Environment Friendly Construction from Plastic Waste

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***Abstract*—Plastic waste which is increasing day by day becomes eyesore and in turn pollutes the environment, especially in high mountain villages where no garbage collection system exists. The main aim of this experiment is to reduce the plastic waste & using it as a construction material. This work uses waste plastics and converts them into building materials with the help of an extruder, thereby reducing the plastic waste which is a key factor for environmental pollution. Out of which brick stand out. Polyethylene terephthalate based waste were recycle and used in the experiment. PET is added with sand and aggregate at various percentage to obtain high strength bricks that possess thermal and sound insulation properties to control pollution and to reduce the overall cost of construction.**

Index Terms—aggregate, PET, plastic waste.

I. Introduction

In many countries the compositions of waste is different, that it is affected by the socioeconomic characters, waste management programs and consumption patterns, but generally the level of plastic in the waste composition is high [1]. As much as 60% of both industrial and urban waste plastic is recycled. Indian construction industry creates lots of employment opportunities and accounts for major portion of the capital outlay in successive 5-year plans of our country. Plastic waste is bulky, heavy and unsuitable for disposal by incineration or composing which result in polluting the environment, posing number of problems for the well-being of human race and resulting in hazardous disease [2]. The world's annual consumption of plastic materials has increased from around 5 million tons in the 1950s to nearly 100 million tons today. Plastics constitute approximately 3-7% of municipal waste. Presently, municipal garbage disposal departments burry the plastics along with other materials in landfill without even recognizing its ill effects [3]. Human and his activities produce a lot of wastes. At the same time, man consumes many things. Amongst the various things man consumes, building materials happen to be the largest in terms of weight being about 5 tons per capita per year, next only perhaps to water [4].

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II. Plastic Waste Recycling

Plastic recycling is the process of recovering scrap or waste plastic and reprocessing the material into useful products. Since the vast majority of plastic is non-biodegradable, recycling is a part of global efforts to reduce plastic in the waste stream, especially the approximately eight million metric tons of waste plastic that enter the Earth's ocean every year [16, 17]. This helps to reduce the high rates of plastic pollution**.** Plastic recycling includes taking any type of plastic, sorting it into different polymers and then chipping it and then melting it down into pellets. After this stage, it can then be used to make items of any sort such as plastic chairs and tables. Soft Plastics are also recycled such as polyethylene film and bags. This closed-loop operation has taken place since the 1970s and has made the production of some plastic products amongst the most efficient operations today. Compared with lucrative recycling of metal and similar to the low value of glass plastic polymers recycling is often more challenging because of low density and low value. There are also numerous technical hurdles to overcome when recycling plastic. A macro molecule interacts with its environment along its entire length, so total energy involved in mixing it is largely due to the product side stoichiometry. Heating alone is not enough to dissolve such a large molecule, so plastics must often be of nearly identical composition to mix efficiently.

Advantages:

- Generally plastic items like toys, bags can be reused in various ways such as in the manufacturing of fashionable accessories and other plastic goods.
- No doubt the recycling of plastic consume more energy and effort compare to its manufacturing but it is a good alternate to prevent the plastic pollution in environment.
- Plastic materials are light in weight, unbreakable, odourless and can be easily moulded.
- They have excellent finishing; possess good shock absorption capacity, high strength as well as toughness.
- The plastics materials are corrosion resistant and these are inert as far chemical or changes due to atmospheric oxygen goes; besides these have low thermal expansion of co-efficient.
- Therefore they possess good thermal and electrical insulating property.
- Plastics have water resistant property and possess good adhesiveness. They are strong, durable, good and cheap to produce.
- It is possible to recycle plastic; therefore no decomposition required which is much more expensive and hazardous than recycling.
- Plastic can be used in building, construction, electronics, packing and transportation industries.
- Plastic can be used to produce other product and reduce soil and wind erosion.
- Because of nonconductive nature of plastic, they can be easily use in electrical installations.

