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EXPERIMENTAL STUDY OF PAVEMENT BLOCKS USING HDPE AND PP PLASTIC WASTE

M.Naga Lakshmi[1], N.Sri Hari[1], M.Siva Kumar[1], A.Tirupathi Rao[1], N.N.V.S.M.Ssatry[1], G.Krihna kanth[2]

[1]UG students, Department of Civil Engineering, Aditya Engineering College (A), Surampalem
[2]Assistant professor, Department of Civil Engineering, Aditya Engineering College (A), Surampalem

ABSTRACT
Our surroundings got a lot of waste generated especially from plastic and that too one time used plastic which resulted in polluting our own habitat. As a civil engineering students we were jolted by watching the huge amount of impact this waste plastic is creating and then we decided to give this problem a solution in our style by giving it a construction touch. That is when we decided to manufacture paver blocks from this waste plastic. Plastic are of different types depending on their use, production and their physical properties they are recycled and reused. In nature HDPE and PP plastic are mostly used, hence they have good moulding capacity, strength and temperature resistant. This project mainly uses plastic waste of HDPE (high density polyethylene) and PP (Poly Propylene) for recycling. Heated up to their plasticity zone and then transferred into a mould and compression force is applied to attain the final product of high quality. By using different moulds we can obtain different sizes of the plastic blocks depending upon the size of it, which are then tested for Compressive strength, Impact load and Absorption of water. These tests will indicate their strength, which ever attains more strength and less water absorption is considered as good plastic paver block.

Keyword: Pavement, HDPE, Polypropylene, Plastic, Mechanical Proiperties

1. INTRODUCTION

The first commercial plastic was developed over one hundred years ago, but the plastic became major consumer material only after the growth of the petrochemical industry in the 1920s. Now plastic have not only replaced many wood, leather, paper, metal, glass, and natural fibre products in many applications, but also have facilitated the development of entirely new types of products that are so versatile in use that their impact on the environment are extremely wide ranging. Once hailed as the ‘wonder material’, plastic now regarded as a serious worldwide environmental and health concern essentially due to its non-biodegradable nature. Careless disposal of plastic bags chokes drains, blocks and porosity of the soil and cause problems for ground water recharge. Plastic disturbs the soil microbe activity, and once ingested, can kill animals. Plastic bags can also contaminate foodstuffs due to leaching of toxic dyes and transfer of pathogens. The rapid rate of urbanization in India has led to increasing plastic waste generation. In fact, a major portion of the plastic bags.

Which is approximately 60-80% of the

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plastic waste generated in India is collected and segregated to be recycled. The rest remains strewn on the ground, littered around in open drains, or in unmanaged garbage dumps. Plastic is material consisting of any of a wide range of synthetic or semi- synthetic organic compounds that are malleable and so can be moulded into solid objects. Plasticity is the general property of all materials which can deform irreversibly without breaking but, in the class of mouldable polymers, this occurs to such a degree that their actual name derives from this specific ability. Plastics are typically organic polymers of high molecular mass and often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, however, an array of variants are made from renewable materials such as polylactic acid from corn or cellulosics from cotton linters.

Due to their low cost, ease of manufacture, versatility, and imperviousness to water, plastics are used in a multitude of products of different scale, including paper clips and spacecraft. They have prevailed over traditional materials, such as wood, stone, horn and bone, leather, metal, glass, and ceramic, in some products previously left to natural materials.

In developed economies, about a third of plastic is used in packaging and roughly the same in buildings in applications such as piping, plumbing or vinyl siding. Other uses include automobiles (up to 20% plastic), furniture, and toys. In the developing world, the applications of plastic may differ-42% of India's consumption is used in packaging. Worldwide, about 50 kg of plastic is produced annually per person, with production doubling every ten years.

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Plastics have many uses in the medical field as well, with the introduction of polymer implants and other medical devices derived at least partially from plastic. The field of plastic surgery is not named for use of plastic materials, but rather the meaning of the word plasticity, with regard to the reshaping of flesh. he world's first fully synthetic plastic was Bakelite, invented in New York in 1907, by Leo Baekeland who coined the term 'plastics'. Many chemists have contributed to the materials science of plastics, including Nobel laureate Hermann Staudinger who has been called "the father of polymer chemistry" and Herman Mark, known as "the father of polymer physics".

