



Faculty of Manufacturing Engineering

**FABRICATION OF FLOOR TILES FROM RECYCLED HDPE
BOTTLE FILLED RECYCLED GLASS COMPOSITE USING HOT
PRESS METHOD**

Nurlina Aimi Bt Ramily

Master of Manufacturing Engineering (Industrial Engineering)

2018

**FABRICATION OF FLOOR TILES FROM RECYCLED HDPE BOTTLE FILLED
RECYCLED GLASS COMPOSITE USING HOT PRESS METHOD**

NURLINA AIMI BT RAMILY

**A thesis submitted in fulfilment of the requirements for the degree of Master of
Manufacturing Engineering (Industrial Engineering)**


Faculty of Manufacturing Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018


DECLARATION

I declare that this thesis entitled “Fabrication of Floor Tiles From Recycled HDPE Bottle Filled Recycled Glass Composite Using Hot Press Method” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 
Name : NURLINA AIMI BT RAMILY
Date : 30/8/2018

APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion this dissertation/report is sufficient in terms of scope and quality as a partial fulfillment of Master of Manufacturing Engineering (Industrial Engineering).

Signature : 
Supervisor Name : **DR. ZURINA BINTI SHAMSUDIN**
Senior Lecturer
Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka
Date : Hang Tuah Jaya
76100 Durian Tunggal, Melaka
26/8/2018

DEDICATION

To Muhammad Asyraf,
my beloved husband,
whose scarifies care for me and our children
made it possible for me to complete this work,
and to our two daughters,
Aisyah and Aminah,
who are indeed a treasure from the Lord.

ABSTRACT

rHDPE tiles are made out of plastics that can be used to cover walls and floors. The purpose of this experiment is to produce rHDPE tiles that are from rHDPE plastic bottles and some portion of Soda Lime Silicate Glass (SLSG) in selected ratio. It is in the interest of this experiment to solve the problems with conventional tiles, which are easily broken and discoloured. rHDPE plastic bottles melted at 140°C for around 4 minutes then the proportion of SLSG powder were poured and the mixed composition were crushed before hot press proses into the designated mould with size (200mm x 200mm x 5mm). The fabrication of the tile is using Hot Press Method. The estimate time needed for the cooling process is between 5 minutes setup within the hot press machine. These samples go through 2 type of test which are Flexural Test and Impact Test. All the mechanical properties of proportion behaviour recorded in the table and analysis on the new properties were done.

ABSTRAK

Jubin rHDPE diperbuat daripada plastik yang boleh digunakan untuk menutupi dinding dan lantai. Tujuan percubaan ini adalah untuk menghasilkan jubin rHDPE yang terdiri daripada botol plastik rHDPE dan beberapa bahagian Soda Lime Silicate Glass (SLSG) dalam nisbah terpilih. Ia adalah untuk kepentingan percubaan ini untuk menyelesaikan masalah dengan jubin konvensional, yang mudah pecah dan berubah warna. Botol plastik rHDPE cair pada 140 ° C selama 4 minit kemudian bahagian serbuk SLSG dituangkan dan komposisi campuran telah dihancurkan sebelum proses akhbar panas ke dalam acuan yang ditetapkan dengan saiz (200mm x 200mm x 5mm). Pembuatan jubin menggunakan Kaedah Tekan Hot. Masa anggaran yang diperlukan untuk proses penyejukan adalah antara persediaan 5 minit dalam mesin akhbar panas. Sampel ini melalui 2 jenis ujian iaitu Ujian Fleksibel dan Ujian Impak. Kesemua sifat mekanikal perilaku perkadaran yang direkodkan dalam jadual dan analisis terhadap sifat-sifat baru telah dilakukan.

ACKNOWLEDGEMENTS

Alhamdulillah, I am grateful to Allah S.W.T on HIS blessing and mercy for making this Final Year Project complete and successful. Thank to Allah, who made all things possible. First of all thanks to my supervisor, Dr. Zurina Binti Shamsudin for her vital encouragement, the understanding and assistance and also for the constant reminders and much needed motivation throughout my project.

Not forgetting, to all batch members, thanks for the full cooperation, shared ideas, data and knowledge during the completion of this project. Without the cooperation from the entire group members of course this project cannot be finished completely.

Finally yet importantly, I would like to give a special and greatest thank to my parents and family for their moral support, understanding, motivation and patience, in which without their support and love we may not be able to complete this dissertation. May Allah S.W.T. reward you all for what the thing that you all had done.

