KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF ARCHITECTURE AND PLANNING

FACULTY OF ARCHITECTURE AND BUILDING TECHNOLOGY

DEPARTMENT OF ARCHITECTURE,

DESIGN THESIS:

PLASTIC RECYCLING PLANT,

DOMPOASE [KUMASI].

A DESIGN THESIS REPORT SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE OF THE KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE POSTGRADUATE DIPLOMA IN ARCHITECTURE.

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(Post Graduate Diploma)

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DECLARATION

I do hereby solemnly declare that the survey, data collection, design and write up of this design thesis report was done by me under the supervision of Mr. E. Botchway

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Signed ....

Prof. G.W.K. Intsiful [Head of Department]

Date..........................May, 2009

DEDICATION

To my mum, Paulina Amponsah, my dear Beatrice Dansowah Konadu and my family for their support and encouragement. God richly bless them.

ACKNOWLEDGEMENT

I express my thanks to the Almighty God for his wisdom and favours throughout my entire course.

I owe a special debt to the staff of the department of architecture for their invaluable help especially Mr. S. O. Afram and undoubtedly my supervisor Mr. E .Botchway.

Finally, my sincere gratitude to all friends and students who in diverse ways helped me in my thesis.

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ABSTRACT

Kumasi metropolis is faced with sanitation problems although it is described as the "Garden City" of Ghana. It is estimated that the metropolis produces 1,500 tonnes of solid waste daily of which 3.52% (54 tonnes) forms the plastic component.

The non-degradable nature of low density polyethylene makes it more devastating as the plastic could be there for months and years without degrading thereby prolonging these sanitation problems.

Recycling and reuse then means less dependence on petroleum. However, concerns over the volume of plastic waste generated have created growing interest in recycling efforts. This thesis seeks to undertake research leading to the design of a plastic recycling plant in an effort to define the role of architectural design in the waste management sector of development.

The designed will meet the needs of all users of the facility in a harmonious atmosphere by the use of modern technology and machines which are environmentally friendly to users together with well designed landscaping to link zoned units.

CHAPTER ONE

1.1 INTRODUCTION

Kumasi the second largest city and metropolis after Accra exhibits a rich Akan cultural heritage which attracts lots of tourist the world over. The question we ask ourselves is; does the current state of the metropolis in terms of sanitation paint the right picture of how it should be?

Market centres now double as 'damp site' as refuse can be left in these environmentally sensitive areas for days unattended to, plastic bags are hipped along principal streets due to improper and indiscriminate refuse disposal.

Waste management continues to be very difficult and challenging on the part of city authorities due mainly to inadequate funding which hinders them from implementing most of their effective and well drawn waste management policies. This seriously undermines the hard earned reputation and status of the metropolis as the 'Garden City'. Flooding and outbreak of sanitation based diseases are on the increase. The increasing use of plastic bags and products for packaging constitutes a herculean task as they are non-biodegradable.

This calls for a more comprehensive waste management system to address these problems. Top on the list of this management system after effective collection and disposal is recycling as it is the only cheapest means to convert solid waste into equally useful product with minimal danger to the environment. Volumes of plastic waste occupied at land fill site will be drastically reduced, flooding and sanitation based diseases will be on the low side if not totally eradicated. This is the right time to consider plastic recycling as a strong alternative to plastic waste disposal.

1.2 PROBLEM STATEMENT

With an estimated 2 million population of the Kumasi metropolis, 1500 tonnes of solid waste is generated daily of which 80% (1200 tonnes) is collected to the Dompoase land fill site.

36,000 tonnes of solid waste is deposited every month, 432,000 tonnes every year of which plastic a non- degradable component constitute 7% (30,240 tonnes).

This creates a menace to the society environmentally and health wise as this plastics choke gutters causing flooding, harboring mosquitoes which causes malaria and making the environment unsightly and prone to disease causing agents. With the main sources of waste generation being residential areas, market centres, industrial areas and hospitals makes the problem more devastating.

The establishment of the plastic recycling plastic at the Dompoase land fill site will enable the recycling of 84 tonnes of plastic daily thereby eradicating the hazards posed by these plastics. The plastic recycling plant project will not only avert the current environmental crises facing the country but will also create jobs, generate funds and provide raw materials to many plastic based firms and manufacturing companies in the country among which include

- Condorplastic Limited – Accra
- Fairview Packaging Company Limited – Accra
- Kaymagic Company Limited - Kumasi
- Blowplast Industrial Limited – Accra
- Sintex Containers (GH) Limited – Accra

1.3 OBJECTIVES

- To generate revenue for the metropolis
- To design a plastic recycling plant by so doing defining the role of architecture in the waste management sector.
- To address the environmental hazards associated with improper waste management thereby keeping the city clean, healthy and safe.
- Produce a less expensive recycled plastic material for industrial use.

1.4 JUSTIFICATION

It is of great interest to invest in viable projects which tend to preserve and conserve the environment such as the plastic recycling plant. Such projects aids in curbing environmental problems and make the environment a clean, healthy and safe place to live in as it is said "we make the environment and the environment makes us".

Recycling the world over plays an important role to the economic and environmental development of many nations. Recycling in the case of Ghana has little to show as such facilities are virtually non-existent and as such hinders economic and environmental growth in this era of golden age of business. Recycling of waste into usable products is much cheaper and environmentally friendly as compared to the hazards associated with improper waste management, hence the need for the Government to pay much attention to and invest in such viable projects as well.

1.5 SCOPE OF THESIS

The thesis will consist of the following aspects of the facility

- Administration.
- Production and maintenance unit
- Warehousing unit
- Welfare and security unit
- landscaping

1.6 CLIENT

Kumasi Metropolitan Assembly is the main client for the project.

1.6.1 CLIENT'S BREIF

The main areas as specified by the client as the main focus of these design are in two parts:

- The recycling plant
- Administration
- Canteen and clinic
- Warehouse
- Maintenance unit
- Landscaping

1.6.2 TARGET GROUP

Target groups for raw materials

- Dompoase land fill site
- Co-operate bodies
- Residential areas
- Market places

Target groups for recycled products

- Manufacturing companies
- Export

1.7 FINANCIERS

The Bank of Ghana together with Kumasi Metropolitan Assembly will finance the project from its inception to completion.

1.8 SITE SELECTION AND JUSTIFICATION

Dompoase industrial area in Kumasi has been chosen as the site for the construction of the recycling plant as it has proposed area for the siting of such a facility. The Dompoase landfill site is about 100 metres from the site thereby making raw materials easily accessible to the facility within the shortest possible distance.

CHAPTER TWO

2.1 A BRIEF HISTORY OF RECYCLING

Recycling has been a common practice for most of human history, with recorded advocates as far back as Plato in 400 BC. During periods when resources were scarce, archaeological studies of ancient waste dumps show less household waste (such as ash, broken tools and pottery)—implying more waste was being recycled in the absence of new material.

In pre-industrial times, there is evidence of scrap bronze and other metals being collected in Europe and melted down for perpetual reuse, and in Britain dust and ash from wood and coal fires was down cycled as a base material in brick making. The main driver for these types of recycling was the economic advantage of obtaining recycled feedstock instead of acquiring virgin material, as well as a lack of public waste removal in ever more densely-populated areas.

(Source; Porter, Richard C. [2002]. *The economics of waste*)

2.1.1 WARTIME RECYCLING

Resource shortages caused by the world wars, and other such world-changing occurrences greatly encouraged recycling. Massive government promotion campaigns were carried out in World War II in every country involved in the war, urging citizens to donate metals and conserve fiber, as a matter of significant patriotic importance. Resource conservation programs established during the war were continued in some countries without an abundance of natural resources, such as Japan, after the war ended.

(Source; Ackerman, Frank. (1997). *Why Do We Recycle?: Markets, Values, and Public Policy*)

2.1.2 POST-WAR RECYCLING

The next big investment in recycling occurred in the 1970s, due to rising energy costs. Recycling aluminum uses only 5% of the energy required by virgin production; glass, paper and metals have less dramatic but very significant energy savings when recycled feedstock is used.

Woodbury, New Jersey was the first city in the entire United States to mandate recycling. Led by Rose Rowan in the early 1970s, the idea of towing a "recycling" trailer behind a waste management vehicle to enable the collection of trash and recyclable material at the same time emerged. Other towns and cities soon followed suit, and today many cities in the U.S. make recycling a requirement.

From 1970 to today, enormous progress has been made in recycling as municipality after municipality handed out bins and ordered paper, cans and other materials is placed in them. In the mid-'80s, there was only one curbside recycling program as compared to more than 8,600 in 2006. That's according to the federal Environmental Protection Agency (EPA) which was formed in 1970.

In 1980, recycling kept 15 million tons out of landfills. A couple of years ago, that figure had risen to 82 million. Curbside pickups, drop-off sites and buy-back centers have stopped 32 percent of our solid waste from ending up in landfills.

Sixty-eight percent of our trash and garbage is still being dumped. The massive Fresh Kill landfill, opened on Staten Island in 1948, closed 2001, was one of three man-made things that could be seen from outer space.

(**Source**; Porter, Richard C. [2002]. *The economics of waste*)

2.2 HISTORY OF WASTE MANAGEMENT IN KUMASI

Kumasi is the second largest city in Ghana and the capital of the Ashanti region, it covers a total surface area of 254km2 and accommodates a population of 1,517,000 (2005, source: United Nations Population Division). Waste service delivery in the Kumasi metropolis has been the responsibility of the central government which exercised control through the local authorities. The Kumasi Public Health Board (KPHB) which was a statutory body was inaugurated in July 1925 to cater for the sanitary amenities of Kumasi. The Kumasi Town Council (KTC) which descended from the board was established in 1943.

