waste. The different ratios are 0%, 10%, 20% and 30% for curing days of 28 days.

IX. Testing Performed

The objective of this research study was to obtain failure load and observation of failure mode. So, in order to know about the failure load and failure mode in the compression testing machine of concrete cylinder of normal, E- waste concretes. After 24 hours of casting the cylinder were demolded and properly cured for different days in curing tank due to design mix. On the 7, 14 and 28 days of curing the cylinder were dragged out of the curing tank and allowed to dry for 24 hours to make them ready for testing. After that, the cylinders were tested in the compressive testing machine of 3000 KN Capacity

The machine was manually set to apply the load at the rate of 0.14 to 0.34 MPa/sec while the area of the cylinder was 18250 mm2. The compressive strength of the cylinder was found to be on 3 specimens of each groups according to design mix and curing of cylinder in the curing tank.

For the test of Split tensile test the machine was manually set to apply the load at the rate of 1.4 MPa/min while the area of the cylinder was 18250 mm2. The split tensile test of the cylinder was found to be on 3 specimens of each groups according to design mix and curing of cylinder in the curing tank.

Now for the Flexural strength test the machine was manually set to apply the load at the rate of 0.9 to 1.21 MPa/min while the area of the beam was 9040 mm^2.

X. TEST RESULT & GRAPH

Considering the objectives of the study, this chapter presents the results obtained after conducting experiments on test specimens. The focus is on the compressive strength, split tensile strength, flexural strength and failure modes of the samples. This chapter includes test results of the compressive strength, split tensile strength and flexural strength of concrete containing natural aggregate and with E-wastes and HDPE in the range of 10%, 20% and 30% by as partial replacement of the weight of natural aggregates.

XI. Experimental Observations

In this project, we use BESTWAY Ordinary Portland cement as binder and Sargodha sand as filler material. To check the quality of the mortar, various tests were performed out on the cement for (compressive strength test, initial set time test, final set time test, etc.). Figures 3 show cement used for preparation of mortar.

Figure. 3 OPC Cement

Table 1 Test Result of Cement

Sr. #	Name of Test	Standard Followed	Result
1	Consistency Test	ASTM C 187-04	27%
2	Initial Setting Time Test	ASTM C 191-04b	89 min
3	Final Setting Time Test	ASTM C 191-04b	219 min
4	Soundness Test	ASTM C151/C151 M	8 mm
5	Fineness Test	ASTM C184-94	91.2%
6	Specific Gravity Test	ASTM C77-40	2.49
7	Specific Surface Test	ASTM C204-18e1	320 m^2/Kg
8	Ignition Loss	ASTM C114	0.62

To know about the properties of Sargodha crush and Electronic wastes we conducted different tests and their test results are shown in table 2.

Table 2 Test Result of Aggregates, E-Wastes and HDPE

Sr. #	Name of Test	Standard Followed	Sargodha Crush	EWaste	HDPE
1	Sp. Gravity Test	ASTM C– 127	2.85	1.04	0.97
2	Bulk Density Test	ASTM C – 29	1602 Kg/m^3	475.8 Kg/m^3	531.6 Kg/m^3
3	Impact Value Test	BS 812-112	11.43 %	3.29 %	2.66 %
4	Fineness Modules Test	ASTM C– 136	2.100	1.677	1.787
5	Water Absorption Test	ASTM C– 128	4.75 %	3.40 %	4.70 %
6	Los Angeles Abrasion Value Test	ASTM C – 131	1.32 %	6.68 %	7.24 %
7	Shape Test	IS 2386	Angular	Angular	Angular
8	Maximum Nominal Size	-	20(mm)	19(mm)	19 (mm)
9	Minimum Nominal size	-	4.75(mm)	4.75(mm)	4.75 (mm)
10	Color	-	Grey	Dark	Dark
11	Grading	ASTM C– 136	Well graded	Well graded	Well graded

Table 3 Test Result of Concrete Workability

Sr #	Test Name	Standard Follow	0% (inch)	10% (inch)	20% (inch)	30% (inch)
1	Work-ability	ASTM C143	0.5	1	1.3	1.8
2				0.8	1.6	1.9

Gradation curve of Sargodha crush and E-wastes were plotted after carrying out sieve analysis of both aggregates and results are plotted in figure 8. The results show that both types of aggregates are well graded. The recorded load data was used to generate bar charts to represent compressive, tensile and flexural strengths of cylinders & beams.

