Experimental study on strength behavior of recycled plastic blocks

R Kesavaram, S Janaki Raman
PG Scholar, Department of Civil Engg, Karunya Institute of Tech & Sciences.
Asst Prof,Department of Civil Engg, Karunya Institute of Tech & Sciences.

Abstract:

Plastic is the major problematic material with which the world is getting into trouble in day to day life. Plastic production is the simple process of polymerization which is the connective monomers in chain these are of three types based on its properties. This plastic waste was generated from various products. They are weight less and odorless easy portable so all the materials were carried by this material as covers packing materials and labels and etc. Among the various types of plastic polymers HDPE is high density polyethylene id the type of plastic which produces less gas while melting so we can utilize this HDPE plastic for recycling and producing paver blocks or conventions plastic bricks. Thus it may bare more compression than the conventional bricks also it process better tensile strength since it has elastic properties.

INTRODUCTION

Polyethylene (Polythene) is one of the world's most popular plastics. It is an enormously versatile polymer which is suited to a wide range of applications from heavy-duty damp proof membrane for new buildings to light, flexible bags, films. Two major types of PE are in use in the films and flexible packaging sector

- LDPE (Low Density) used generally for trays and heavier duty film such as long-life bags and sacks, poly tunnels, protective sheeting, food bags etc.
- HDPE (High Density) which is used for most thin gauge carrier bags, fresh produce bags and some bottles and caps.

There are other variants on these two main types and PAFA members can recommend the best material for your application. All offer an excellent vapour or moisture barrier qualities and are chemically inert. By altering the formulation and gauge of polyethylene, the producer/converter can adjust impact and tear resistance; transparency and tactility; flexibility, formability and coating/laminating/printing capability. PE can be recycled and many bin bags, agricultural films and long-life products such as park benches, bollards and waste bins use recycled polyethylene. Due to its high calorific value, PE offers excellent energy recovery through clean incineration.

High-density polyethylene (HDPE) or polyethylene high-density (PEHD) is a polyethylene thermoplastic made from petroleum. It is sometimes called "alkathene" or "polythene" when used for pipes. With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, geomembranes, and plastic lumber. HDPE is commonly recycled, and has the number "2" as its resin identification code.

In 2007, the global HDPE market reached a volume of more than 30 million tons.

DIFFERENT TYPE OF PLASTIC (POLYMER)

1. (PETE) :- PETE is one the most recycled plastic. It finds usage in various bottles like that of soda and cooking oil, etc.

2. (HDPE) :- HDPE is generally used in detergent bottles and in milk jugs.

3. (PVC) :-PVC is commonly used in plastic pipes, furniture, water bottles, Liquid detergent jars etc.,

4. (LDPE) :-LDPE finds its usage in dry cleaning bags, food storage containers, Packaged drinking water packets etc

POLLUTION PROBLEMS CREATED BY PLASTIC

Plastics are made from low molecular weight monomer precursors, organic material, which are mostly derived from petroleum, that are joined together by a process called "polymerization".
Corroborating reports and findings worldwide demonstrated that fragmented plastics debris' increase and massive presence on and off shores does constitute reason for raised worries and awareness. Studies on small plastic pellet by Dr Richard Thompson and by Hideshige Takada, Yukie Mato professor of organic geochemistry at Tokyo University, have shown that plastic debris meeting other pollutants in the oceans absorbs harmful chemicals from the sea water they float in, acting like a pollution sponges.These studies have been conducted on plastic nurdles not just because of their uniform size and shape, thus easier to study and compare by scientifics, but also because of their wide spread presence on the world's beaches.In UK, mermaid tears are the second common plastic litter found on the beaches according to the Marine Conservation Society's 2007 data and a Surfers Against Sewage (SAS) report.According to Charles Moore, these resin pellets account for around 8 percent of annual oil production and are the raw material for the 260 million tons of plastic consumed yearly worldwide. Lightweight and small, they escape in untold volumes during transport and manufacture and wash in the ocean.