Under the Municipal Council's Ordinance, Kumasi became a municipal with a significant advance in local government. The Kumasi Municipal Council (KMC) descended from the KPHB and the KTC. Kumasi achieved the status of a city on the 24th of March, 1962 when Ghana became a republic with it the creation of Kumasi City Council (KCC). The KCC was responsible for the general sanitation services of the city as well as infrastructure development. As a result of the creation of District and Metropolitan Assemblies in 1988/89, Kumasi was elevated to a metropolis and with it the creation of the Kumasi Metropolitan Assembly (KMA).

In the Kumasi metropolis, the responsibility of providing waste management services lies with the district or metropolitan authority which in this case is the Kumasi Metropolitan Assembly (KMA). According to the UNDP-KSP Report only 40%-45% of the total waste generated in the metropolis is effectively collected and transported for final disposal.

(**Source**; Kumasi Metropolitan Assembly)

2.2.1 SOLID WASTE GENERATION IN KUMASI

The daily waste generated per Capita is estimated to be 0,6kg, giving a yearly specific per Capita of 219kg and a total of about 263Mt per annum for the entire city. Out of this amount an estimated 70% is collected by private companies and dumped without pre-treatment on a sanitary landfill site in Dompoase. The rest (which is not collected) is dumped by individuals usually in open spaces or in drains. Household waste comprising mainly organic waste is collected without source separation in 120L bins, old boxes, buckets, polythene bags etc The Waste Management Department (WMD) of the Kumasi Metropolitan Authority (KMA) has the responsibility of overseeing the activities of the companies sub-contracted for household waste collection in the metropolis.

In Kumasi, the bulk of household waste was found to be Organic waste with an overall average of 55%.

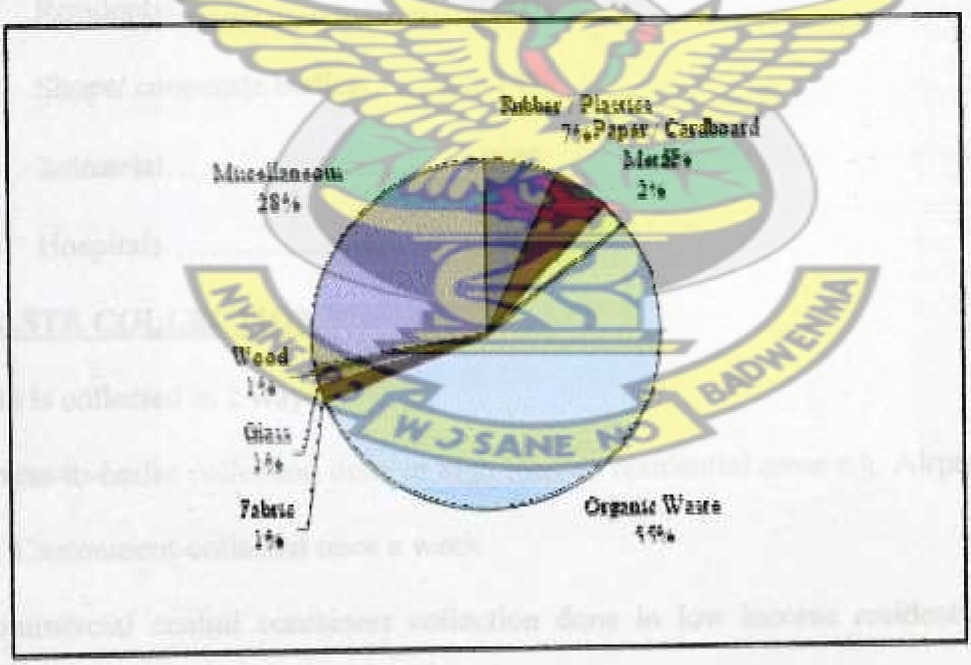


Fig. 1 **Solid waste generation in Kumasi** (source KMA)

Density - 0.47 t/m3 Moisture content- 40%

Average Household solid waste composition of all areas in Kumasi

2.2.2 DAILY QUANTITIES OF WASTE GENERATED IN KUMASI METROPOLIS

YEAR	GENERATION Tons/day	DEPOSITION Tons/day
2002	607.0	445.1
2003	625.8	469.3
2004	645.2	494.6
2005	665.2	521.0
2006	685.8	548.6
2007	707.0	577.4
2008	729.0	577.4

2.2.3 MAIN SOURCES OF WASTE GENERATION

- Residential……………………………60%
- Shops/ cooperate bodies…………14%
- Industrial……………………………20%
- Hospitals……………………………6%

2.2.4 WASTE COLLECTION

Waste is collected in 2 ways

1-House-to-house collection done in high income residential areas e.g. Airport residential area, Cantonment-collected once a week

2-Commercial central containers collection done in low income residential areas e.g. Nima-collected daily

Areas recording higher levels of waste generation are markets, lorry stations and low income residential areas.

2.3 RECYCLING

Recycling involves processing used materials into new products in order to prevent the waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from landfilling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to virgin production. Recycling is a key component of modern waste management and is the third component of the "Reduce, Reuse, Recycle" waste hierarchy.

Recyclable materials include many kinds of glass, paper, metal, plastics, textiles, and electronics (e.g., cell phones and computers). Although similar in effect, the composting or other reuse of biodegradable waste – such as food or garden waste – is not typically considered recycling. Materials to be recycled are either brought to a collection center or picked up from the curbside, then sorted, cleaned, and reprocessed into new materials bound for manufacturing.

Critics of recycling claim that it often wastes more resources than it saves, especially in cases where it is mandated by government. But municipal recycling may nevertheless still be worthwhile if the net cost is less than the landfill or other disposal costs for the same amount of material.

2.3.1 BENEFITS OF RECYCLING

- Recycling Saves Landfill Space.
- Recycling Can Reduce the Cost of Waste Disposal.
- Recycling Can Save Energy.
- Recycling Saves Natural Resources.
- Recycling Can Reduce Air and Water Pollution.
- Recycling Creates Jobs

2.3.2 COST-BENEFIT ANALYSIS

ENVIRONMENTAL EFFECTS OF RECYCLING

Material	Energy Savings	Air Pollution Savings
Aluminum	95%	95%
Cardboard	24%	—
Glass	5-30%	20%
Paper	40%	73%
Plastics	70%	—
Steel	60%	—

2.4 PLASTIC RECYCLING

Plastic recycling is the process of recovering scrap or waste plastics and reprocessing the material into useful products. Compared to glass or metallic materials, plastic poses unique challenges. Because of the massive number of types of plastic, they each carry a resin identification code, and must be sorted before they can be recycled. This can be costly; while metals can be sorted using electromagnets, no such 'easy sorting' capability exists for plastics. In addition to this, while labels do not need to be removed from bottles for recycling, lids are often made from a different kind of non-recyclable plastic.

To help in identifying the materials in various plastic items, resin identification code numbers 1-6 have been assigned to six common kinds of recyclable plastic resins, with the number 7 indicating any other kind of plastic, whether recyclable or not. Standardized symbols are available incorporating each of these resin codes, as shown in the following table:

2.4.1 TABLE OF RESIN IDENTIFICATION CODES

Plastic Identification Code	Type of plastic polymer	Properties	Common Packaging Applications
01 PET	Polyethylene Terephthalate (PET, PETE)	Clarity, strength, toughness, barrier to gas and moisture.	Soft drink, water and salad dressing bottles; peanut butter and jam jars
02 PE-HD	High Density Polyethylene (HDPE)	Stiffness, strength, toughness, resistance to moisture, permeability to gas.	Milk, juice and water bottles; trash and retail bags.
03 PVC	Polyvinyl Chloride (PVC)	Versatility, clarity, ease of blending, strength, toughness.	Juice bottles; cling films; PVC piping
04 PE-LD	Low Density Polyethylene (LDPE)	Ease of processing, strength, toughness, flexibility, ease of sealing, barrier to moisture.	Frozen food bags; squeezable bottles, e.g. honey, mustard; cling films; flexible container lids.
05 PP	Polypropylene (PP)	Strength, toughness, resistance to heat, chemicals, grease and oil, versatile, barrier to moisture.	Reusable microwaveable ware; kitchenware; yogurt containers; margarine tubs; microwaveable disposable take-away containers; disposable cups and plates.

06 PS	Polystyrene (PS)	Versatility, clarity, easily formed	Egg cartons; packing peanuts; disposable cups, plates, trays and cutlery; disposable take-away containers;
07 O	Other (often polycarbonate or ABS)	Dependent on polymers or combination or polymers	Beverage bottles; baby milk bottles; electronic casing.

(Source; Porter, Richard C. [2002]. *The economics of waste)*

2.4.2 USES OF PLASTIC

Packaging represents the largest single sector of plastics use. For example the sector accounts for 35% of UK plastics consumption and plastic is the material of choice in nearly half of all packaged goods.