2. LITERATRE REVIEW:

Large-scale use of recycled plastic in eco-friendly construction materials such as bricks and concrete may lead to sustainable management of this waste material (Hama and Hillal, 2017). Though results in several studies have shown promise, the technology is yet to find adoption in commercial level application (Gu and Ozbakkaloglu, 2016). Further research is necessary for improving properties of the end products and increasing the percentage of plastic in construction materials. The present research introduces new process for incorporating waste thermoplastic to produce self-compacting lightweight and porous fly ash bricks. The results of the study clearly indicate viability of the proposition. The findings pave the way towards sustainable recycling of waste plastic and making them alternative materials for construction industry.

Plastic consumption has grown continuously over the last 50 years. Recovery and recycling have not mirrored the huge consumption leading to dumping

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in landfill and ocean. Global production of plastic has registered clear increasing trend during the recent years (2011, 2012, 2013, 2014 and 2015) as reported in 'Plastic – the Facts' (2016). The plastic production has registered growth of 4,396% from 1960 to 2013 (Devezas et al. 2017). The growth in production of plastic goods during 2017 is also expected to remain positive. The conveniences, with which plastic can be used in multifarious applications, which is only growing with new innovative use such as in filament of 3D printing, are likely to increase consumption in the future. Thus, unless recycling gains momentum, the amount of littered waste is likely to increase compounding the environmental challenge. Growth in recycling plastic after end-of-life is slow resulting in increase in net disposal in the environment. Recycling rate of plastic in the USA from municipal waste shows an increasing trend from 1961 to 2014, but the rate has barely reached 9.3% during 2014 (EPA 2015), whereas, in Europe, it has reached 29.7% in 2014 (Plastics – the Facts 2016).

In 2016, New Delhi in India became the most polluted city in the world due, in large measure, to the incineration of waste materials containing large percentage of waste plastic (Rajput & Arora 2017). Plastic bags choke drainage system, reduce water permeability of land affecting fertility, and increasing cost to Municipal Corporations to manage these wastes (Othman et al. 2013). Unless recycled, natural biological process takes indefinite period of time to degrade those (Kyrikou & Briassoulis 2007, Papong et al. 2014). Thermoplastics constitute about 80% of all plastic consumption and thermoset about 20% (Gawande et al. 2012), some of which are safe to recycle and some are not. Part of it remains littered, part used in illegal landfilling, and rest is incinerated for energy harvesting, giving off significant emission. The cost of emission outweighs the benefits of the energy generated when compared to recycling in terms of implicit abatement of CO2 emission (Gradus et al. 2017).

Jayaprakash et al. (2016) they have shown the use of waste plastic PET (Poly-ethylene Terephthalate) bottles as constructions entity to standardized bricks. As plastics are non-biodegradable its disposal as always been a problem. This is an environmental issue as waste plastic bottles are difficult to biodegrade and involves processes either to recycle or reuse. Green building is one that may represent a regenerative process where there is actually an improvement and restoration of the site and its surrounding environment. The ideal "green" project preserves and restores habitat that is vital for sustaining life and becomes a net producer and exporter of resources, materials, energy and water rather than being a net consumer. Green building is the practice of constructing or modifying structures to be environmentally responsible, sustainable and resource-efficient throughout their life cycle. Thus, to envisaged the sustainable development and energy consumption in the construction of green building for quality living concept to fulfil the paradigm of the development of country. The present work may give the same sort of solution in the construction of buildings by using waste plastic PET bottles which are dumped on the open land. It may solve the reuse of the waste plastic PET bottles as a benefit to minimize the solid waste in the form of environment friendly green building concept for living as a cost effective material.

3. METHODOLOGY

3.1DESIGN OF MOULD*:*

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In this design the mould has two basic parts.

1. Mould
2. Compression Plate

Fig 2 Mould

Fig 3 compression plate

3.2 FABRICATION OF MOULD:
Different moulds are used to be fabricated for different applications like Bricks, Potholes & Paver blocks. By obtaining an average block dimensions and general clay block dimensions we designed mould with respect to the average block size by measuring different clay blocks and keeping the equipment available in mind.

Fig: 3 Marking Dimensions on the Iron Plate.

Fig 5 Cutting the Plates According to the Dimensions.

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It is quite a tough task to fabricate a mould but once you have obtained it with perfection you would be amazed by the products, we can make with it. Moulds are an integral part of the Plastic ecosystem and could almost be considered a world on its own. Moulds give shape to the molten plastic and create the final product. For an easy extraction of the plastic block from the mould, the inner walls are given with smooth touch. The metal used for the fabrication of mould is Mild steel which has good strength and low in cost. The major complicated part in this fabrication of mould is welding the side plates with the Base plate at exact positions.