RECYCLE AND REUSE OF PLASTIC WASTE

Source reduction Retailers and consumers can select products that use little or no packaging. Select packaging materials that are recycled into new packaging – such as glass and paper. If people refuse plastic as a packaging material, the industry will decrease production for that purpose, and the associated problems such as energy use, pollution, and adverse health effects will diminish.
Currently most plastic recycling in of the developed countries are of 'process scrap' from industry, i.e. polymers left over from the production of plastics. This is relatively simple and economical to recycle, as there is a regular and reliable source and the material is relatively uncontaminated. This is usually described as reprocessing rather than recycling. HDPE is safe to recycle without cause any danger to our environment. Many of the countries will reduce the plastic waste content by recycling and use it in a better way.

Advantages of reuse and recycle of plastics – It has been observed, to reduce bad effects of waste plastics, it is better to recycle and re-utilize waste plastics in environment-friendly manners. As per statistics, about 80% of post-consumer plastic waste is sent to landfill, 8% is incinerated and only 7% is recycled. In addition to reducing the amount of plastics waste requiring disposal, recycling and reuse of plastic can have several other advantages, such as:
(i) Conservation of non-renewable fossil fuels – Plastic production uses 8% of the world's oil production, 4% as feedstock and 4% during manufacture.
(ii) Reduced consumption of energy.
(iii) Reduced amounts of solid waste going to landfill.
(iv) Reduced emissions of carbon-dioxide (CO_2), nitrogen-oxides (NO_x) and sulfur-dioxide (SO_2).
Recycling involves the collection of used and discarded materials processing these materials and making them into new products. It reduces the amount of waste that is thrown into the community dustbins thereby making the environment cleaner and the air more fresh to breathe.

POLYETHYLENE Chemical formula	$(C_2H_4)_n$
Density	0.91–0.96 g/cm3
Melting point	115–135 °C (239–275 °F) (388–408 K) (239–275 °F)
Magnetic Susceptibility(χ)	-9.67×10^{-6} (HDPE, SI,22°C)

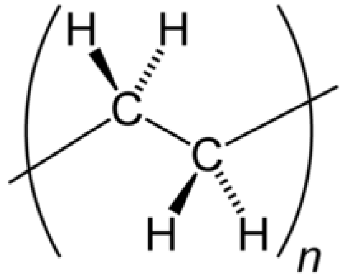


Fig 1.1 Molecular formula for polyethylene

The repeating unit within polyethylene in the most stable staggered conformation Polyethylene (abbreviated PE) or polyethene (IUPAC name polyethene or poly(methylene)) is the most common plastic.

HIGH DENSITY POLY ETHYLENE (HDPE)

High-density polyethylene (**HDPE**) or **polyethylene high-density** (**PEHD**) is a polyethylene thermoplastic made from petroleum. It is sometimes called "alkathene" or "polythene" when used for pipes. With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, geomembranes, and plastic lumber. HDPE is commonly recycled, and has the number "2" as its resin identification code. In 2007, the global HDPE market reached a volume of more than 30 million tons

HDPE Physical Properties:	Value:
Tensile Strength:	0.20 - 0.40 N/mm2
Notched Impact Strength:	no break
Thermal Coefficient of Expansion:	100 - 220 x 10-6
Max. Continued Use Temperature:	65oC (149oF)
Melting Point:	126oC (259oF)
Density:	0.941 - 0.965 g/cm3

The ethylene molecule is C2H4 (CH2=CH2)

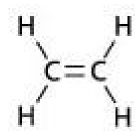


Fig 1.2 Molecular formula for Ethylene

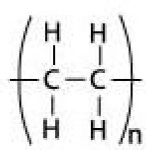


Fig 1.3 Molecular formula for Polyethylene Polymer

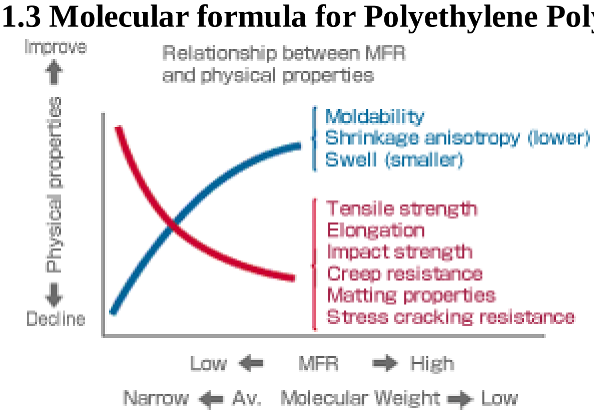


Fig 1.4 Relation between MFR and physical properties

J.M.L. Reis*and et.al. describes a study of the tensile behavior of post-consumer recycled high density polyethylene (HDPE) tested at different strain rates. The main goals of this study are to experimentally characterize recycled HDPE and to propose a one-dimensional viscoelastic phenomenological model able to yield a physically realistic description of strain rate sensitivity and damage observed in tensile tests that can be used in engineering problems. The material parameters that appear in the model can be easily identified from just three tests performed at different constant strain rates. The results of tensile tests conducted at different prescribed strain rates are presented and compared to model estimates of damage progression, and show good agreement.