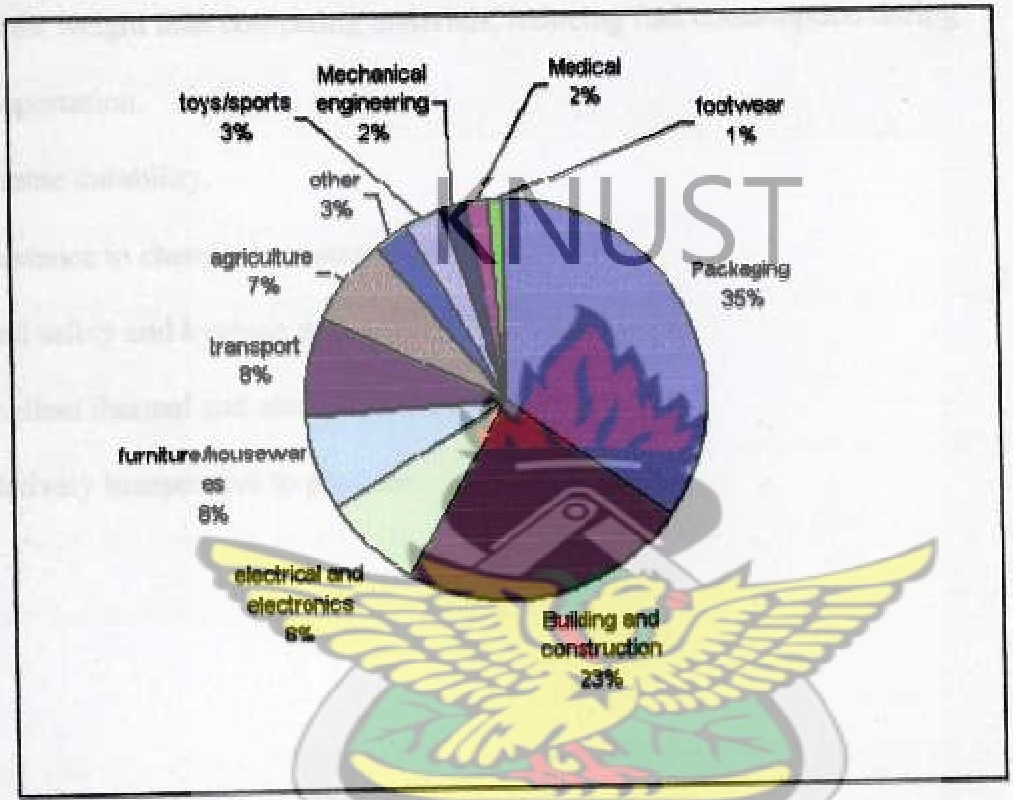


Fig. 2 **Chart showing plastic usage in UK** (Porter, Richard C. [2002]. *The economics of waste*)

2.4.3 USES OF RECYCLED PLASTIC

There is a wide range of products made from recycled plastic. This includes polyethylene bin liners and carrier bags; PVC sewer pipes, flooring and window frames; building insulation board; video and compact disc cassette cases; fencing and garden furniture; water butts, garden sheds and composters; seed trays; anoraks and fleeces; fibre filling for sleeping bags and duvets; and a variety of office accessories.

2.4.4 BENEFITS OF PLASTICS

The considerable growth in plastic use is due to the beneficial properties of plastics. These include:

- Extreme versatility and ability to be tailored to meet very specific technical needs.
- Lighter weight than competing materials, reducing fuel consumption during transportation.
- Extreme durability.
- Resistance to chemicals, water and impact.
- Good safety and hygiene properties for food packaging.
- Excellent thermal and electrical insulation properties.
- Relatively inexpensive to produce.

2.5 THE PROCESS OF RECYCLING PLASTICS

2.5.1 Post Industrial Polyolefin Recycling Process

. There are several types of plastic recycling available:

- Plastic Scrap (also called process scrap) - is the recycling of any polymers left over from the production of plastics.
- Post Consumer - is the recycling of plastic material arising from products that have undergone a first full service life prior to being recovered.
- Mechanical - refers to processes which involve the melting, shredding or granulation of waste plastics.
- Feedstock - refers a range of recycling techniques to make plastics, which break down polymers into their constituent monomers, which in turn can be used again in refineries, or petrochemical and chemical production.

The diagram below is a flow chart describing the mechanical recycling process for polyolefin scrap. In this process, plastics are first sorted either by trained staff who manually sort the plastics into polymer type and/or colour, or by automatic techniques such as X-ray fluorescence, infrared and near infrared spectroscopy, electrostatics and flotation. Once sorted, the plastic is either melted down directly and moulded into a new shape, or melted down after being shredded into flakes and then processed into granules called regranulate.

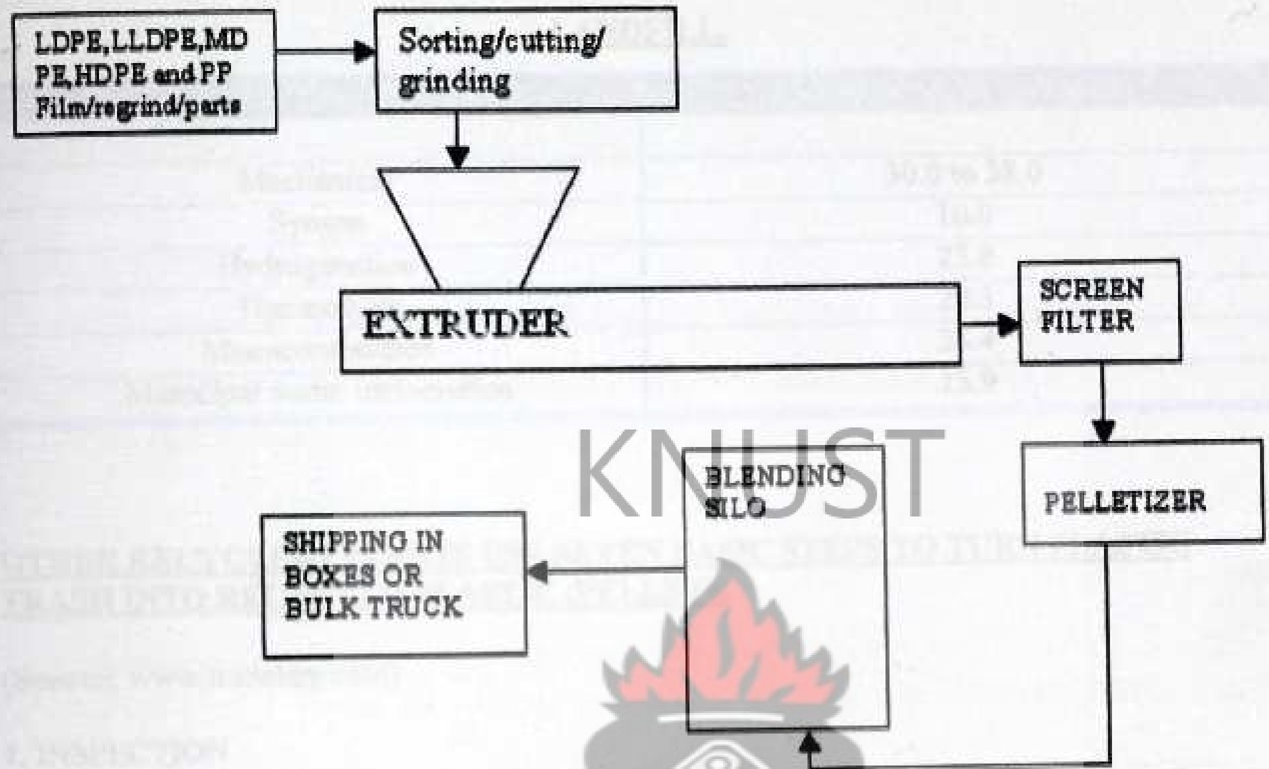


Fig. 3 Plastic recycling production line

(**Source**; Jiangsu Plastics Limited)

The flow chart above is a typical set up for recycling polyolefin scrap by mechanical recycling.

The other two options for plastic recycling include:

- Feedstock Recycling: specific for polymeric materials, also in a mixed form.eg. chemical depolymerization, pyrolysis, gasification, hydrogenation.
- Energy Recovery: suitable for mixed/contaminated plastics. The calorific content of plastics is recovered by burning the plastics waste alone or together with fossil fuels.

ENERGY SAVINGS OF SEVERAL RECYCLING OPTIONS IN COMPARISON TO LANDFILL.

RECYCLING OPTION	ENERGY SAVING (MJ/kg)
Mechanical	30.0 to 38.0
Syngas	10.0
Hydrogenation	23.8
Thermolysis	29.3
Monocombustion	26.4
Municipal waste incineration	15.9

OTHER RECYCLING PLANTS USE SEVEN BASIC STEPS TO TURN PLASTIC TRASH INTO RECYCLED PLASTIC (PELLET):

(Source; www.tradekey.com)

1. INSPECTION

Workers inspect the plastic trash for contaminants like rock and glass, and for plastics that the plant cannot recycle.

2. CHOPPING AND WASHING

The plastic is washed and chopped into flakes.

3. FLOTATION TANK

If mixed plastics are being recycled, they are sorted in a flotation tank, where some types of plastic sink and others float.

4. DRYING

The plastic flakes are dried in a tumble dryer.

5. MELTING

The dried flakes are fed into an extruder, where heat and pressure melt the plastic. Different types of plastics melt at different temperatures.

6. FILTERING

The molten plastic is forced through a fine screen to remove any contaminants that slipped through the washing process. The molten plastic is then formed into strands.

7. PELLETIZING

The strands are cooled in water, then chopped into uniform pellets. Manufacturing companies buy the plastic pellets from recyclers to make new products. Recycled plastics also can be made into flowerpots, lumber, and carpeting.

2.5.2 ENVIRONMENTAL IMPACT OF RECYCLING PLASTICS

The production and use of plastics has a range of environmental impacts. Firstly, plastics production requires significant quantities of resources, primarily fossil fuels, both as a raw material and to deliver energy for the manufacturing process. According to the 'Ecoweb' (by the University of Virginia), it is estimated that 4% of the world's annual oil production is used as a feedstock for plastics production and an additional 3-4% during manufacture.

