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Development of Constructional Bricks from the solid waste and their Mechanical Testing

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***Abstract*— In the modern era, waste management is one of the key issues faced by every country in the world. As all this waste ends up in landfills, water bodies or into air by burning. The health problem and diseases generated by them are highly hazardous. The problem is not much with the degradable waste like Vegetable and fruits, agricultural waste, paper waste but with the non- degradable waste such as plastic bags, plastic bottles, styro-foam cups, metals, leather. Plastic is extensively used everywhere and can't be replaced by other materials because of its uncountable benefits. As plastic does not decompose biologically; the amount of plastic waste in our surroundings is steadily increasing which on break down into micro plastics is one of the emerging concerns of today's society. This work represents a way to deal with such problems and propose the development of bricks using plastic waste and M-sand which is produced by cutting of rocks. The plastic waste used is the Polyethylene Terephthalate which is generally used for plastic bottles. The proposed sand brick which is made up by adding plastic bottle waste in crush form in sand bricks may help to reuse the plastic bottle waste as one of the additives materials of bricks, and to help the disposal problem of plastic waste.**

Keywords—Plastic, waste management, No- bio-degradable, M-sand, bricks

INTRODUCTION

India is getting buried and dumped in its own garbage waste as a huge quantity of solid waste generated daily is never picked up which destroy land, air and water. According to the Press Information Bureau 2016[1], India generates 62 million tons of waste (mixed waste containing both recyclable and non-recyclable waste) every year, with an average annual growth rate of 4% (PIB 2016). The generated waste in India can be divided into three major categories: Organic (include biodegradable waste), dry (or recyclable waste) and biomedical (or sanitary and hospital waste). India, the world's second highest populated country with population exceeding a billion and one of the fastest urbanizing countries, is a land of physical, climatic, geographic, ecological, social, cultural and linguistic diversity. The annual rate of growth of urban population in India is 2.3% (2018) [2]. The proportion of population living in urban areas has increased from 17.35% in 1951 to 26.15% in 1991(CPCB, 1999). The 46 metro cities in India generates about 30,000 tons of such wastes per day while about 50,000 tons are generated daily from the Class I cities. It is estimated that solid waste generated in all category of cities and town i.e.; rural, urban and metropolitan cities and towns in India is about 0.1 kg, 0.3kg and 0.5 kg(approx.) per capita per day respectively. The estimated annual increase in per capita waste quantity is about 1.33% per year.

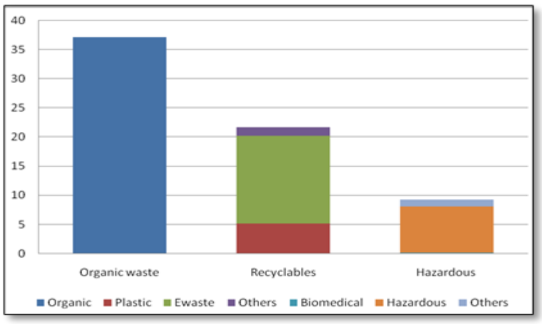

Figure 1 Waste Composition of India, in Million Metric Tons per annum (Source: PIB 2016[1])

With rapid urbanization and industrialization, India is facing massive waste management challenge. Over 377 million urban people live in 7,935 towns and cities and generate about 62 million tons of municipal solid waste per annum out of which only 43 million tons (MT) of the waste is collected, 11.9 MT is treated and 31 MT is dumped in landfill sites [3]. Solid Waste Management (SWM) is one among the basic essential services provided by municipal authorities in the country to keep urban centre clean and hygienic [3]. However, almost all municipal authorities deposit solid waste at waste treatment plant or at a dump yard within or outside the city haphazardly. Experts believe that India is following an unreliable system of waste disposal and management. With changing consumption patterns and rapid economic growth, it is estimated that urban municipal solid waste generation will increase to 165 million tons by 2030.