Factors affecting brick:

- Temperature
- Humidity

III. Material Requirements

For brick:

- Aggregate (Coarse and Fine)
- Cement
- Bitumen
- Waste plastic

TABLE I
TYPES OF PLASTIC AND ITS TEMPERATURE

S. No.	Type Of Plastic	Temperature
1	PET(Poly Ethelene Terepthalate)	260-280°C
2	HDPE(high density polyetheleene)	210-270°C
3	LDPE(Low density polyethelene)	180-240°C
4	PP(Poly Propylene)	250-290°C

For Road Construction:

- Polymer(PE,PP,PS)
- Aggregate
- Waste Plastic
- Bitumen

There are 3 types of bitumen grade:

- 30040 grade
- 60l70 grade
- 8010 grade

IV. Methodology

Generally, there are many methods of utilization of plastic waste such as, plastic convert in to brick, waste plastic convert into road construction, bags, fuel oil , plastic beads,etc.

Dinesh.S, Dinesh.A, Kirubakaran.K has aimed at the mixture of plastic waste, river sand and red oxide. Take the ratio of mixture is 1:2, 1:3, 1:4, 1:5, 1:6 respectively. We should collect the waste plastic bags and the polyethylene bags are sorted out and remaining are disposed safely. Then the collected waste bags are cleaned and burned out by using stones and firewood. T Then the plastic bags are added to the drum one by one and the river sand is added to the plastic when it turns into hot liquid. The sand is added is mixed thoroughly using rod and trowel before it hardens. In case of Paver blocks, Red oxide is added (less than 10% of the total weight) to impart dark red color. These mixtures are then poured in to the brick mould and they are compacted using steel rod and surface is finished using trowel. Before placing the mixture into the mould, the sides of the mould are oiled to easy removal of bricks [1].

J.Premalatha and S.Afzal Ahamed has aimed at reusable plastic waste will be collected and crushing out. The various mix proportion of plastic waste the concrete cubes, cylinder and prism have been prepared for 7days and 28days. The cube specimen were used for compressive strength whereas cylinder specimens were used for split tensile strength and prism specimens were used for flexural strength. Now, concrete cubes, cylinders, prisms are casted, which are of standard dimension of 0.15 m x 0.15 mx 0.15 m, 0.15 m x 0.3 m, 0.5 m x 0.1 m x 0.1 m. The specimens are kept for curing and tested for its compressive strength on different days (7days & 28days).then the check young's modulus [2].

Pawan Sikka has concluded that the Municipal solid waste in India contain 1-4 per cent by weight of plastic waste. India′s rate of recycling of plastic waste is the highest (60%) in the world as compared to other countries (China 10%, Europe 7%, Japan 12%, South Africa 16%, and USA 10%). As a source of hazard to environment, plastic account for 16% of chlorine in the environment and have 54 carcinogens, polythene bags for disposal if burnt irresponsibly releases highly toxic gases like phosgene, carbon monoxide, chlorine, sulphur dioxide, nitrogen oxide, besides deadly dioxin [3].

Mr.Desai Vinayak Subhash, Bahadur Asim Akram, Babar Sumit Anil, Keskar Kiran Gopal, Majahar Mahibub Baraskar has aimed at non bio degradable waste like glass and plastic. From literature support, glass, and plastic with cement, fly ash and crush sand are used as ingredient of the mix with various proportions [4].

Mostafizur Rahman, Akhtarul Islam, Mainuddin Ahmed and Abdus Salam has aimed at the using the components like Portland cement, sand, coarse aggregates (1:2:4) collected from localities and the waste plastics (HDPE and PUF based polymer materials) used in this study had been procured from waste plastic wholesaler. The amounts of waste plastic added were 10%, 15%, 20% and 25%. To prepare the fresh concrete, calculated amount of cement, sand, stones chips, waste plastic and water were mixed following a method and technique as prescribed by ASTM C 31-84 [5].

Noel Deepak Shiri, P. Varun Kajava, Ranjan H. V., Nikhil Lloyd Pais, Vikhyat M. Naik has aimed at Switch on the heater and set the temperature slightly above the melting point of different waste plastics. Mixing waste plastics, rubber composites and calcium carbonate in required quantity and is poured into the hopper when the required temperature in the control box has reached. Switch on the motor and the screw conveyor starts rotating at 80 rpm. The waste plastics from the hopper gets melted and conveyed towards the nozzle. A brick mold is kept at the end of the nozzle tip and the molten plastic/rubber composite material starts filling the mold box. After the mold is filled completely the mold box is removed from the nozzle tip dipped in the water bath and kept inside the bath for an hour for proper cooling. The final product is removed from the mould box and is sent for compression testing using Hydraulic Brick testing machine [6].