A report on the production of carrier bags made from recycled rather than virgin polythene concluded that the use of recycled plastic resulted in the following environmental benefits:

- reduction of energy consumption by two-thirds
- production of only a third of the sulphur dioxide and half of the nitrous oxide
- reduction of water usage by nearly 90%
- reduction of carbon dioxide generation by two-and-a-half times

A different study concluded that 1.8 tonnes of oil are saved for every tonne of recycled polythene produced.

In addition, plastics manufacture requires other resources such as land and water and produces waste and emissions. The overall environmental impact varies according to the type of plastic and the production method employed.

The disposal of plastics products also contributes significantly to their environmental impact. Because most plastics are non-degradable, they take a long time to break down, possibly up to hundreds of years - although no-one knows for certain as plastics haven't existed for long enough - when they are landfilled. With more and more plastics products, particularly plastics packaging, being disposed of soon after their purchase, the landfill space required by plastics waste is a growing concern.

Plastic waste, such as plastic bags, often becomes litter. For example, nearly 57% of litter found on beaches in 2003 was plastic.

2.5.3 SPECIAL STUDIES

1. EXTRUSION MACHINES

MACHINE DIMENSION

Width-1400	Width- 1400
Length- 470	Length-4700
Height- 10450mm	Height-10450mm

Fig.4 Showing Extrusion Machines

(**Source**; Jiangsu Plastics Limited)

Fig.5 Showing Extrusion Machines

(Source; Samplastic **Products Ltd**)

2. SORTING OUT MACHINE

MACHINE DIMENSIONS .

Width 1200– 3400mm.
Length 6200–7200mm.
Height 2150–2250mm.

Width 815 mm.
Length 550 mm.
Height 1770 mm.

Width 815 mm.
Length 550 mm.
Width 1800 mm.

Fig.6 Showing Sorting-Out Machine (**Source**; Jiangsu Plastics Limited)

3. WASHING AND GRINDING MACHINE

Width 815 mm.
Length 6550 mm.
Width 1800 mm.

Fig.7 Showing Washing and Grinding Machine (Source; Jiangsu Plastics Limited)

4. THE AGGLOMERATOR MACHINE

Fig.8 Showing the Agglomerator Machine (Source; Jiangsu Plastics Limited)

5. SCREEN FILTER MACHINE

Machine dimension: 3500*1000*800mm

Fig.9 Showing Screen Filter Machine (Source; Jiangsu Plastics Limited)

6. PELLETIZER MACHINE

MACHINE DIMENSION .
12000x1500x 1800mm
4000 x 1800 x 2500mm

Fig.10 Showing the Pelletizer Machine

(Source; Jiangsu Plastics Limited)

7. BLENDING SILO

SIZES:
- HEIGHT A : 4'770 MM
- WIDTH B : 1'760 MM
- LENGTH C : 1'970 MM
- SCREEN'S HOLES Ø 14 MM

Fig.11 Showing the Blending Silo

(Source; Jiangsu Plastics Limited)

6. CONVEYOR BELT

Fig.12 Showing the Conveyor Belt

(Source; Jiangsu Plastics Limited)

Dimension: 356x1829x0.25t(mm).

CHAPTER THREE

3.1 METHODOLOGY

The author employed the following which aided with the research, analysis and design

- **Reconnaissance survey and analysis** – a visit to stake holders of recycling such as Kumasi metropolitan Assembly aided in getting first hand information to develop a basis for the justification and execution of the project
- **Case studies** – a visit to the site and other relevant facilities both local and foreign is of importance to know the scale of the project and what goes into it in terms of construction, materials and services.
- **Interviews** - formal and informal meetings was arranged to know what both clients and the prospective users of the facility will like to have and see. People in the industry were also interviewed.
- **Photography** – graphic representation was used to really know what pertains in such industrial facilities. This aided in the design of façade and most especially the interior spaces of the plant.
- **Electronic and print media** – the internet, various news papers, architectural magazines, relevant books and brochures aided as a source of getting information. It provided access to electronic books, journals, articles and pictures that have been written concerning the subject of study.
- **The Library** - The library was the author's second major source of research information. Some specific books authored by architects about factory design were available in the library. Available at the library were varying architectural books, journals, magazines, pictures and student dissertational works for research.

3.2 RESEARCH INSTRUMENT

Among some of the instruments used in the research and design of the facility included Camera, field note book, graph book, tape measure among others.

3.3 LIMITATION

Most recycling plant available for study were private owned and as such there were restriction as to taking pictures, measurements and getting data.

Bureaucracy was also a major problem in securing data from various stakeholders. Accessing information from the internet was extremely difficult. Inadequate funds was also a major hindrance to the execution of the project.

CHAPTER FOUR

4.0 CASE STUDY (SAMPLASTIC PRODUCTS LIMITED)

DESIGN

The harmonious use of vertical shading devices together with horizontal bans makes the entire architectural piece very pleasing. The effective use of arches pronounces the entrance and welcomes you to the main administration. This tends to shield the boring and flat façade of the main production unit.

Fig. 13 **Main entrance to the administration** (source; Samplastic Products Ltd)

SECURITY

The whole facility is walled and has only one entrance and exit which had a well designed security checkpoint with automated door securing the entire factory premises.

Fig. 14 **Security post and main entrance to factory** (source; Samplastic Products Ltd)

PRODUCTIVITY

The design provides both a visual and direct link between the main administration and the production floor thereby providing a good relationship between workers of both departments as the administration is located on a mezzanine floor overlooking the production area. This facilitates easy flow of information and helps the main administration to play its supervisory role effectively.

Fig. 15 **Entrance and link between administration and production floor**
(Source; Samplastic Products Ltd)

VENTILATION AND LIGHTING

Some of the machines require higher level of ventilation to operate effectively and as such there was the need to use lower level windows to achieve that requirement at specific sections of the production floor. On other sections of the production floor, higher level windows are used to achieve general ventilation together with day lighting.

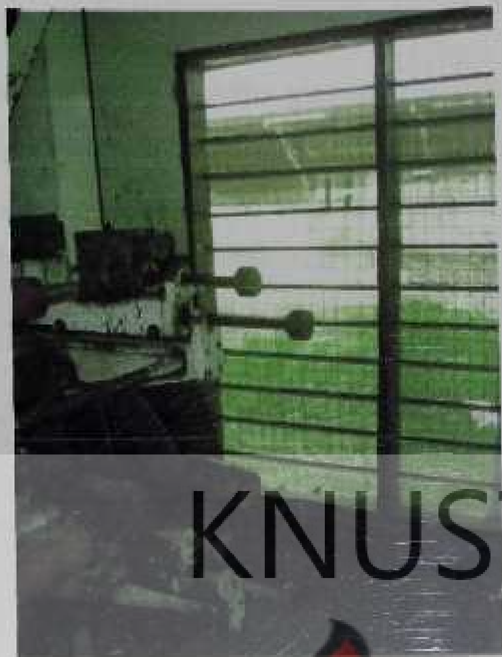


Fig.16 **Lower level windows used for ventilation** (Source; Samplastic Products Ltd)

Fig. 17 **Higher level windows used to supplement lighting and ventilation**

(Source; Samplastic Products Ltd)

Daylighting is again admitted into the production floor from the roof through the use of perspex. This is in turn supplemented by the artificial lighting used. On the whole, the general lighting level was adequate.

POWER SUPPLY

Other supporting facilities used were the standby generator which could run for a maximum of 24 hours when electricity supply is interrupted. This needs higher level of ventilation and as such the plant is sheltered under a steel structural shed with aluminium roofing sheet without walls.

Fig.18 **Generator plant used at factory** (Source; Samplastic Products Ltd)

Fig.19 **Step down transformer used at factory** (Source; Samplastic Products Ltd)

COLD WATER SUPPLY

The facility has a cold water supply unit which supplied cold water through pipes to specific machines which need cold water to cool off and maintain their optimum temperature.

Fig.20 Cold water storage unit (Source; Samplastic Products Ltd)

STRUCTURAL SYSTEM

Steel truss were used to anchor the roof to achieve the long span needed to shelter the machinery in the production unit which had heights reaching up to 10 metres high. The production floor had a span of about 20 metres with a 5 metre column interval at the extreme ends of the unit. The same structural system is used for adjoining facilities of the main production unit such as the storage unit as shown in fig. 13.