3.3 HEATING PROCESS:
BURN PLASTIC IN A STOVE
Burning any material well and without smoke and noxious fumes needs a high temperature and plenty of oxygen. Thi is best achieved in a stove, where the heat is concentrated and can be put to good use. We keep three rules in mind. To keep the fire burning you need
1) FUEL; this can be any combustible material- usually wood or gas, but plastic does the job as well.
2) OXYGEN; 21% of air is made of it and a continuous supply of air is a must. Then the last factor is one people tend to forget, since it is not so obvious.
3) HEAT TRANSFER; solid fuel does not in fact burn, the gaseous products of its decomposition do. Decomposition takes place by supplying heat to t e solid fuel. If not enough heat is supplied, no gaseous products are created and the fire stops burning. Most fires are based on these principles and a fire will keep growing until one of the three components becomes limiting. Then it will reach a

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"steady state combustion".

3.4 INCINERATOR

An incinerator is a furnace for burning waste. Many paper and pulp mills incorporate them into their pollution mitigation systems. Incineration involves the high-efficiency combustion of certain solid, liquid, or gaseous wastes.

Fig : 7 Stove eating

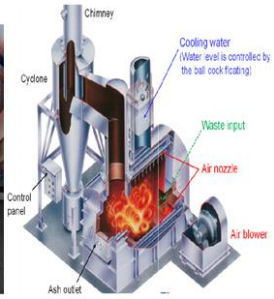
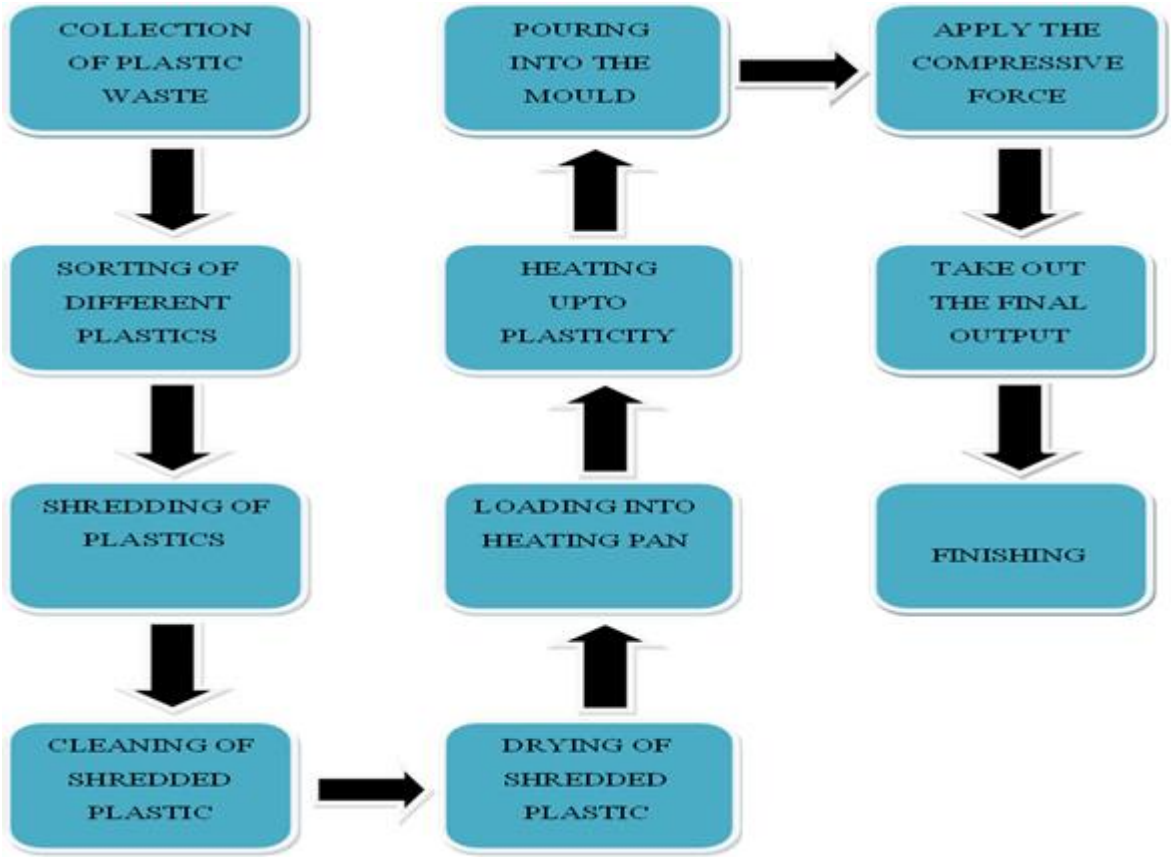