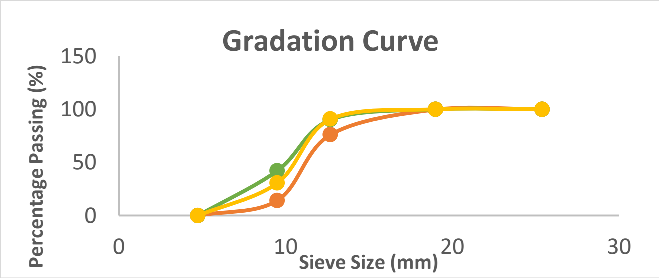

Figure. 4 Gradation Curve for Natural Aggregates, E waste and HDPE

XII. Compressive Strength test (Cylinder)

The recorded load data was used to generate bar charts to represent compressive strength test results of all cylinders after 7, 14 and 28 days curing periods.

In the case of the compressive strength shown in Table 04, where it is evident that the maximum compressive load for 28 days supported by the normal concrete cylinder was 19.5 MPa and in the case of partially replaced concrete E waste 10% replacement of the residue after 28 days was 9.3 MPa, and 10% of the partially replaced concrete HDPE after 28 days was 11.8 MPa.

Furthermore, it was observed that the behavior of the concrete cylinder before failure was almost linear. In addition to the failure mode of the concrete cylinders, this was due to de-lamination of the binding of cement mortar and plastic aggregate, resulting in brittle concrete failure.

Table 4 Test Result of Compressive Strength Test

Sr. #	7 days (MPa)	Avg. (MPa)	14 days (MPa)	Avg. (MPa)	28 days (MPa)	Avg. (MPa)
Compressive Strength Test at 0% Plastic						
Control	13.9	12.8	17.1	15.9	20.3	19.5
	12.8		16.2		19.4	
	11.7		14.5		18.7	
Compressive Strength Test at 10% Plastic						
EW	7.2	7.3	7.8	7.5	9.6	9.3
	7.5		7.5		9.3	
	7.1		7.3		9.1	
HDPE	9.2	9.5	10.8	10.8	11.4	11.8
	9.6		11.3		12.3	
	9.8		10.4		11.8	
Compressive Strength Test at 20% Plastic						
EW	4.4	4.6	7.0	7.2	7.3	7.5
	4.6		7.2		7.5	
	4.8		7.4		7.7	
HDPE	6.5	6.7	7.4	7.6	9.1	9.3
	6.7		7.6		9.3	
	6.9		7.7		9.4	
Compressive Strength Test at 30% Plastic						
EW	4.0	4.3	5.5	5.7	6.9	7.1
	4.3		5.7		7.0	
	4.6		5.8		7.3	
HDPE	5.6	5.8	6.2	6.3	7.2	7.4
	5.8		6.3		7.4	
	5.9		6.5		7.7	