Moayad N.Khalaf & et.al. Mechanical properties of (HDPE) with three filler (inorganic and organic) composites were assessed with respect to the effect of the filler content. The filler varied from (5% to25%) by weight in the composite. Obvious improvement in the mechanical parameters was recorded depending on the filler type and mesh size. The mechanical properties of loaded compressed sample have been evaluated through several parameters concerning the elastic deformation based on measuring the load–elongation characteristics.The behavior of stress–strain curve was analyzed in terms of cold drawing model. No experimental difficulties appeared at any mixing ratio, and these difficulties were due to the separation in phase which makes the sample possible for processing in the normal extruders.

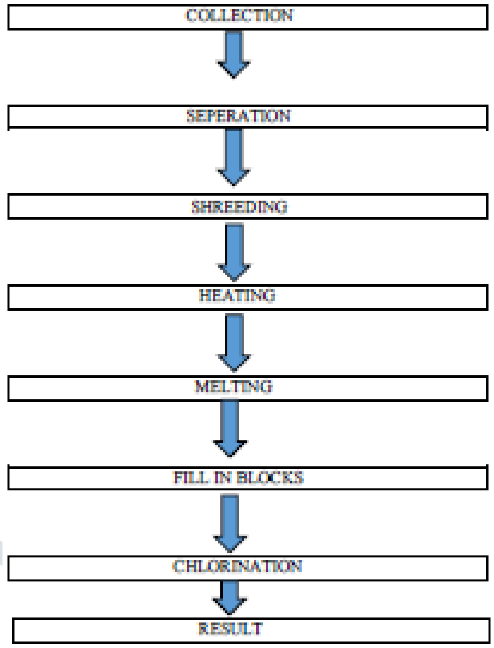
Sibele Piedade Cestari, Luis Claudio Mendes et.al Composites of recycled high density polyethylene (HDPE-R) and coffee dregs (COFD) were elaborated. The blends were made at the proportions of 100-0, 90-10, 80-20, 70-30, 60-40, 50-50 and 40-60% polymer-filler ratio. The materials were evaluated through scanning electron microscopy (SEM), differential scanning calorimetry (DSC), thermogravimetry/derivative thermogravimetry (TGA), and compressive resistance test. The composites degraded in two steps. The first one was in a temperature lower than the neat HDPE, but higher than the average processing temperature of the polymer. The melting temperature and the degree of crystallinity of the composites resulted similar to the neat HDPE ones. The compressive moduli of the composites resulted similar to the neat polymer one. The results show that these composites have interesting properties as a building material.

Thermal properties of high density polyethylene composites with natural fibres: Coupling agent effect High density polyethylene composites with curaua fibres were prepared using an intermeshing co-rotating extruder and two different coupling agents. The thermal stability of the components was studied by thermo gravimetric and differential scanning analysis, as well as by the oxidation induction time. Maleic anhydride grafted polyethylene, used as coupling agent, affected the composite stability more markedly than did poly(ethylene-*co*-vinyl acetate). However, oxidation induction times were analogous for composites with and without coupling agents. Results also indicated that a higher fibre–matrix interaction precludes the crystallinity enhancement caused by the fibre.