Amin.

TABLE OF CONTENTS

	PAGE
DECLARATION	
APPROVAL	
DEDICATION	
ABSTRACT	i
ABSTRAK	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vi
LIST OF FIGURES	viii
LIST OF ABBREVIATIONS	x
 CHAPTER	
1. INTRODUCTION	
1.1 Background of Study	1
1.2 Problem Statements	2
1.3 Objectives	4
1.4 Scope	5
1.5 Outline of Thesis	5
 2. LITERATURE REVIEW	
2.1 Introduction	7
2.2 High Density Polyethylene, HDPE	9
2.3 Previous Studies on use of Plastic Wastes	11
2.4 Soda-Lime Silicate Glass, SLSG	14
2.5 Previous Studies on use of Glass Waste	16
2.6 Previous Research on Recycled Material as a Tiles	18
2.7 Flexural Properties Testing (ASTM D790)	23
2.7.1 Flexural Properties Testing Scope	23
2.7.2 Flexural Test Procedure	23
2.7.3 Specimen size	24
2.8 Charpy Impact (ISO 179)	24
 3. METHODOLOGY	
3.1 Introduction	26
3.2 Preparation of Raw Materials	28
3.2.1 Recycle High Density Polyethylene (rHDPE)	28
3.2.2 Recycle Soda Lime Silicate Glass (SLSG)	30
3.3 Batch Formulation	33
3.3.1 Mass Calculation for 1st sample	33
3.3.2 Mass Calculation for 2nd sample	34
3.3.3 Mass Calculation for 3rd sample	34
3.4 Batch Mixing	35
3.4.1 Preparation of Sample 1 (100% rHDPE)	36
3.4.2 Preparation of Sample 2 (95% rHDPE + 5% SLSG)	36
3.4.3 Preparation of Sample 3 (80% rHDPE + 20% SLSG)	37
3.5 Sample Fabrication using Hot Press	39
3.6 Preparation of Specimen	41

3.7 Testing	42
3.7.1 Flexural Test	42
3.7.2 Impact Test	44
4. RESULT AND DISCUSSION	
4.1 Introduction	45
4.2 Hardened Properties Tests Result	45
4.2.1 Flexural Testing	45
Average Flexural Strength vs Substitution % SLSG	47
Average Max. Strength vs Substitution % SLSG	49
Flexural Stress-Strain Curve	50
4.2.2 Impact Testing	52
Average Impact Energy vs Substitution % SLSG	53
Average Impact Strength vs Substitution % SLSG	54
5. CONCLUSION AND RECOMMENDATION	
5.1 Summary	56
5.2 Conclusion	56
5.3 Recommendations	57
REFERENCES	58
APPENDICES	

LIST OF TABLES

TABLE	TITLE	PAGE
1.1	Problem Statements	4
2.1	Mechanical properties and cell classification of HDPE (ASTM International Standard)	10
2.2	Compositions and the uses of different common forms of glass	14
2.3	Comparison on previous findings that used Recycled Material as tiles	13
3.1	Proportion and volume fraction for each sample	33
3.2	Mass of sample and material proportion	35
3.3	Composite weight per batch for Sample 1 (100% rHDPE)	36
3.4	Composite weight per batch for Sample 2 (95% rHDPE + 5% SLSG)	37
3.5	Composite weight per batch for Sample 3 (80% rHDPE + 20% SLSG)	37
3.6	Parameter value of Hydraulic Hot Moulding Machine for hot pressing process	39
3.7	Different shape and dimension of specimen preparation base on testing type	41
4.1	Flexural result of mix SLSG 0%	45
4.2	Flexural result of mix SLSG 5%	46

4.3	Flexural result of mix SLSG 20%	46
4.4	% increasing of flexural strength	47
4.5	% increasing of maximum force	49
4.6	Flexural Stress-Strain Curve data	50
4.7	Impact result of mix SLSG 0%	52
4.8	Impact result of mix SLSG 5%	52
4.9	Impact result of mix SLSG 20%	53