LITERATURE REVIEW

The increase in the popularity of using environmentally friendly, low cost and lightweight construction materials in building industry and road construction industry has brought about the need to investigate how this can be achieved by benefiting to the environment as well as maintaining the material requirements affirmed in the standards. Brick is one of the most accommodating masonry units as a constructional material due to its properties. Attempts have been made to incorporate waste in the production of bricks such as the use of paper processing residues, cigarette butts, fly ash, textile effluent treatment plant (ETP) sludge, polystyrene foam, plastic fiber, straw, polystyrene fabric, cotton waste, dried sludge collected from an industrial wastewater treatment plant, rice husk ash, granulated blast furnace slag, rubber, craft pulp production residue, limestone dust and wood sawdust, processed waste tea, petroleum effluent treatment plant

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sludge, welding flux slag and waste paper pulp.[10] In [11], it describes the used of various types of waste materials in different proportions and adopted different methods to produce bricks. Different tests were conducted on produced bricks to evaluate their properties following the various available standards. Compressive strength and water absorption are two common parameters considered by most researchers as required by various standards. Recently, in [13] mentioned that there are various research works have been done to find out the safe and environment friendly disposal of plastics Different attempts have been done to develop brick from waste. As in [14], extrusion machine was built to produce bricks from reprocessed LDPE through melting of shredded plastic waste. Paper also showed the use of industrial waste PP, LDPE and rubber powder waste for production of bricks and suggested the significance of extruder in the reprocessing of waste plastic and composition of 70% industrial waste PP, 20% waste rubber as the optimum one since it has highest compressive strength. Another work [15] showed the mixing of PET plastic waste with laterite quarry waste to produce plastic soil bricks as the laterite waste is abundantly available in the coastal Karnataka and some northern parts of Karnataka and also in the northern parts of Kerala, due to which lot of quarrying of laterite bricks takes place.

CLASSIFICATION OF WASTE

Wastes are mainly classified into 5 different types:

Solid Waste: RCRA states that "solid waste" means any garbage or refuse, sludge from a waste water treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, resulting from industrial, commercial, mining, and agricultural operations, and from community activities.

Liquid Waste: Liquid waste is commonly found both in households as well as in industries. This waste includes industrial liquid waste, liquid chemical waste, organic liquids, wash water, waste detergents and soap and even rainwater.

Organic Waste: Organic waste is another common household. All agriculture waste like food waste, garden waste, manure and rotten meat are classified as organic waste. Over time, organic waste is turned into manure by microorganisms.

Recyclable Rubbish: Recyclable rubbish includes waste items that can be converted into useful products that can be used again or simply say reusable waste.

Hazardous Waste: These items can harm us as well as the environment and should be disposed of correctly.

Some of hazardous waste produce in India are:

Plastic Waste: Plastic waste or plastic pollution, is the accumulation of plastic objects (e.g.: plastic bottles and much more.

Kinds of plastic waste:

PET plastic: Polyethylene terephthalate (PET or PETE) is a general-purpose thermoplastic polymer which belongs to the polyester family of polymers.

LDPE Plastic: Low-density polyethylene (LDPE) is a thermoplastic made from the monomer ethylene

HDPE plastic: High-density polyethylene (HDPE) or polyethylene high-density (PEHD) is a thermoplastic polymer produced from the monomer ethylene. **PP plastic:** Polypropylene (PP) is a thermoplastic polymer used in a wide variety of applications. It is produced via chain-growth polymerization from the monomer propylene. **PVC plastic:** - Polyvinyl Chloride (PVC) is one of the most commonly used thermoplastic polymers in the world (next to only a few more widely used plastics like PET and PP.

METHODOLOGY AND EXPERIMENTATION

Plastic as Filler

The purpose of this method was to have a mix that reaped all the benefits of the plastic but not inherit the disadvantages. The main benefit that this method uses is the consumption of plastic waste, while the disadvantage that would be avoided with this method is the prevention of releasing toxic gases into the atmosphere. Since this method is very much like current standard of cement mixes the implementation will be easy because all concrete mix companies need to do is simply add the plastic in the desired ratio. This also means that for this method no molding is required since it will behave like regular concrete. One disadvantage that this method has is the amount of plastic used per kg of mix. In this method the plastic would account for a three to fifteen percent of a kg. Another disadvantage that this method has to suffer is the fact that it would be harder for regular people to implement since the plastic has to be shredded in small particles which required heavy machinery for effective production.