Fig.21 **Steel truss structural support used in the factory production floor**

(**Source**; Samplastic Products Ltd)

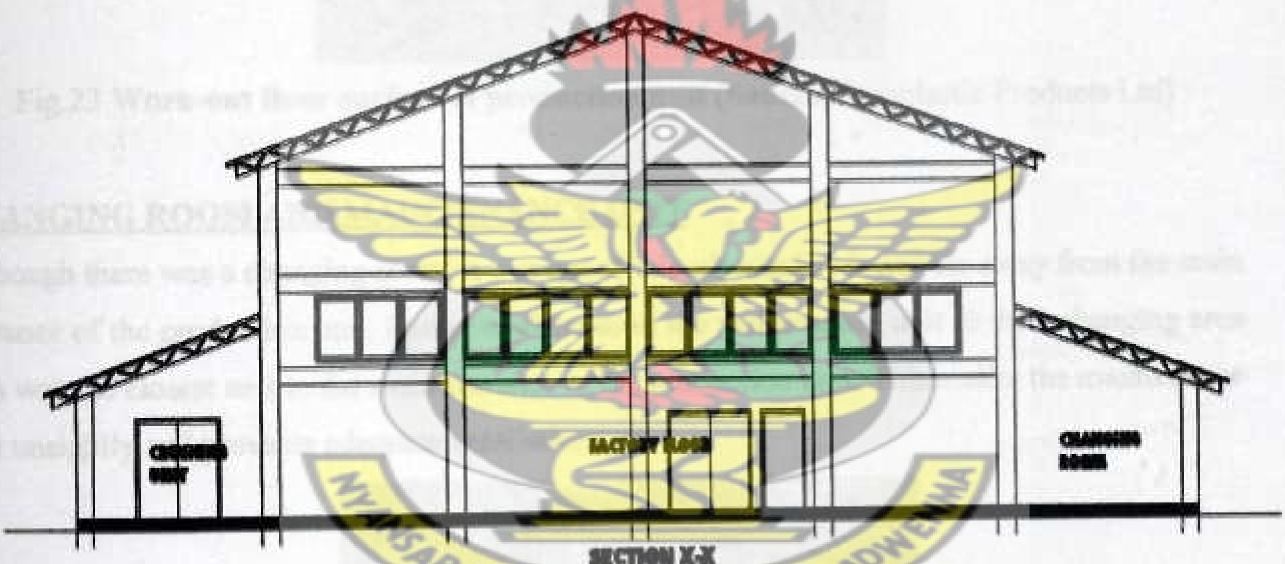


Fig.22 Schematic sectional drawing of main production unit

(**Source**; Samplastic Products Ltd)

PROBLEMS

FLOOR DETAIL

There were some challenges facing the production unit among which included worn out floor which impedes efficient machinery and human movement. This can be attributed to poor floor design which could not bear the heavy load of the machinery.

Fig.23 **Worn-out floor surface of production unit (Source**; Samplastic Products Ltd)

CHANGING ROOM AND MAINTENANCE UNIT

Although there was a changing room, it was not efficiently used as it was far away from the main entrance of the production unit. Rather workers used the maintenance unit as their changing area as it was the closest unit to the main entrance of the production unit. This makes the maintenance unit unsightly and prevents adequate ventilation.

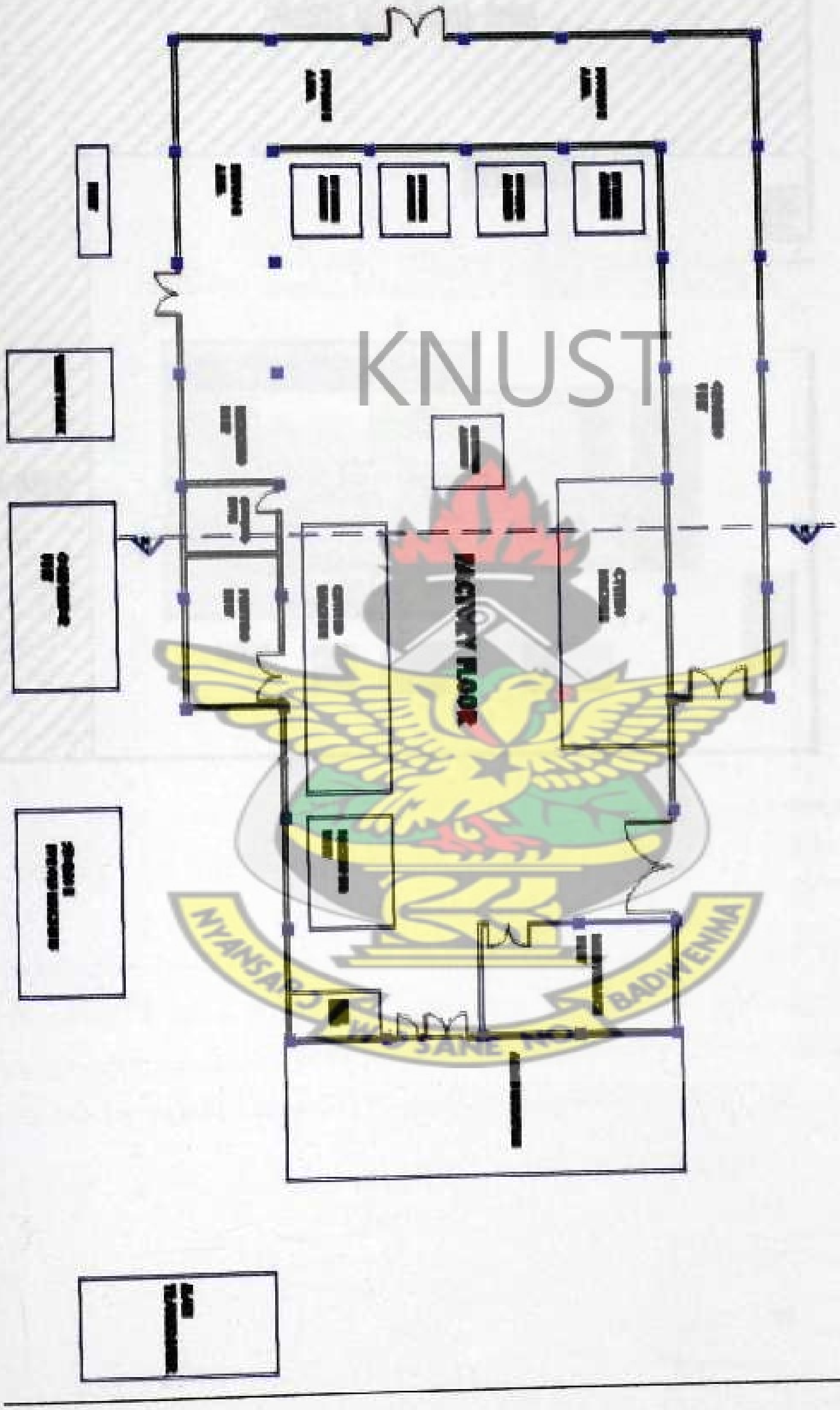
Fig.24 **Misuse of maintenance unit as changing area** (**Source**; Samplastic Products Ltd)

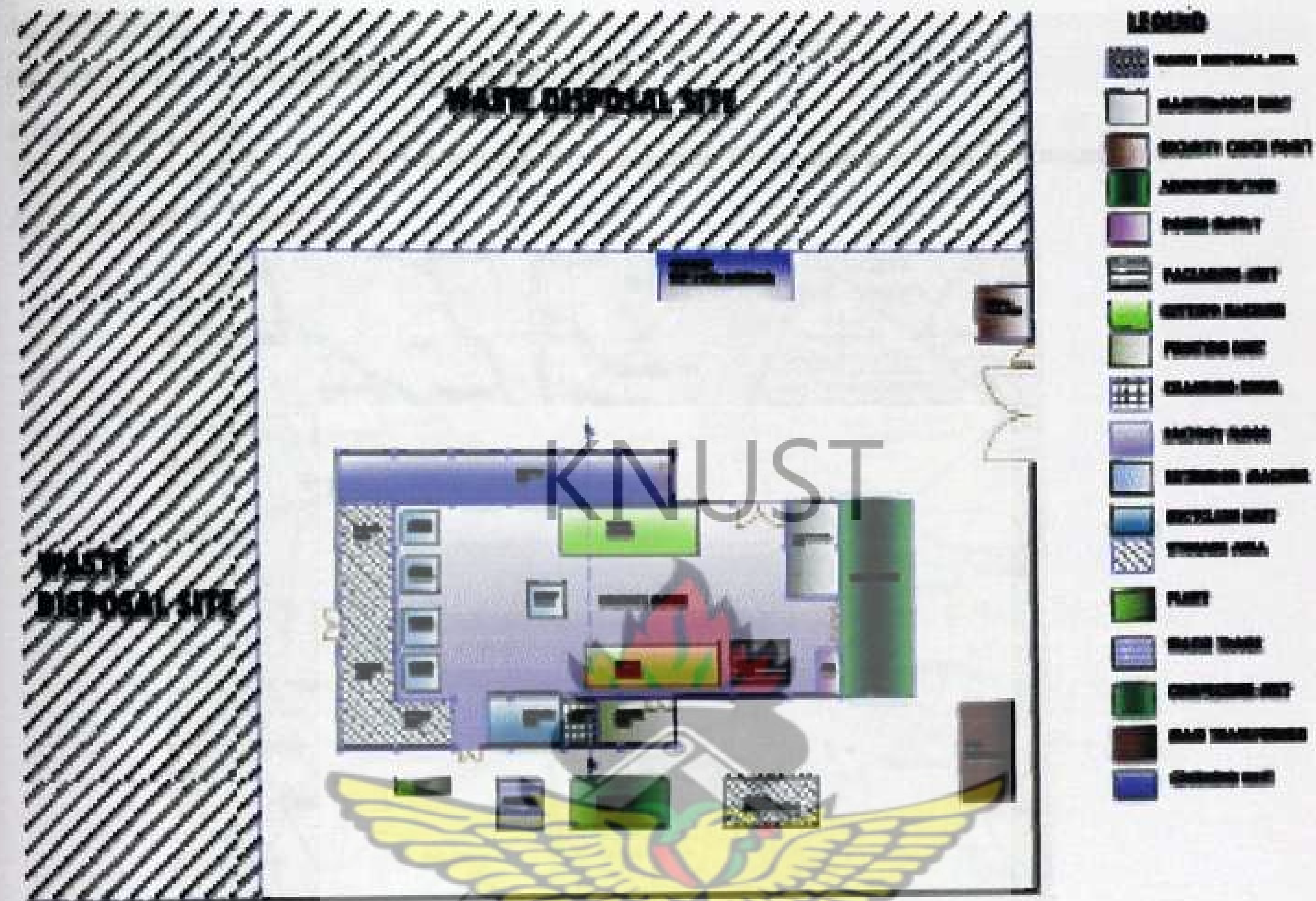
STORAGE UNIT

Another problem was the use of the main factory yard for dumping plastics awaiting recycling. This poses a lot of problems for the factory among which include making the yard unsightly and increased cost of production from cleaning the plastics which might have been made dirty from being dumped in the open yard and left at the mercy of the weather.