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Composition of Solid Waste Disposal	3
2.1	K-Chart for covered area of research study	7
2.2	Polyethylene Molecular Chain	9
2.3	Flexural properties testing (ASTM D790)	24
2.4	Charpy Impact Strength (ISO 179) with Flatwise Impact	25
3.1	Process Flowchart	27
3.2	rHDPE bottle collected from Dobi Shop (Brand: Depex)	28
3.3	General flow of preparation of recycled HDPE bottle	29
3.4	Sheet of rHDPE after cut by knife	29
3.5	Granulator / Crusher Machine used to crush the rHDPE sheet into small flakes	29
3.6	Flakes of rHDPE sheet after repeated shredding process using granulator	30
3.7	General flow of preparation of recycled SLSG bottle	30
3.8	SLSG collected from Dobi Shop around Pasir Gudang area	31
3.9	Crumbled glass after crush manually using hammer	31
3.10(a)	'OCTAGON' Digital Sieve Shake	32
3.10(b)	Metal sifters used to separate the glass size	32
3.11	The Ball Mill Machine used to crush the SLSG into powder form	32

3.12	The end product of SLSG after turn into powder	32
3.13	Extruder and Mixer Machine used to produce the composite blob	38
3.14	Completed mixed composite stored in different coloured and labelled	38
3.15(a)	Mixed composite in blob form after mixing process	39
3.15(b)	Composite particles after crushing process	39
3.16	Hydraulic Hot Moulding Machine for fabricate the composite	40
3.17	Composite particles were flatten in the mould for hot-pressing process	40
3.18	Particle of composite were flanked between two metal plates before pressed	40
3.19	Successful sample just after go through hot-pressing method	41
3.20	Specimen categorization for testing procedure	42
3.21	Illustration of specimen placed at flexural machine	43
3.22	Specimen were been tested after pressure is applied until it failed	43
3.23	Impact test result (in Joule) gathered using impact test equipment	44
4.1	Graph of average flexural strength vs substitution SLSG composition	47
4.2	Physical specimen after flexural test conducted	48
4.3	Graph of average maximum force vs substitution SLSG composition	49
4.4	Flexural Stress-Strain Curve	50
4.5	Graph of average impact energy due to SLSG composition	53
4.6	Average Impact Strength due to SLSG composition	54

LIST OF ABBREVIATIONS

rHDPE	Recycle High Density Polyethylene
SLSG	Soda Lime Silicate Glass
SEM	Scanning Electron Microscopy
CoF	Coefficient of Friction
ASTM	American Society for Testing and Materials
SPI	Resin Identity Symbol System
PET	Polyethylene Terephthalate
PVC	Polyvinyl Chloride
LDPE	Low Density Polyethylene
PP	Polypropylene
PS	Polystyrene
ESCR	Environmental Stress Crack Resistance
HDB	Hydrostatic Design Basis

CHAPTER 1.0

INTRODUCTION

This chapter discussed an overview of the project background, activities and goals containing a common description of what is expected to be done within the project and prior to the implementation process for the targeted goal. It included the primary focus, a list of key reasons for launch, a very common description of how to perform this project and plain explanation of the desired outcomes.

1.1 Background of Study

Floor was the important structure for support the load inside the building structure. Load means here include the weight of tiles as floor finishing and also the human (user) weight. Floor tiles is not only for finishing purposes or to touch-up the final looking of the structure, but actually the tiled floor is stronger than non-tiled floor (Dinanurjilla, 2009).

Nowadays, there are a lot of floor tiles types such as marble stone, granite, ceramic tile, mosaic, homogeneous tile and clay. Usually, for making a tile it will involve two combustion processes before coated with the polish material. There are three (3) types of tile surfaces which are glazed wall tiles, half-lighted floor tiles and shiny tiles.

High Density Polyethylene (HDPE) was one of the plastic polymer that widely used in manufacturing. It is because HDPE was light, has high density and durability and also has a good tensile strength. The best point is, HDPE is not effected by high temperature up to 120°C (Thomas, 2012). This is the main factor why HDPE was chosen rather than other type of plastic waste. Commonly, the HDPE symbol can be seen on bottles and food containers.

Thus, it means that rHDPE was safe to use because it has ability to prevent the chemical reaction between the plastic packaging with drink or food stuffed in them.

This research is planned to go through melting, making and moulding process of rHDPE tile before going for several testing for analysis purposes. This is to ensure that this new purpose tile is good and ready enough to replace the current one. Flexural strength tests are performed to measure the bending for floor, wall and roof packaging (Samsudin, 2006). Flexural strength also known as the strength of material bend. This is the test to measure the maximum tile strength before it start to crack.