Fig : 8 Incinerator

FLOW CHART:



Flow chart for preparation of Blocks

4.PLASTIC PREPARATION:

4.1COLLECTING OF PLASTIC:

Plastic consumption has grown at a tremendous rate over the past two decades as plastics now play an important role in all aspects of modern lifestyle. Collection and disposal of plastic waste has emerged as an important environmental challenge and its recycling is facing roadblocks due to their non-degradable nature. There are four basic ways in which communities can offer plastic recycling collection services for plastic bottles and containers- curbside, drop-off, buy-back or deposit/refund programs.

4.2CURBSIDE RECYCLING:

The first, and most widely accessible,

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collection method is curbside collection of recyclables. Curbside collection is considered a low-risk strategy to reduce waste volumes and increase recycling rates. Materials are usually collected in large bins, coloured bags or small open plastic tubs specifically designed for content.

Fig: 9

4.3 Collection of Plastic.

Curbside recycling programs are generally the most convenient for community residents to participate in and yield high recovery rates as a result. Communities that provide curbside collection generally request residents to separate designated recyclables from their household garbage and to place them into special receptacles or bags, which are then set out at the curb for collection by municipal or municipally-contracted crews.

4.4 DROP-OFF RECYCLING:

In this method, containers for designated recyclable materials are placed at central collection locations throughout the community, such as parking lots, mosques, schools, malls or other civic associations. The containers are generally marked as to which recyclable material should be placed in them. Residents are requested to deliver their recyclables to the drop-off location, where recyclables are separated by material type into their respective collection containers. Drop-off recycling programs are more suitable when residents are taking their garbage to a central waste collection facility or transfer station. Such programs suffer from low or unpredictable throughput.

4.5 BUY-BACK CENTERS:

Most buy-back recycling centers are operated by private companies and pay consumers for recyclable materials that are brought to them. Buy-back centers usually have purchasing specifications that require consumers to source separate recyclable materials brought for sale. These purchase specifications can greatly reduce contamination levels and allow the buy-back center to immediately begin processing the recyclables they purchase, while providing consumers with an economic incentive to comply with the specifications. Buy-back centers are similar to drop-off centers expect they pay waste generators for their items based on market values.

4.6 DEPOSIT/REFUND PROGRAMS:

These programs requires collection of a monetary deposit purchase of a plastic container. When container is returned to an authorized redemption center, or to the original seller, the deposit is partly or fully refunded to the redeemer. These programs are familiar to anyone in the USA who has ever purchased a beverage ina can or bottle.

4.7 SORTING:

Sorting, the first step in recycling plastic waste after collection, separates, cleans and prepares materials intended for recycling. Depending on its nature, sorted plastic waste wil be processed directly on the site of the recycling company responsible for receiving it or be taken to a specialist recycling centre. Since there are many categories of materials and many processes, varying according to the type of product, We are going to identify the main methods used by Paprec, follow the route taken by materials in recycling centers and detail the treatment methods specific to the various types of plastic waste.

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4.8 SHREDDING:

Due to its format, components and characteristics, plastic is a very versatile material that is primarily used in industrial mass production. The resulting plastic waste can be recycled by shredding and washing the material, before generating a reusable, recycled granulates. Shredded plastic waste can also be used for energy generation. Our plastic shredders were developed specifically for the processing of these components. They deal effortlessly with all kinds of plastics, ranging from foils, lumps, profiles, fibers, ribbons, PET bottles and hollow parts to post-consumer and production waste. Thanks to a range of different cutting systems, rotor diameters and shapes as well as different blade sizes, the shredders are suitable for thermoplastics, duroplastics and elastomers and may be customized to suit your individual requirements.

4.9 CLEANING:

Plastic which are collected from the scrap facilities is very dirty and it requires cleaning before recycling it. The shredded plastic pieces are cleaned by water and properly filtered. After it is washed it is required to dry before being melted.

Fig: 10 Plastic Shredding Machine. & Fig: 11 Removing Unwanted Scrap and Cleaning.

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4.10 DRYING:

Fig: 12 Drying of Cleaned Plastic in Sunlight and Air.