Fig.25 **Raw materials being stored in the open (Source**; Samplastic Products Ltd)

PLAN OF PRODUCTION FLOOR (Source; Samplastic Products Ltd)




WASTE DISPOSAL SITE
WASTE DISPOSAL SITE
LEGEND

4.1 THE SITE

PROJECT LOCATION AND SITE ANALYSIS

4.1.1 LOCATION

The proposed plastic recycling plant project is located at Dompoase a suburb in Kumasi in the Ashanti region of Ghana.

Fig.26 Map of Kumasi

Kumasi is located on latitude 060 43'N and longitude 090 36'W. The average altitude of the district is 292 metres. It has a land area of approximately 150km^2 and consists of an original plateau which has been reduced to a dissected plateau through erosion. The original plateau level is preserved by occasional crests separated by gently sloping valleys.

4.2 THE SITE SELECTION CRITERIA AND JUSTIFICATION

4.2.1 SITE SELECTION

In selecting a suitable site for the plastic recycling plant, certain factors had to be considered among which included;-

1. Proper zoning of site for such a purpose
2. Proximity to market centres
3. Easy accessibility to the site
4. Energy supply
5. Manpower supply

Two sites came up for consideration after the above factors were considered, one in Kaase and the other in Dompoase industrial site.

The site at Kaase referred to as "Site A" is a 15 hectares. The site is situated about 10 km from the outskirts of Kumasi along the abattoir road in the Kaase light industrial area.

Fig.27 Layout of site "A"

The site in Dompoase referred to as "Site B" is a 40 hectare site with about 28 hectares being used as a landfill site. The remaining 12 hectares is however undeveloped and zoned for recycling. The site is located approximately 5km from the core of Kumasi.

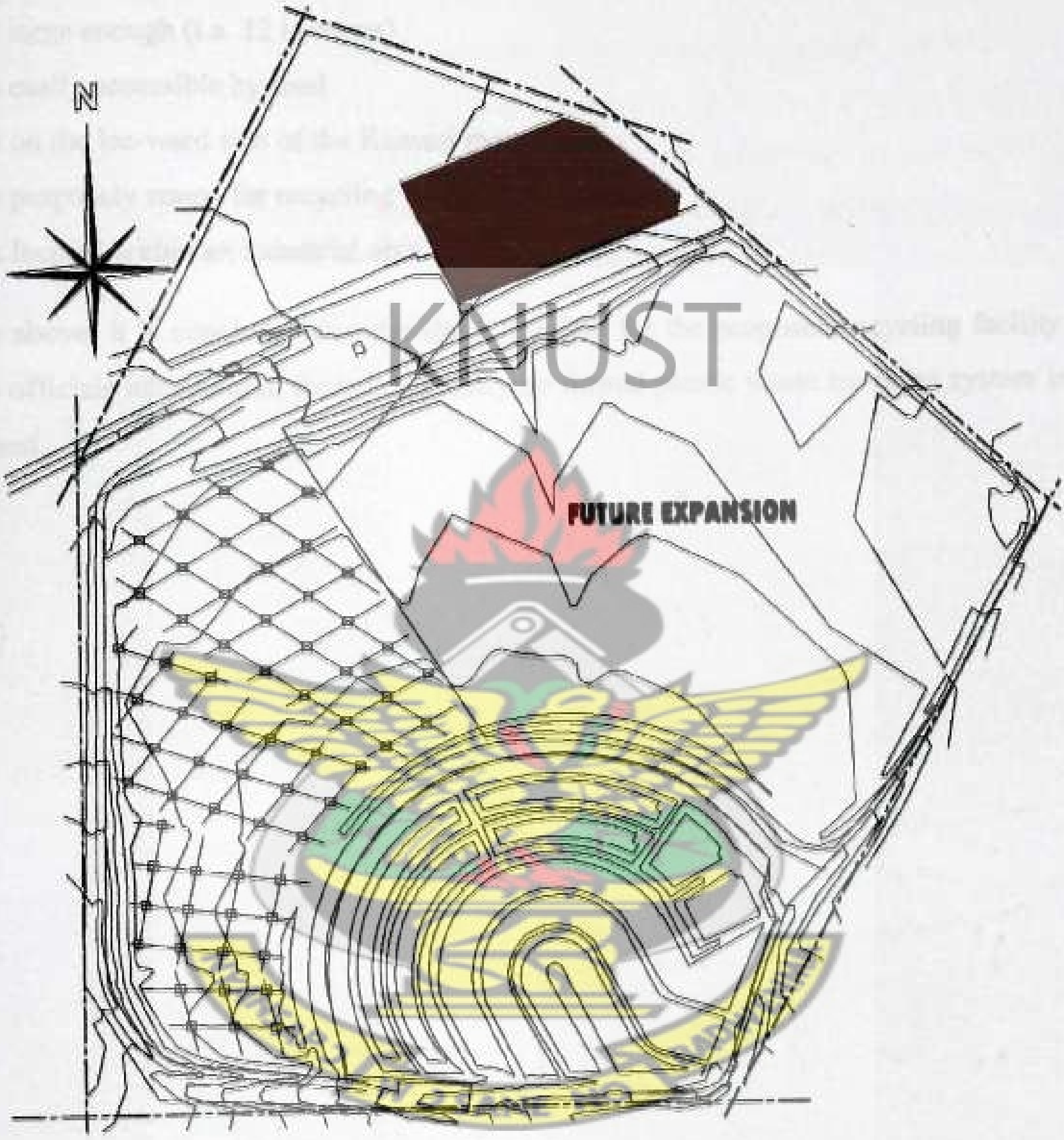


Fig.28 Layout of site "B"

Site "A" has some advantages in that it is accessible by road. However, it has a limited area for development and has a steeply slope.

Upon careful consideration, site "B" was seen to be the best choice due to the following factors;

1. Site is large enough (i.e. 12 hectares)
2. Site is easily accessible by road
3. Site is on the lee-ward side of the Kumasi metropolis
4. Site is purposely zoned for recycling
5. Site is located within an industrial area.

Based on the above, it is concluded that the site is feasible for the proposed recycling facility. According to officials interviewed, there is currently no formal plastic waste handling system in place in Kumasi.

4.3 EXISTING SITE CONDITIONS AND INVENTORY

There is a landfill occupying about 28 hectares of the site and 12 hectares reserved for the construction of a recycling plant. Site level is approximately 280m above sea level.

The 1.5km long access road to the landfill links the Dompoase road through the industrial township to the north-western corner of the site. There is a security fence around the perimeter of the site with a buffer zone which has been allowed for by the developers of the adjacent properties of about 500m. The site is irregular in shape and has an overall area of 40 hectares.

SITE PICTURES

Fig.29 Main Entrance to site

Fig.30 Showing Engineered Landfill Site

Fig.31 Truck dumping liquid waste on site

Fig.32 Showing Engineered Liquid Waste Treatment Pond

Fig.33 Existence of varying vegetation cover

Fig.34 Showing evergreen vegetation cover

Fig.35 Good soil structure to support landscaping

Fig.36 Existence of onsite plastic sorting out

Fig.37 Existing Administration Block

Fig.38 Showing car washing bay

Fig.39 High tension pole onsite

Fig.40 Showing ongoing development beyond site boundary

Fig.41 Main Transformer onsite

Fig.42 Showing good motor able road to site

Fig.43 Showing borehole with pump fitted

Fig.44 Showing overhead water storage

4.4 DESCRIPTION

After the entrance to the facility, a drained concrete hardstand with high pressure washer has been provided so that trucks and waste collection vehicles wheels can be washed before these vehicles leave the site (this is currently broken down and as such out of use). The site level is approximately 280 m above sea level.

4.5 CLIMATIC FEATURES AND CONSIDERATIONS

The area falls within the transitional wet semi-equatorial climatic region. It has double rainfall maxima with a mean annual rainfall of between 125mm and 2000mm. the major rainfall season starts in May/June, with the heaviest rain in June. The minor rainy season occurs in September/October. The area has a high humidity range between 75% and 90%. Average daily temperatures vary from a minimum of 20°C to a maximum of 34°C. During April, May, August, September and October, the average rainfall exceeds the average monthly evaporation on a monthly basis, with May, June, September and October having a significant higher rainfall than the evaporation.

On an annual basis, the evaporation and the rainfall is about the same at about 1400mm. Because the average temperature is so constant throughout the year, and the rainfall season is so defined, the year can be divided into two distinct periods, i.e.