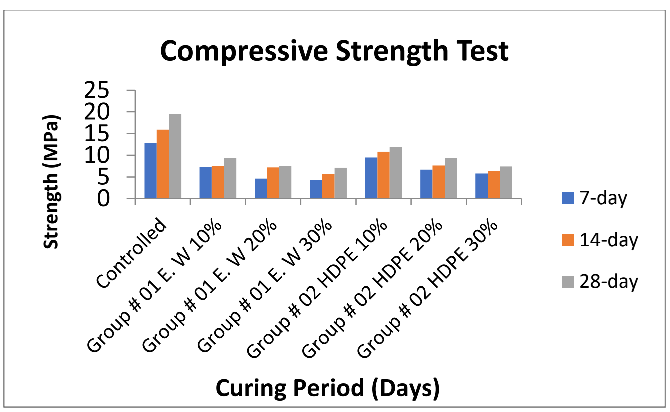

Figure. 5 Compressive Strength Test Result

XIII. Flexural Strength test (Beam)

In the case of the Flexural strength shown in Table 05, where it is evident that the maximum flexural load of 28 days taken by the concrete beam was 7.7 MPa in the case of normal concrete and in the case of the plastic concrete (E waste) 10% of residues after 28 days was 5.25 MPa and 10% of the partially replaced HDPE concrete after 28 days was 5.07 MPa.

Furthermore, it was observed that the behavior of the concrete beam before failure was almost linear. In addition to the failure mode of the concrete beam, this was due to de-lamination of the binding of cement mortar and plastic aggregate, resulting in brittle concrete failure.

Table 5 Test Result of Flexural Strength Test

Flexural Strength Test at 0% Plastic		
Sr. No	**28-days** (MPa)	**Avg.** (MPa)
Flexural Strength Test at 0% Plastic		
EW	7.2	7.5
	7.6	
	7.8	
HDPE	7.4	7.7
	7.7	
	7.9	
Flexural Strength Test at 10% Plastic		
Sr. No	**28-days** (MPa)	**Avg.** (MPa)
EW	5.23	5.25
	5.25	
	5.27	
HDPE	5.05	5.07
	5.07	
	5.08	
Flexural Strength Test at 20% Plastic		
EW	5.23	5.04
	5.25	
	5.27	
HDPE	4.56	4.58
	4.58	
	4.59	
Flexural Strength Test at 30% Plastic		
EW	4.77	4.79
	4.79	
	4.81	
HDPE	3.97	3.98
	3.98	
	3.99	

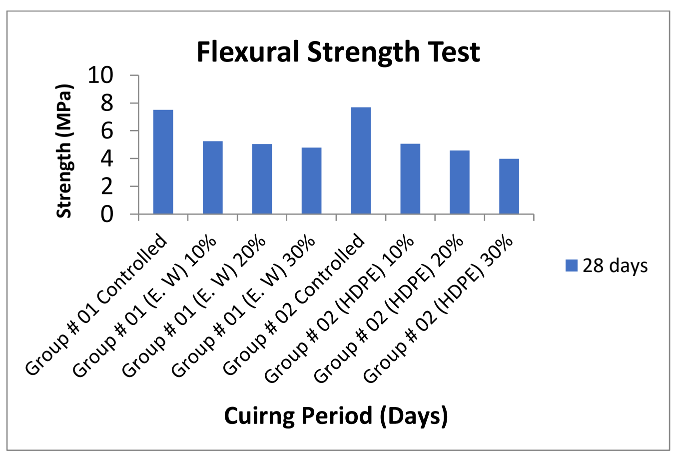

Figure. 6 Flexural Strength Test Result

XIV. Tensile Strength test (Cylinder)

In the case of the Tensile strength shown in tables 06, where it is noticed that the maximum Tensile strength in 28 days supported by the controlled concrete beam is 5.98 MPa and in the case partially replaced concrete (E waste) the 10% of residues in 28 days was 5.64 MPa, the 10% of partially replaced concrete HDPE in 28 days was 5.71 MPa.

Furthermore, it was observed that the behavior of the concrete cylinder before failure was almost linear. After the partially replaced concrete beam failure mode was changed, this was due to delamination of the cement mortar and plastic aggregate, which occurred to the brittle failure of concrete.