1T.Subramani, V.K.Pugal has aimed at experimental study on plastic waste as a coarse aggregate for structural concrete. Initially the dry materials cement, aggregate and sand are mixed. The liquid component of the mixture was then added to the dry material and mixing continued for further 4 minutes and cast in to the moulds after mixing, in 3 layers for cube specimens. For compaction of the specimen, each layer was given 60 to 80 manual strokes using a rodding bar, and then vibrated for 12 to 15 seconds on a vibrating table. Before the fresh concrete was cast into the moulds, the slump value of the fresh concrete was measured [8].

S. Vanitha, V. Natrajan and M. Praba has aimed at to find the properties of coarse , fine aggregates and cement and physical properties of waste plastic and to conduct mixed design as per IS:SP 23-1982. To cast both paver block and solid blocks with waste plastic. To study the compressive strength in 0 – 10% waste plastics added samples as a replacement of coarse aggregate [9].

Puttaraj Mallikarjun Hiremath, Shanmukha Shetty, Navaneeth Rai. P. G, Prathima .T.B has carried out the study to develop an efficient way too effectively to utilized the waste plastic which is a great threat for the sustainment of ecological balance. The laterite quarry waste was collected and is cut from the quarry nearly 15-20% of laterite waste is obtained. This waste was crushed using rammers and sieved in a 2.36mm IS sieve. Bricks of different mixed proportions were prepared, for each brick 3 kg of the laterite soil was added with varying bitumen content of 2, 5 and 10% along with variation in % of plastic [10].

Vidula Swami, Abhijeet Jirge, Karan patil, Suhas patil, Sushil patil, Karan salokhe has concluded that the Waste plastic bags were collected from road construction for different area waste-buyers at Rs. 5-6 per kg. The collected Plastic waste was sorted as per the required thickness. Generally, polyethylene of 60 micron or below is used for the further process. Less micron plastic is easily mixable in the bitumen at higher temperature (160°c-170°c).It is clean by de-dusting or washing if required. Collected Plastic was cut into fine pieces as far as possible. The plastic pieces were sieved through 4.75mm sieve and retaining at 2.36mm sieve was collected. Firstly, Bitumen was heated up to the temperature about 160°c-170°c which is its melting temp. Pieces were added slowly to the hot bitumen of temperature around 160-170°c.The mixture was stirred manually for about 20-30 minutes. In that time period temperature was kept constant about 160-170°c. Polymer-bitumen mixtures of different compositions were prepared and used for carrying out tests [11].

S.S. Verma has aimed at the Waste plastic is ground and made into powder; 3 to 4 % plastic is mixed with the bitumen. Plastic increases the melting point of the bitumen and makes the road retain its flexibility during winters resulting in its long life. Use of shredded plastic waste acts as a strong binding agent for tar making the asphalt last long. By mixing plastic with bitumen the ability of the bitumen to withstand high temperature increases. The plastic waste is melted and mixed with bitumen in a particular ratio. Normally, blending takes place when temperature reaches 45.5°C but when plastic is mixed, it remains stable even at 55°C. The vigorous tests at the laboratory level proved that the bituminous concrete mixes prepared using the treated bitumen binder fulfilled all the specified Marshall mix design criteria for surface course of road pavement. There was a substantial increase in Marshall Stability value of the BC mix, of the order of two to three times higher value in comparison with the untreated or ordinary bitumen. Another important observation was that the bituminous mixes prepared using the treated binder could withstand adverse soaking conditions under water for longer duration [12].

Amit Gawandea, G. Zamare, V.C. Renge, Saurabh Tayde, G. Bharsakale has conclude that there are two process 1) Dry process and 2) Wet process. In dry process the flexible pavement, hot stone aggregate (170 0C) is mixed with hot bitumen (160 0C) and the mix is used for road laying. The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity as per IS coding. The bitumen is chosen on the basis of its binding property, penetration value and viscoelastic property. The aggregate, when coated with plastics improved its quality with respect to voids, moisture absorption and soundness. The coating of plastic decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement. It is to be noted here that stones with <2% porosity only allowed by the specification [13].