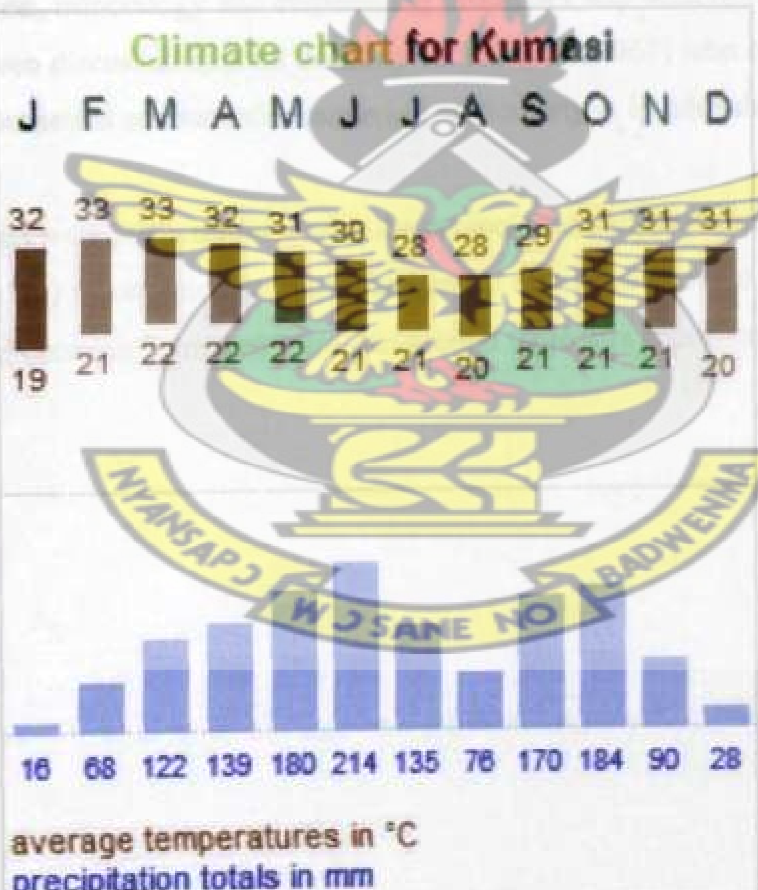
- A wet, hot period in March and October and
- An arid period in November, December, January and February

Shade temperatures can range between 20°C during the cool months and 34°C during the hot and dry months. Monthly climatic statistics are given below

CLIMATIC STATISTICS FOR KUMASI

J	F	M	A	M	J	J	A	S	O	N	D
16	68	122	139	180	214	135	76	170	184	90	28
32	33	33	32	31	30	28	28	29	31	31	31
19	21	22	22	22	21	21	20	21	21	21	20

average temperatures in °C
precipitation totals in mm



4.5.1 GEOLOGY

Kumasi and its environs are underlain by rocks of Lower Birimian System, consisting principally of phyllites, greywackers and schists, intruded in places by quartz veins and stringers and massive granitic batholiths which are, in turn, often cut by pegmatite veins. A substantial part of the city is underlain by the so-called Kumasi granitic batholiths.

The project site has been mapped by MURRAY (1961) as lying within the Kumasi granitic batholiths, which is a post Birimian intrusive is Pre-Cambrian age. However, no rocky outcrops are visible on the project site which is covered by lateritic soils which are essentially products of intense chemical weathering of the underlying granitic bedrock.

There is an operational sandpit approximately 300m from the project site along the proposed access road to the landfill site. No major geologic discontinuities such as faults and shear zones have either been observed or inferred in the vicinity of the project area.

The mode of formation, mineralogy and engineering properties and behavior of residual soils in Kumasi area have been discussed in great detail by RUDDOCK(1967) who concluded that these soils are generally competent as foundation material, particularly at levels substantially above the groundwater table.

Sub surface conditions were fairly uniform over the project area and consisted of a relatively thin capping (typically 0.3m) of organic topsoil, underlain by a mottled lateritic clay horizon which extended to depths of between 2.4m and 3.6m. No ground table was encountered.

4.5.2 THE PHYSICAL TOPOGRAPHY

A section through the north-south gives a relatively flat land. The site however slopes gently from east to west.

The surface water run-off drains to adjacent watercourses. The Oda River runs along the south-eastern boundary of the site. It is joined by south east flowing tributary which runs along the north eastern boundary of the site and a seasonal tributary that flows south east through the extended site. An adjacent hill to the north shields the site from nearby existing industrial areas.

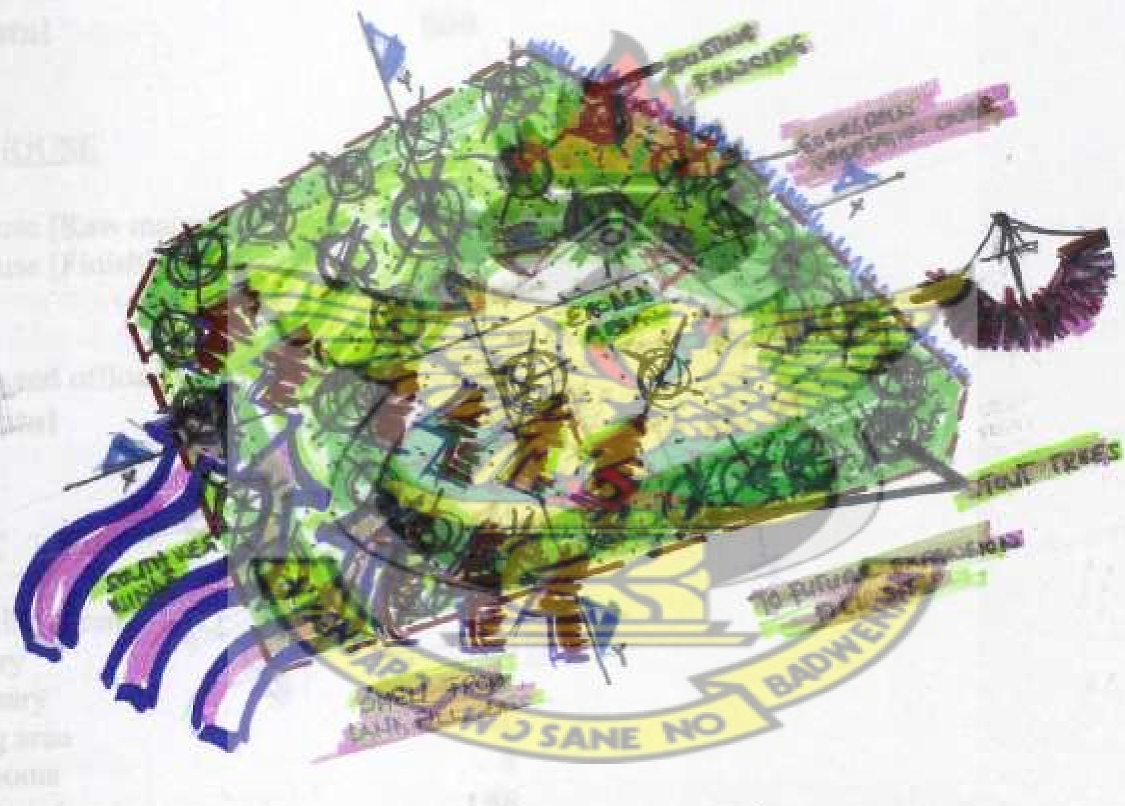


Fig.45 Site Inventory and Analysis

4.6 DESIGN BRIEF

ADMINISTRATION

Facility	Area (m^2)
Entrance	50
Reception	30
Parking	300
Washrooms	40
Store	10
Circulation	100
Staff room	30
Board room	
Kitchenette	15
Offices	160
Sub Total	**800**

WAREHOUSE

Facility	Area (m^2)
Warehouse [Raw material]	600
Warehouse [Finished products]	300
Office	30
Store	10
Loading and offloading bay	900
Sub Total	**1840**

CLINIC

Facility	Area (m^2)
Consulting room	30
Recovery	50
Dispensary	30
Waiting area	40
Washrooms	8
Sub Total	**158**

ANCILLARY FACILITIES

Facility	Area (m^2)
Transformer	15
Security post	12
Parking [long vehicle]	450
Generator	12
Parking [Visitors]	150
Parking [Production staff]	225
Parking [Administration staff]	150
Water treatment and storage	50
Sub Total	**1064**

CANTEEN

Facility	Area (m^2)
Junior staff dining	100
Senior staff dining	40
Kitchen	50
Store	20
Matron's office	12
Kitchen yard	15
Servery	6
Washrooms and Changing room	25
Dish washing area	15
Sub Total	**347**

MAINTENANCE UNIT

Facility	Area (m^2)
Workshop [Mechanical]	100
Washrooms and Changing room	25
Workshop [Electrical]	50
Store	25
Waiting area	15
Parking	150
Office [Supervisor]	15
Office [Mechanical engineer]	15
Office [Electrical engineer]	15
Sub Total	**501**

PRODUCTION FLOOR

Facility	Area (m^2)
Production unit	1200
Offices	70
Washrooms and Changing room	100
Laboratory	40
Sub Total	**1346**

Unit	Total Area (m^2)
ADMINISTRATION	800
CANTEEN	347
WAREHOUSE	1840
CLINIC	150
ANCILLARY FACILITY	1064
PRODUCTION FLOOR	1346
MAINTENANCE UNIT	501
TOTAL	**6048**

4.7 DESIGN PHILOSOPHY

"Fluidity and order"

With the current waste management problem coupled with the inexistence of plastic recycling plant in the metropolis, the author decided to make the design deviate from the normal industrial design outlook. Rather the design should stand out and be an icon to serve as a catalyst for others to emulate. "FLUIDITY and ORDER" was therefore chosen as the philosophy.

4.7.1 DESIGN CONCEPT

Among some of the elements employed to convey my philosophy was to have a free flowing roof scape with varying height according to the requirement of the spaces and span as depicted in the figure below.

Symmetry, a vital element of order was well adopted in the design of most of the facilities to re-echo the philosophy chosen for the project.

Various units in the facility are well zoned to meet the requirement of varying users of the plant re-emphasizing order in space and administrative hierarchy. Well zoned areas are linked by fluid elements of design such as soft landscaping and covered walkways.

4.7.2 CONCEPTUAL SITE PLANNING AND DESIGN

FUNCTIONAL RELATION

A study was undertaken to know how the various units are related and linked for efficient means of transporting users of the facility from one unit to the other. The main administration and the production unit formed the main blocks upon which other facilities revolve around.