MAKING BLOCKS OUT OF HDPE PLASTICS

This is a brief explanation of the process that I have used to reuse one gallon HDPE (recycling #2) milk jugs. There are plenty of FAQs documenting HDPE sheet welding for fabric and vacuum forming sheet stock, but I couldn't find anything on forming solid blocks. I was looking for an inexpensive material to use for test blocks that I could put on the CNC machine that would not abuse the router bits. The process is quite simple. Cut up the bottles, stew them in really hot canola oil on the stove in a pot, and then take the hot plastic and press it into a form to cool. Please note that melting some plastics can release toxic fumes. I have had no issues with HDPE, however I am not a chemist and cannot comment on the health risks of this process. The pieces of cut up bottle can be any size that fit in the pot. I washed the bottles and removed the labels before cutting. Pouring a small amount of near boiling water into the bottle and swishing it around will help release the glue on the labels. Otherwise the labels tend to tear.Most any cooking oil will work, and you don't need too much. I just put a couple of inches in the bottom of the pot. Canola oil is inexpensive and has a smoke point of over 400 F (204 C). The melting point of HDPE is in the mid 200 F range but the "extrusion" temperature range is 350 - 500 F. I uses oil heated on my stove top to a little over 350. Just make sure that the bottle pieces are dry or the water will cause oil to pop out of the pot. I used a candy thermometer to keep track of the temperature.

METHOD AND PROCESS



COLLECTION OF PLASTIC

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.

Fig 4.1 Collection of plastics

SEPERATION OF PLASTIC

Devise your own method to determine the approximate density of the plastics. You will be provided an alcohol solution, water and the two salt solutions. Plastics that sink have a density greater than the solution. Plastics that float are less dense than the solution or are being held on the very top of the solution by surface tension. Push the piece of plastic below the surface of the solution before making density observations.As the raw mixture usually includes various kinds of waste plastics, this makes the Separation an important process that should be carried out prior to recycling.

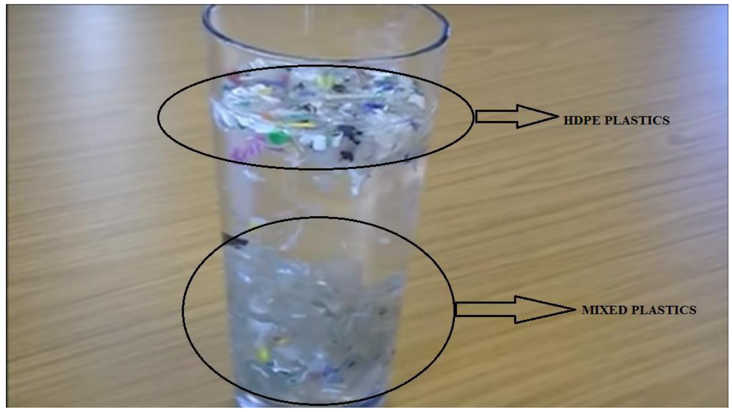


Fig 4.2 symbol of HDPE Fig 4.3 water test on plastic

The HDPE plastic piece are float on water, we can also analyzed the HDPE by this process like in figure **4.3**

SHREADING OF HDPE PLASTICS

An **industrial shredder** is a machine used for reducing the size of all kinds of material. Industrial shredders come in many different design variations and many sizes. The main categories of designs used today are as follows: horizontal hammer mills, vertical hammer mills, slow speed shear type shredders of single, dual, triple and quad shaft design, single shaft grinders of single or dual shaft design, granulators, knife hogs, raspers, mawlers, flails, cracker mills, and refining mills.

Fig 4.4 Shredding Machine

HEATING AND MELTING OF PLASTICS

After the process of serperation the heating and melting of HDPE process is carried out by using furnace. The temperatures must be in the range of 120°C/ 248 °F for short periods for HDPE. During the tensile test filled HDPE composites showed stress whitening zones appear and develop along the gauge length. Volume measurements during tensile tests showed an increase in volume strain with deformation, due to the matrix-particle debonding phenomenon, while pure HDPE showed actually a decrease in volume with elongation.

FILL IN THE BLOCKS

After the process of melting the melted HDPE is filled carefully into the blocks the blocks must be covered by using the parchment paper so it cannot get stick in the block. The form that I used applies pressure from all sides. This is important because it will squeeze out most of the bubbles of oil that are inside the blob of hot plastic and give a better starting point for milling the blocks. we drop the blob in the middle of the form and then press the top on with the two C clamps. Then we insert the two end blocks and clamp them together. The material holds heat for a long time. we left the block in the form for 15 min. and when we took it out it was still to hot to hold. The form we used was plywood that we had lightly oiled with the canola oil.
The residual oil in the pot will get really thick when cool from what we assumed was some of the dissolved HDPE, however it does clear up when heated and can be reused. We are not sure how many times you can reuse the oil. We assume that this type of remelting does weaken the material over time, but the small blocks

that we made cannot be bent by hand at all. we have also shown a block of plastic that we formed in a muffin tin and cut in half to show the consistency of the reformed material. Once the blocks were cool and washed. We ran them through a joiner and a planer to clean up the dimensions. The blocks machine easily with all woodworking tools and can be carved with a knife without difficulty. The HDPE has a very waxy feel to it. It will weep a little oil overtime because of tiny fissures in the plastic that hold small amounts off fluid.