Table 6 Test Result of Tensile Strength Test

Sr. #	7 days (MPa)	Avg. (MPa)	14 days (MPa)	Avg. (MPa)	28 days (MPa)	Avg. (MPa)
Tensile Strength Test at0% Plastic						
	3.98		4.2		5.5	
EW	3.99	3.99	4.3	4.3	5.65	5.64
	4.01		4.4		5.77	
	5.1		5.5		5.97	
HDPE	5.23	5.28	5.7	5.7	5.98	5.98
	5.5		5.9		6.0	
Tensile Strength Test at 10% Plastic						
	3.98		4.2		5.5	
EW	3.99	3.99	4.3	4.3	5.65	5.64
	4.01		4.4		5.77	
	4.62		5.1		5.62	
HDPE	4.63	4.63	5.25	5.22	5.72	5.71
	4.65		5.32		5.79	
Tensile Strength Test at 20% Plastic						
	3.54		3.97		5.23	
EW	3.56	3.57	3.99	4.0	5.34	5.34
	3.56		4.04		5.44	
	3.87		5.01		5.55	
HDPE	3.88	3.88	5.03	5.04	5.64	5.63
	3.89		5.08		5.69	
Tensile Strength Test at 30% Plastic						
	3.24		2.88		5.12	
EW	3.26	3.26	2.94	2.99	5.14	5.14
	3.27		3.14		5.15	
	3.34		4.33		5.24	
HDPE	3.45	3.44	4.38	4.38	5.26	5.26
	3.52		4.43		5.27	

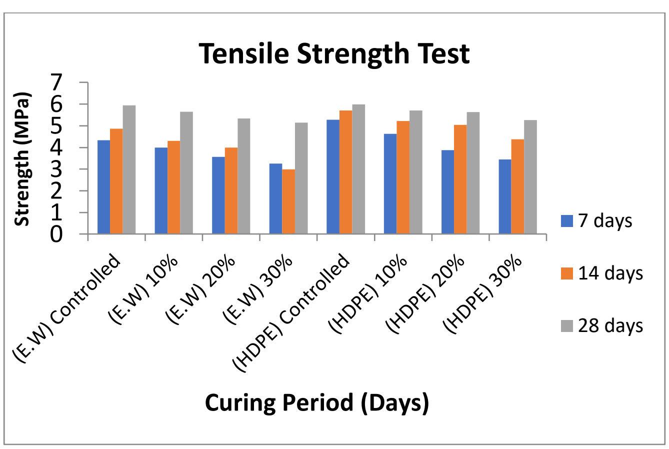

Figure. 7 Tensile Strength Test Result

XV. Failure Mode

Figure. 8 Compressive Strength Tested Specimen

Failure of a normal concrete cylinder and a partially replaced concrete cylinder indicated that the concrete specimen was tested on a compression tester under a uniform load of 0.14 to 0.34 MPa / s per unit area of the specimen. A sudden and brittle material failure occurred in the cylinder. The partially replaced cylinder were failed in the flexure direction have not fully bonded and engaged properly. The figure 08 shows a view of the destruction of a controlled concrete sample.

The failure indicated that the sample cylinder was completely compacted, resisting the load until maximum strength was reached, while the sample cylinder was fractured and destroyed. The controlled cylinder showed good resistance to applied load and had a tensile strength at the end. The partially replaced concrete cylinder specimens showed less strength compared to controlled concrete specimens because the plastic aggregates was separated during the compaction of the concrete(Due to less bonding strength). The figure shows a view of the destruction of a partially replaced concrete sample

Failure of a normal concrete cylinder and a partially replaced concrete cylinder indicated that the concrete specimen was tested using a split tensile testing machine with a uniform load of 0.7 to 1.4 MPa / min per unit area of the specimen. A sudden and brittle material failure occurred in the cylinder. A partially replaced cylinder has failed in the shear direction and the flexure is not engaging properly.

The failure indicated that the controlled sample cylinder was completely compacted, resisting the load until maximum strength was reached, while the sample cylinder was broken and failed. The controlled cylinder showed good resistance to applied load and had a tensile strength at the end. The partially replaced concrete cylinder specimens showed less strength compared to controlled concrete specimens because the plastic specimens separated during the compaction of the concrete. The figure 09 shows the mode of destruction of a concrete sample.