1.2 Problem Statement

Formerly of the building construction, concrete floor was the common surface used as it is stronger, durable and economical. High quality of concrete floor used will promised the high resilience and can be used for a long time of period. However, concrete floor are seen as less attractive surfaces. Hence, floor finishing was introduced and important to highlight the inner beauty of the building (Noor, 2003).

When floor tiles was introduced, the main aims is to make the floor surface look attractive, luxurious and high of quality. Thus, the major element when choosing the floor tiles is the design, strength, comfort and safety. Other than that, there are demand for floor tiles to have ability for absorbing the sound and light to give more interesting effect in a space.

In recent year, several type of floor tiles was innovated in tile industry such as porcelain tile and ceramic tile. The major raw material for both tiles is clay. When focus on the surface for porcelain tile, it need the use of kaolin, feldspar and quartz. Lacking of natural raw material becomes one of the reason why alternative materials are needed while saving the costs. The worst case is when mining activities not only impact the erosion on the surface

of earth but also effecting the flow of underground water especially in the mining area. Other than that, the production of dust in factories and quarries also affects workers' health.

While looking on the other aspect, ceramic tile was very sensitive, fragile and easily crack especially when there is single stress acting on the tile. This resulting in wastage on the construction site and also endangering the site worker (Beaumont Tiles, 2017). Therefore, the contractor needs to supply tiles more than the actual quantities to ensure the project progress run smoothly.

In the other hand, by knowing the hazard that accompany the improper disposal of plastic waste and in view of helping earth to converting and maximize the use of all HDPE waste, rHDPE tile seen as one of the alternatives in producing a tile. rHDPE tile is expected to have flexural strength, slippage resistance and better water absorption. Below show composition of solid waste disposal in Malaysia:

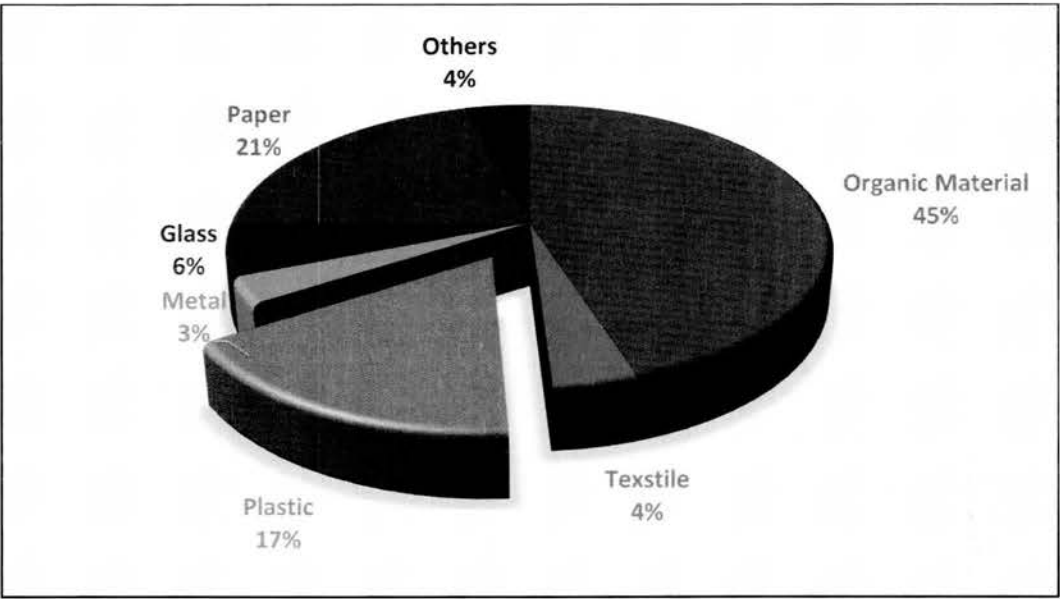


Figure 1.1 - Composition of Solid Waste Disposal (National Seminar on the Management and Utilization of Solid Waste, 2016)

Table 1.1: Problem Statements

Element	Problem Statement	Impact
Floor Tile	Fragile and sensitive	Wastage on construction site, cost and safety issues
	Lacking of natural raw material	Become costly because hard to find day by day
	Impact of mining activities	Erosion on the surface of earth and effecting the flow of underground water
HDPE	Environmental issues	Dumping dumps that cannot be disposed of

1.3 Objectives of Study

Objectives to be accomplished at the end of this project are:

- i. To study the effect of SLSG powder as filler loading on rHDPE's tiles.
- ii. To evaluate the mechanical properties of rHDPE: SLSG composite by mechanical testing (Flexural and Impact Test).
- iii. To correlate the mechanical properties with filler loading of rHDPE: SLSG composite.