4.10 MANUFACTURING OF BLOCKS:

The required amount of shredded plastic is weighed as per plastic block needed. Plastic is taken and placed into the heated pan. Now mix plastic pieces continuously for uniform melting. The heating of plastic is once achieved bring the plastic to a melting state (semi liquid) within a period of time. Once sufficiently melted the plastic can eventually get out through the pan and place it in the mould. Applying external force using the compression plate from the top of the mould to get uniform shape and to remove voids.

5.RESULTS AND DISCUSSION

5.1 IZOD IMPACT TEST:

Izod impact testing is an ASTM standard method of determining the impact Resistance of materials. A pivoting arm is raised to a specific height (constant potential energy) and then released. The arm swings down hitting a notched sample, breaking the specimen. The energy absorbed by the sample is calculated from the height the arm swings to after hitting the sample. A notched sample is generally used to determine impact energy and notch sensitivity.

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ASTM for plastic the size of the specimen is 75 X 9 X 9 mm

Fig: 4.3 Test specimen.

Fig: 4.2 Izod Impact Test.

The ASTM International standard for Izod Impact testing of plastics is ASTM D256. The results are expressed in energy lost per unit of thickness (such as ft-lb/in or J/cm) at the notch. Alternatively, the results may be reported as energy lost per unit cross-sectional area at the notch (J/m^2 or ft lb/in^2). In Europe, ISO 180 methods are used and results are based only on the cross-sectional area at the notch (J/m^2). The dimensions of a standard specimen for ASTM D256 are 75 x 9 x 9 mm. The most common specimen thickness is 3.2 mm (0.13 in), but the width can vary between 3.0 and 12.7 mm (0.12 and 0.50 in).

HDPE 100%

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Fig Specimen Before Impact Test

Fig Specimen After Testing

HDPE 50% & PP 50%:

Fig: 4.6 Specimen Before Impact Test
Fig: 4.7 Specimen After Testing.

PP 100%:

Fig: 4.8 Specimen Before Impact Test.

Fig: 4.9 Specimen After Testing.

Table IMPACT ENERGY READINGS:

S. No	Type of Plastic	Impact Energy Absorbed (J/m^2)
1	HDPE-100%	8.8
2	HDPE-50% & PP-50%	5.92
3	PP-100%	5.92

INFERENCE: From the above experiment analysis we can say that 50:50 compositions of

5.2 COMPRESSION TEST:

Compressive strength or compression strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to

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elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently.

Fig: 4.10 Compression Testing Machine

HDPE 100%:

Fig: Block Before Testing

Fig: 4.12 Block After Testing.

HDPE 50% & PP 50%:

Fig: 4.13 Block Before Testing.

Fig: 4.14 Block After Testing.

PP 100%:

Fig: 4.15 Block Before Testing.

Fig: 4.16 Block After Testing

CLAY BLOCK:

Fig: 4.17 Before Testing.

Fig: 4.18 After Testing.

Table – 4.2: Compressive Stress Of Various Blocks:

S. No	Type of Block	Area in cm^2	Compressive load (KN)	Stress Kg/cm^2
1	Clay Block	225	-	15-25
2	Cement Block	225	-	20-50
3	HDPE-100%	225	397.64	180.21
4	HDPE-50% & PP-50%	225	381.71	173
5	PP-100%	225	353.98	160.42

INFERENCE: From the above results we can conclude that the Block made with of HDPE-100% sustains more compressive strength compared to others.

TABLE – 4.3: WATER ABSORPTION PERCENTAGE:

S. No	Type of Block	Water Absorption Percentage
1	Clay Block	20-50
2	Cement Block	15-40
3	HDPE-100%	0.35
4	HDPE-50% & PP-50%	0.36
5	PP-100%	0.6

INFERENCE: From this test we can infer that blocks which are made from plastic are very bad for absorption. So, they can be used in cold weather conditions or can be used as Plastic sleeper ties and Paver blocks.

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FINAL INFERENCE: But they can sustain high compressive forces and can elongate unlike breaking easily. Because of this high compressive strength of these blocks they are suitable to be used to plastic bricks for construction, replace the potholes, and paver blocks on foot paths, Roof tiles etc. An average size of 15X15X5cm recycled block of HDPE can with stand a load of 17.67 N/mm^2 according to the calculations from the tests conducted which is remarkable.

6. CONCLUSION

This work effectively converts waste plastic into useful building material like pavement blocks and inter locking bricks which can effectively reduce the environmental pollution and further decrease the problem of waste plastics in the society. Rather than the waste plastic going into the landfill or incineration it can be used as construction materials at a much lower cost after undergoing certain specific processing. It also reduces the construction cost by eliminating the use of mortar during construction by using recyclable plastic/composite bricks.

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