Figure. 9 Split Tensile Tested Specimen

Failure of a normal concrete beam and a partially replaced concrete beam showed that the concrete specimen was tested on a flexural strength testing machine under a uniform load of 0.9 to 1.21 MPa/min per unit area of the specimen of 9040 mm^2. The beam suddenly broke and the material became brittle. The partially replaced beam has failed in the shear direction and the bend is not fully engaged properly.

The failure indicated that the controlled beam was fully compacted, resisting the load until maximum strength was reached, while the controlled beam was broken and destroyed. The controlled beam showed good resistance to applied load and had a tensile strength at the end. The partially replaced concrete beams showed less strength compared to controlled concrete specimens because the plastic specimens separate with an increase in percentage of plastic and during compaction of the concrete. The figure shows the mode of destruction of a concrete sample.

XVI. Comparison with Experimental Results

The failure load of Compressive strength of normal and plastic (E- waste) samples of concrete cylinder was recorded respectively, the maximum applied load was 19.5 MPa and 9.3 MPa on an area of 18250 mm^2. As shown in the figure 10.

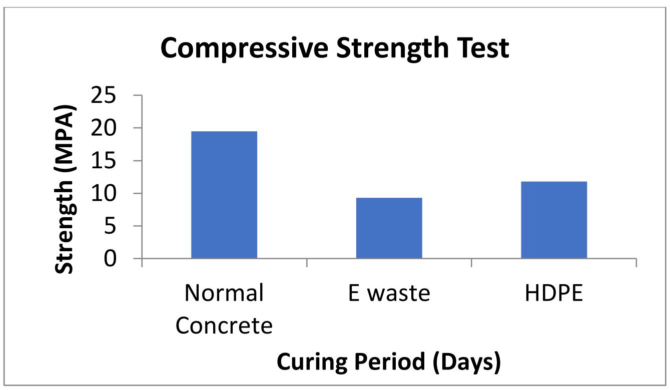

Figure. 10 Compressive Strength Test Graph

The failure load of Tensile strength of normal and plastic (E waste & HDPE) samples of concrete cylinder was recorded respectively, the maximum applied load was 5.98 MPa, 5.64 MPa and 5.71 MPa on an area of 18250 mm2. As shown in the figure 11.

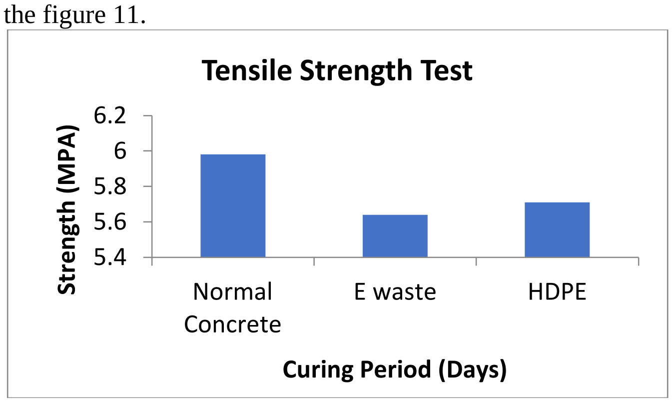

Figure. 11 Tensile Strength Test Graph

The failure load of Flexural strength of normal and plastic (E waste & HDPE) samples of concrete cylinder was recorded respectively, the maximum applied load was 7.7 MPa, 5.25 MPa and 5.07 MPa on an area of 18250 mm2. As shown in the figure 12.