1.4 Scope of Study

The project scope will cover aspects such as follows:

- i. The waste used is recycled High Density Polyethylene (HDPE) and recycled Soda Lime Silicate Glass (SLSG).
- ii. Sample will be produced based on 3 (three) different ratio which are:
 - a. 100% rHDPE (100:0)
 - b. 95% rHDPE + 5% SLSG (95:5)
 - c. 80% rHDPE + 20% SLSG (80:20)
- iii. Characteristic of Composite Tiles:
 - a. The following aspects are considered:
 - (a) Mix proportion
 - (b) Material Strength
 - (c) Maximum Force
 - (d) Impact Energy and Strength
- iv. Characteristic of Hardened Tiles:
 - a. To obtain the hardened of the tile's sample, the following test are covered:
 - (a) Flexural Test
 - (b) Impact Test / Charpy Impact Test

1.5 Outline of thesis

This thesis is presented in 4 chapters as detailed below:

Chapter 1 will gives the introduction to current situation with conventional tiles, rHDPE, roughly the impact when implement rHDPE tile, objective and scope of the research.

Chapter 2 showed literature review presents the work done by various researchers in the field of tiles structure.

Chapter 3 outlined details the scheme of planned experimental, materials used, variables involved, moulding process, casting and testing of specimens and materials.

Chapter 4 discussed the data recoded form the experimental based and discussed to any related field to achieving the research objective.

Chapter 5 will gives the final conclusion and some recommendation if any for future work that can be done related to the study field.

CHAPTER 2.0

LITERATURE REVIEW

Literature review is in depth evaluation of previous research. It is actually the summary and synopsis the same topic or at least the related article belongs to the research to be done. All the important aspect will be summarize together and come out the reasons why me is pursuing this particular research program.