Plastic as Binder

In this process, sand will be added to the melted plastic, and then mixed thoroughly. Once a liquid plastic state will be obtained, the next step will be to pour this material into a metal mold that had been bought specially to withstand the heat of the melted plastic. It is critical to avoid air bubbles from forming while the plastic is cooling down in order to improve the strength of this material. So, this method looks into the melting of plastic approach which consists melting the plastic and turning it into liquid form to which then sand is added into the plastic liquid and then poured into molds of desired shapes such as pavers and then cooled down. For this particular method the setting time will be only of about three to five hours in order for it to cool down and be implemented into a use. This method will not only consume plastic in large quantities but will also reduce the need for cement in casted structures such as pavers. This reduction in cement use will decrease the pollution arriving from the process of making cement. Although this method is very efficient at reducing pollution it comes with the drawback of producing pollution in the melting process of the plastic. Some measures that can be used to minimize the pollution from the gases produced by this method are implementing air filtration systems to capture as much toxic gas and aerial pollutants as the plastic is melted. Another way to minimize these effects is by not having a fire to melt the plastic but rather melting the plastic only by heating the container it is in. This way a lot of the toxic gases that would have otherwise escaped into the atmosphere are not released. This is due to the way plastic burns. When plastic burns the flames create ambient conditions for black smoke to form which is where a lot of the toxic gases and aerial particles are released, which is the reason why melting plastic by conductivity will be ideal for this process. The use of the

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composite from this method can be used all round the world. The potential use of the product from this method would not only be limited to first world countries but to second and third world countries.

Table 1: Constituent composition of prepared samples

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Plastic(%age)	12.82	15.30	25	15.30	10
Cement (%age)	56.41	58.67	50	58.6	60
Water (%age)	30.77	26.03	25	26.03	30
Water to cement ratio	0.54	0.44	0.50	0.443	0.5
Curing time (days)	6(under water)	5(daily pouring)	6(under water)	12	10

RESULTS AND DISCUSSION

Table2: Testing Results

Sample	Compressive Strength (MPa)	Water Absorption (%by weight)	Weight (grams)	Density (kg/m3)
1	9.80	0.75	2150	1762.584
2	10.78	0.82	2650	1810.40
3	8.00	0.81	1350	1800.00
4	5.00	0.50	1000	1818.18
5	2.57	0.16	1350	1928.57

- From the compression test result, we analyzed that maximum compressive strength was when plastic was **25% of total weight of brick i.e 10.78MPa**. This was much higher than **minimum i.e. 3.5MPa** required for common burnt clay brick.
- After testing and breaking the sample and analyzing the internal structure we found that fine **aggregate particles were well bind** and held in place by plastic. There were many air bubbles inside the brick which may be due to heating in open and heating was uncontrolled and temperatures were not measured.
- Although due this plastic hardened and became brittle which is much required in bricks. Hence **not buckling or barreling occurs.**
- Doing sieving was of no help as the **size of aggregate particle decreased strength also decreased.**
- Still the procedure we adopted was good and economical and we can proceed with it and make future samples keeping this study in mind while making the improvement.

Table3: Comparison with Existing Product

Parameters	Pre-casted Concrete Pavement Bock (M-30)	Our Material (25% plastic(PET), 75% sand dust, (weight basis))
Compressive strength (MPa)*	30	10.78
Weight (Kg)	5.00	2.650
Strength to weight ratio	6.00	4.06
Compressive strain	0.00	0.05-0.083
Water absorption	6-7% by weight	0.82
Efflorescence	Less than 10%	0.00
Flame properties*	Inflammable	Flammable
Environmental impacts	Bacterial and Microbial	Anti-static, Antimicrobial, Antibacterial
Cost	Rs. 15-20	May cost Rs. 15-22
Thermal aspects	Moderate thermal conductivity	Very low thermal conductivity
UV light characteristics*	Not such measurable decrease in strength	Strength decreases with passage of time due to exposure.

Major problem was seen with respect to strength to weight ratio, flame properties, UV light characteristics but these all can be improved. Coming on the strength problem we observed many voids and holes inside the bricks which we observed were due to our hand lay process and uncontrolled heating in open environment and we found that it can be resolved if we use a systematic process to build the material and for which we require a set up to heat and fill the molds.

CONCLUSION

After extensive research and conducting experiments, we conclude that plastic can be reused in the form of bricks. The compressive strength 10.78 MPa of specimen with 25% waste plastic (PET) and 75% M-sand (dust) by total weight of the brick can be helpful in this respect compared to others presently used (M-30 pre-cast concrete pavement). The challenge that everyone faces in implementation of such idea at mass level, is also dealt in above sections for production of mass manufacturing of bricks. Our product will be helpful to give growth to green construction movement as it utilizes waste and saves large amount of energy required for manufacturing cement and water is also saved in very large amount which is required in concrete mixtures.

Use of our bricks in the sidewalk and footpath is the perfect initial application area. And with the further research and development in the product quality and properties it can be used for building houses and offices etc.

All this will bring down the existence of waste in the environment and prevent the pollution of air, water, and land. Having such creative uses around people will generate feeling of connectedness with the environment and fulfill the goal of 3 R's of the environment management.

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