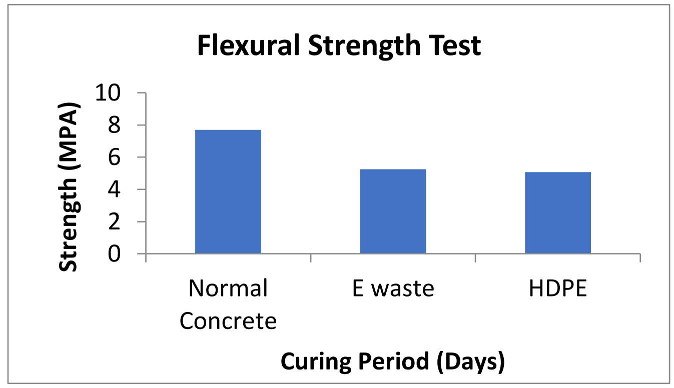

Figure. 12 Flexural Strength Test Graph

XVII. Comparison between Normal concrete and concrete containing plastic Aggregates

Normal concrete is a mixture of Portland cement, water, aggregates and in some cases admixtures. Since concrete is a versatile construction material, adaptable to a wide variety of agricultural and residential construction uses. Normal concrete has strength, durability, versatility and economy. It can be placed or molded into virtually any shape and reproduce any surface texture.

Normal concrete has relatively high compressive strength if it does not crack underweight but significantly lower tensile strength if it cracks when being pulled. The compressive strength is typically controlled with the ratio of water to cement when forming the concrete and tensile strength is increased by additives, typically steel to create reinforced concrete. Mechanical properties of normal concrete including compressive strength, tensile strength, and elastic modulus may effect on its structural changes and with elevated temperature, normal concrete will lose its hydration because of water evaporation and may cause reduction of strength.

Concrete containing plastics like E- waste have common properties such as white or colored and have the ability of easy processing, good balance of rigidity and high impact strength and good resistance against chemical attacks. Recently asphalt binders modified with electronic waste E-waste, from recycled computer plastics to improve its performance. It has also been observed that the strength decreased with increase of E- waste plastic aggregates. E-Waste plastic has low unit weight and considerable ductility.

However, incorporation of plastic aggregate concrete (E-waste) as an aggregate replacement in concrete has given scope to develop new construction materials valuable for both construction and for plastic waste recycling industries.

XVIII. CONCLUSIONS

Based on the findings of the experimental study reported in this research study, following conclusions are drawn

- Since normal concrete is strong in compression and tension (when steel is used), plastic aggregate concrete has less compressive strength and tensile strength.
- Normal concrete have greater strength as compared to plastic aggregate concrete (E- waste).

- Normal concrete is widely adaptable in building construction but plastic aggregate concrete (E- waste) is some time a difficult task in construction.
- Plastic aggregate concrete is non adaptable over a major construction project but may be preferred for a small construction project.
- The failure of plastic aggregates (E- waste) with respect to normal concrete is brittle due to de-bonding of concrete materials in plastic aggregate concrete.
- Plastic aggregate concrete (E- waste) is a promising construction material due to its low carbon dioxide emission.
- The reduced CO2 emissions of Plastic aggregate concrete (E - waste) make them a good alternative to normal cement concrete.
- Cost of normal concrete with plastic aggregates (E - waste) was almost the same.
- Plastic aggregate concrete (E - waste) has excellent properties within both acid and salt environments.
- The properties of concrete containing varying percentages of plastic were tested for compressive strength and split tensile strength and showed an appreciable improvement of concrete by introducing plastic aggregates (E - waste).

XIX. Recommendation

In continuation of present research study, following research works related to Sand Coating of Concrete may be carried out in future in Civil Engineering Department, C.E.T Sargodha.
This study recommends the following future research,

- Sand coating may be carried out to protect the external surface of plastic aggregates (E- waste) and for enhancement of plastic aggregates bonding with concrete.
- Adhesives like Epoxy, Glue can be used for sand coating of plastic aggregates (E- waste) for proper bonding of concrete mix.
- Another direction of research work in the subject area may be to study the durability of concrete containing plastic aggregates (E- waste).
- It has been observed that plastics from different sources may vary the compressive strength of the plastic aggregates concrete (E- waste). Thus, the effects of plastic aggregates concrete (E- waste) from different sources in the compressive strength needs to be further explored.
- Its strength and workability as well as compressive, split tensile and flexural strength can also be increased by adding Admixture to the concrete.

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