Fig 7.7 Fill in blocks

CHLORINATION

Chlorine is a chemical element with symbol **Cl** and atomic number 17. The second-lightest of the halogens, it appears between fluorine and bromine in the periodic table and its properties are mostly intermediate between them. Chlorine is a yellow-green gas at room temperature. It is an extremely reactive element and a strong oxidising agent: among the elements, it has the highest electron affinity and the third-highest electronegativity, behind only oxygen and fluorine

COMPRESSION TEST ON BLOCKS

Compression test should be tested for normal block, cement block, mixed plastic block, HDPE block and we check a better among these

We should check compression on a compression testing machine

- Normal brick will be tested for compression and it will be break at 50KN
- Cement brick will be tested for compression and it will be break at 150KN
- Mixed plastic block will be tested for compression and it will be break at 400KN
- HDPE block will be tested for compression and it will be break at 440KN

Specific gravity of HDPE will be 0.95% and it will be auto clavable unlike polypropylene. It will be opaque we not able to seen through it

- It normally attain a temperature of 150 degree celcius.
- We add a additional component as a chlorine to make a block as fire resistant

25% of chlorine in a block will enough to attain a heat

Fig 6.1 Compression test on blocks

Table 6.1 HDPE Physical Properties

HDPE Physical Properties	Value
Tensile Strength	0.20 - 0.40 N/mm2
Notched Impact Strength	no break
Thermal Coefficient of Expansion	100 - 220 x 10-6
Max. Continued Use Temperature	65oC (149oF)
Melting Point	126oC (259oF)
Density:	0.941 - 0.965 g/cm3

Table 6.2 Compression Test

BLOCKS	LOAD WITHSTAND	
Normal brick	50 kN	
Cement brick	150 kN	
Mixed plastic brick	400 kN	
HDPE plastic brick	440 kN	

CONCLUSION

Therefore our project will be finalized with a better result, it attain a compressive strength of 440KN, it is higher when compare to ordinary clay block of 50KN, cement block 150KN, mixed plastic block 400KN., so we got a best result of 440KN, it is moderate in cost and easy to manufacture and mainly to reduce the pollution due to HDPE plastics.

REFERENCE

1. R.Crawford(1985).Plastics and Rubber-Engineering Design and Application.MEP Ltd=Location=London. p. 148. ISBN 0-85298-571-1.

2. O.Balkan, H.Demirer, A.Ezdesir, H.Yildirim (2008). "Polym.Engin.Sci.". 48:732. ISSN 1548-2634.

3. Pipe materials. level.org.nz "Market Study: Polyethylene HDPE". Ceresana Research. Thermoforming HDPE. Dermnet.org.nz Typical Properties of Polyethylene (PE). Ides.com. Retrieved on 2011-12-30.

4. Compare Materials: HDPE and LDPE. Makeitfrom.com. Retrieved on 2011 12-30. Retrieved 2016-4-20 Dermnet.org.nz. Dermnet.org.nz (2011-07-01). Retrieved on 2011-12-30. Kreiger, M. A.; Mulder, M. L.; Glover, A. G.; Pearce, J. M. (2014)."Lifecycle analysis of distributed recycling of post-consumer high density polyethylene for 3-D printing filament". Journal of Cleaner Production. **70**: 90. doi:10.1016/j.jclepro.2014.02.009.

5. The importance of the Lyman Extruder, Filamaker, Recyclebot and Filabot to 3D printing– VoxelFab, 2013. Archived March 18, 2014, at the Wayback Machine. Kreiger, M.; Anzalone, G. C.; Mulder, M. L.; Glover,A.;J.M.Pearce,M. (2013). "Distributed Recycling of Post-Consumer Plastic Waste in Rural Areas". MRS Proceedings. **1492**. doi:10.1557/opl.2013.258.