2.1 Introduction

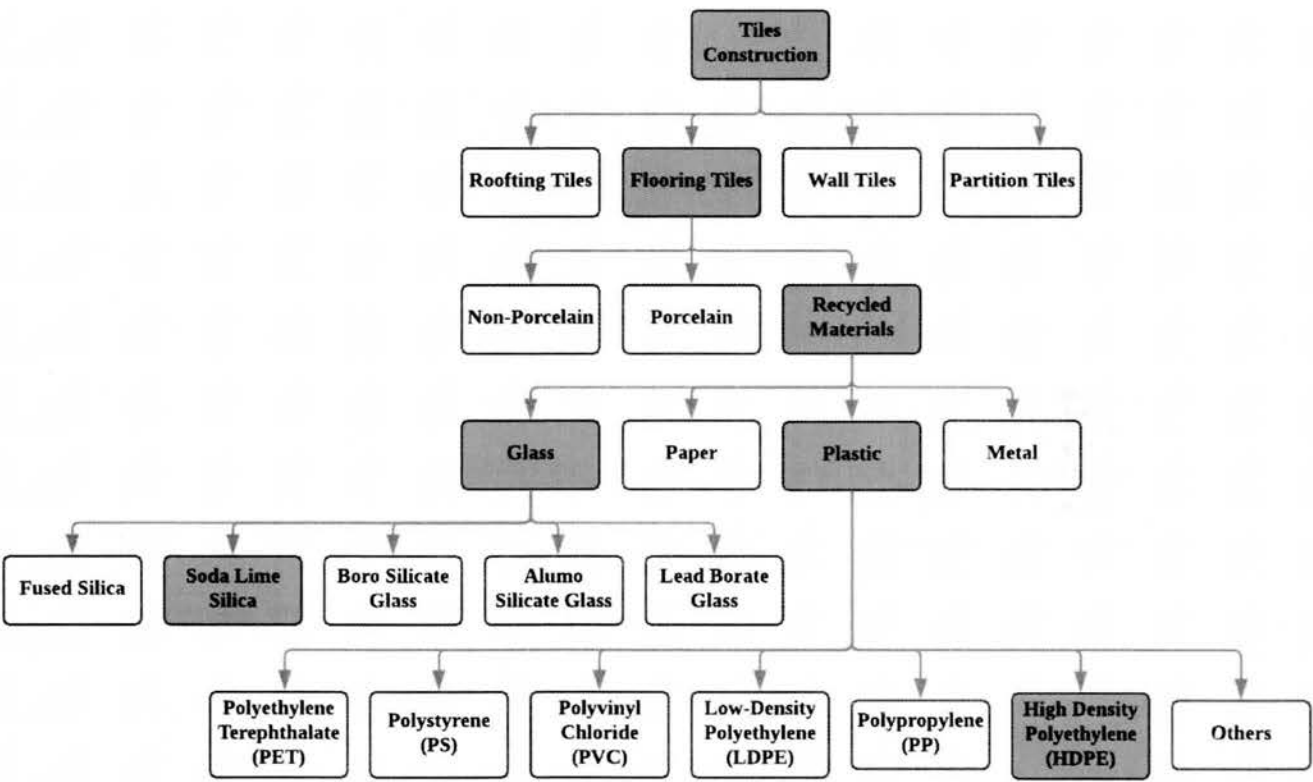


Figure 2.1: K-Chart for covered area of research study

Plastics are polymers, a profoundly and astronomically immense molecule composed of more minuscule units called monomers which are joined together in a chain by a process called polymerization. The polymers generally contain carbon and hydrogen with, sometimes, other elements such as oxygen, nitrogen, chlorine or fluorine (UNEP, 2009).

Today, plastics have become an essential part of our daily lives. The amount of plastic used every day become higher day by day, it increased in steadily mode. Because of low density, strength, designs, fabrication abilities, duration of live, light in weight, and cheap offered by the plastic, they become the factors behind such phenomenal evolution. Plastics have been used widely in wrapping, manufacturing, automotive, medical, housing, communication materials, and many more. With these such broader applications, plastics contribute large amount in the solid waste stream. Based on the world's annual consumption, the plastic materials has increased from around 5 million tons in the 1950s to nearly 100 million tons in 2001 (Siddique et al., 2008).

Glass is one of the earliest human made materials. It had been manufactured in various forms such as packaging and container glass, bulb, and many more. They all have their own limited life manufactured forms thus they need to be recycled to avoid environmental issues if they was ignored and throw-out to the landfills.

The amount of plastic and glass waste have been rising promptly during the recent decades due to the increasing of industrial development and the improvement in the standards of living style, but unfortunately, these waste quantities are not being recycled in total but somewhat abandoned causing serious problems to the environment such as the lacking natural resources and pollution (Husni Al-Najar, 2005).

Thus by recycling of this plastic and glass waste by converting it to aggregate components, it might be help to reduce the area of landfill used and also moderate the demand for natural raw material for construction actions.

2.2 High Density Polyethylene, HDPE

High-density polyethylene, HDPE ($0.941 < \text{density} < 0.965$) is a thermoplastic material composed of carbon and hydrogen atoms joined together forming high molecular weight products as shown in Figure 2.2 below (Lester, 2005). The property characteristics of polyethylene depend upon the arrangement of the molecular chains. The property characteristics of polyethylene depend upon the arrangement of the molecular chains.

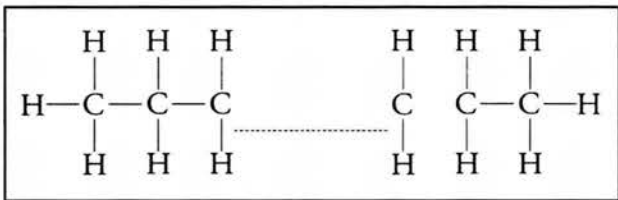


Figure 2.2 Polyethylene Molecular Chain

Polyethylene is characterized as a semi-crystalline polymer, made up of crystalline regions and amorphous regions. High-density polyethylene resin has a greater proportion of crystalline regions than low-density polyethylene. The size and size distribution of crystalline regions are determinants of the tensile strength and environmental stress crack resistance of the end product. HDPE has a greater proportion of crystals, which results in greater density and greater strength.

The melting point of polyethylene is defined as that temperature at which the plastic transitions to a completely amorphous state. In HDPE and other thermoplastic materials, the molecular chains are not cross-linked and such plastics will melt with the application of a sufficient amount of heat. With the application of heat, thermoplastic resins may be shaped, formed, moulded or extruded. A lower MI (higher average molecular weight) is predictive