Vinoth. N has conclude that they are using a dry process in the plastic waste will be collected and the cleaned it then the plastic waste can be in small size of pieces. Then the aggregate is heated and slowly added a plastic waste and mixed the bitumen shredding plastic and aggregate [14].

Shweta N. Rokdey, P. L. Naktode, M. R. Nikhar are using a 2 two process 1) Dry process and 2) Wet process. In dry process the hot bitumen and shredding plastic will be use. In wet process the Waste plastics by direct mixing with hot bitumen at 160°C. Mechanical stirrer is needed. Addition of stabilizers and proper cooling. Since the wet process require a lot of investment and bigger plants, not commonly used [15].

Taher Baghaee Moghaddam, Mohamed Rehan Karim, Mehrtash Soltani has conclude that the Marshall cylindrical samples were fabricated at 160-165˚C and 140˚C of mixing and compaction temperatures, respectively. Different percentages of asphalt cement were designated (5%, 5.5%, 6%, 6.5% and 7% by weight of aggregate particles) in this investigation. Marshall Stability and flow test were conducted on cylindrical sample according to ASTM D 1559. The specimen is placed in the water bath at the temperature of 60°C for 30 min just before commencement of the test. Marshall Stability is the maximum load applied at a constant strain (2 in. per minute) which causes failure. During the stability test the dial gauge is used to measure the vertical deformation of the specimen. Marshall Flow value is expressed as the vertical deformation happens at the failure point of specimen and usually in the units of 0.25mm. High flow values generally indicate a plastic mix that was experience permanent deformation under traffic, whereas low flow values may indicate a mix with higher voids than normal value and insufficient asphalt for durability and one that may experience premature cracking due to mix brittleness during the service life of the pavement. In addition, bulk specific gravity of compacted mixture determined in accordance with ASTM D 2726 [16].

V. Results

For Brick:

TABLE II
Properties of Bricks

Property	Plastic incorporated concrete block	Ordinary concrete block
weight	16.2 kg	19.8 kg
Block density	1800 kg/m^3	2200 kg/m^3
Water absorption	2.6%	4%

For Road Construction:

The increase in percentage of polymer decreased the penetration value. This shows that the addition of polymer increases the hardness of the bitumen. The penetration values of the blends are decreasing depending upon the percentage of polymers and the type of polymer added. The ductility decreased by the addition of plastic waste to bitumen. The decrease in the ductility value may be due to interlocking of polymer molecules with bitumen. Flash and fire point increased with the increase in the percentage of polymer .The polymer bitumen blend road surfaces are less affected by fire hazards.

VI. Conclusion

For Brick:

This work effectively converts waste plastic into useful building materials like building bricks and floor interlocks which can effectively reduce the environmental pollution and further decreases the problem of waste plastics in the society. The numerous advantages further research would improve the quality and durability of plastic sand bricks and paver blocks. The use of waste glass as fine aggregate decreases the unit weight of concrete.

The solid concrete blocks with plastic aggregates can be used as light weight concrete blocks since its weight is less than that of ordinary concrete blocks. Also water absorption and block density is found to be less for plastic incorporated concrete blocks. On comparing the cost of solid concrete blocks with plastic as partial replacement and without replacement, cost of former is lower than the latter when made in a large quantity.

Lastly, we strongly conclude that, using plastic waste in mix is the best option for the disposal of plastic and will help to increase the strength and avoid disposal of plastic waste by incineration and land filling and ultimately reduces the plastic pollution in the environment and develop a technology which is eco-friendly.

For Road Construction:

The process is environment friendly. The use of waste plastics in the manufacture of roads and laminated roofing also help to consume large quantity of waste plastics. Thus, these processes are socially highly relevant, giving better infrastructure. The modified bitumen shows good result when compared to standard results. The problems like bleeding are reduce in hot temperature region. Plastic has property of absorbing sound, which also help in reducing the sound pollution of heavy traffic. The waste plastics thus can be put to use and it ultimately improves the quality and performance of road.

The use of the innovative technology not only strengthened the road construction but also increased the road life as well as will help to improve the environment and also creating a source of income. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. It is hoped that in near future we will have strong, durable and eco-friendly roads which will relieve the earth from all type of plastic-waste. Adding higher amount of plastic bottles resulted in higher flow value.

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