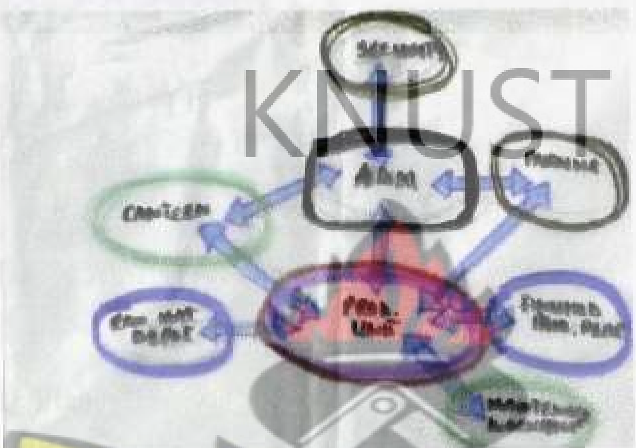


Fig.46 Functional Relation

OPTION ONE

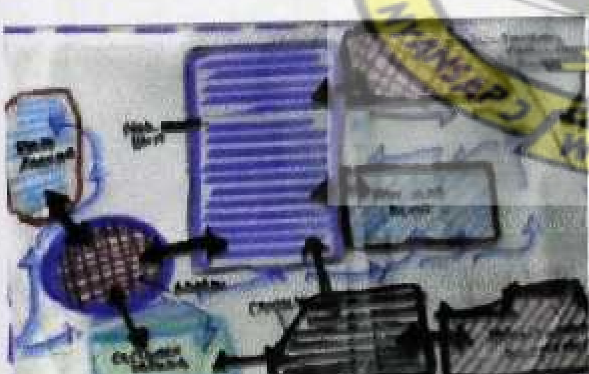


Fig.47 Conceptual Site Plan

OPTION TWO

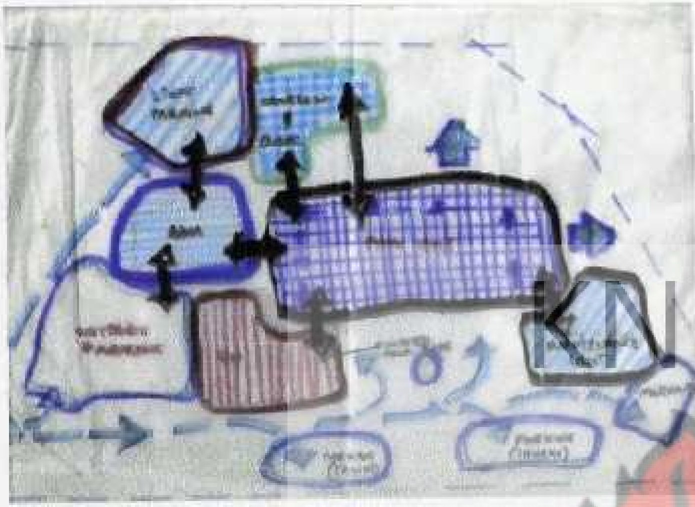


Fig.48 Conceptual Site Plan

Two options were considered to enable the design philosophy to be achieved. Upon careful analysis, option two was chosen as its merits outweighed that of option two. Option two made efficient use of space, created open spaces for ventilation, lighting and landscaping. The blocks were well zoned and linked in the most functional as well as efficient way.

Fig.49 Conceptuals

The main idea of the design was to have individual blocks and units being separate from each other but then liked with a covered walkway. The main factor to this decision was to prevent the spread of fire through different blocks of the facility and to improve on ventilation levels.

Fig. 50 Conceptuals

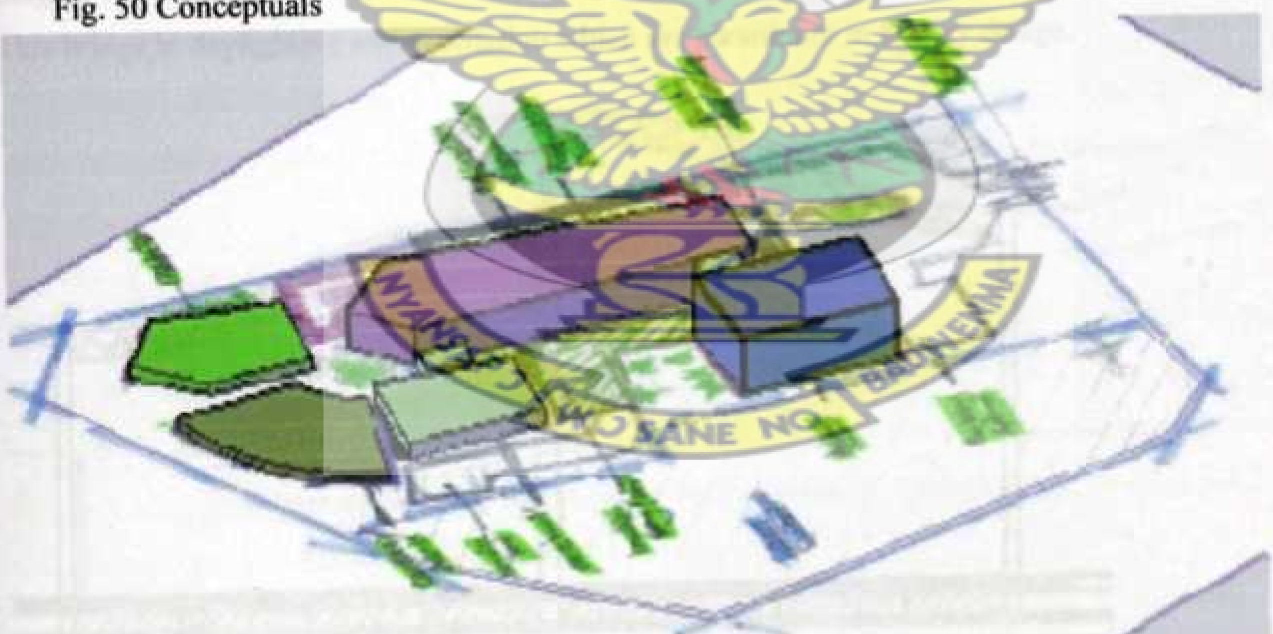


Fig.51 Conceptuals

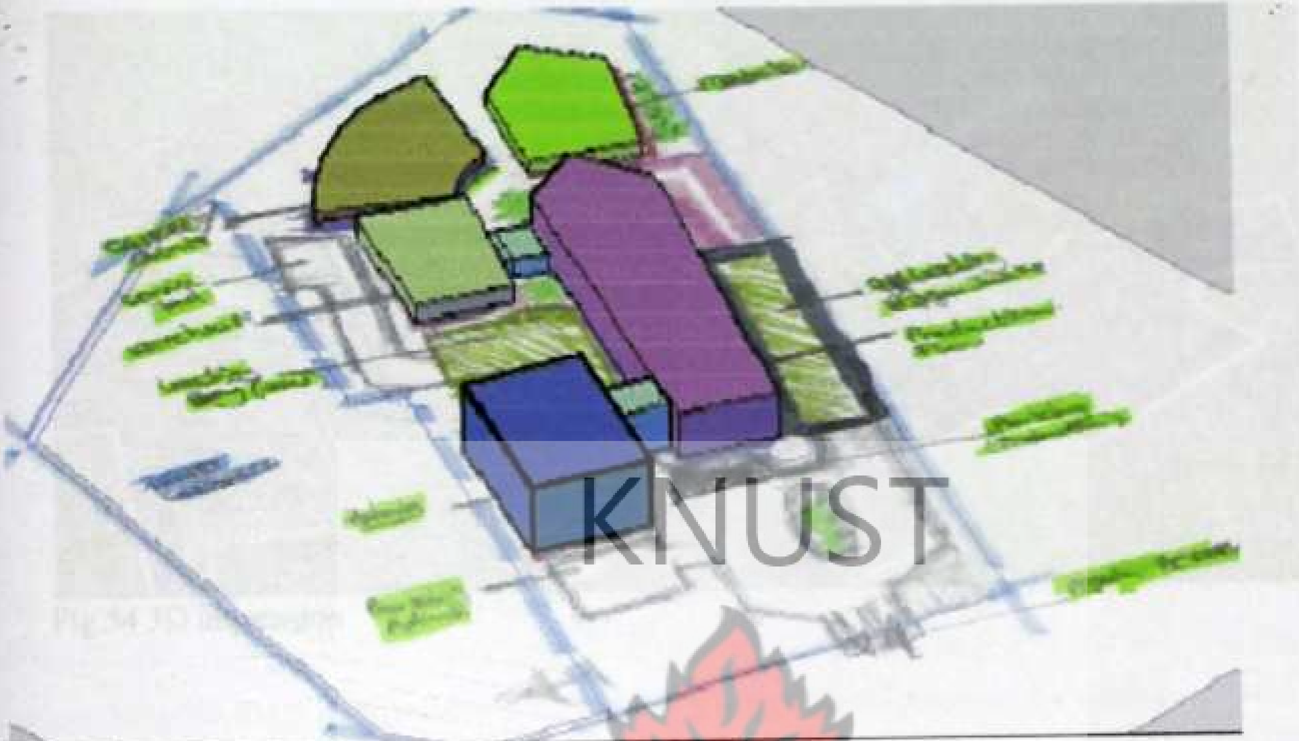


Fig. 52 Conceptuals

The break in roof was employed in the design of the production unit as machines of uniform heights were grouped in one area with the higher once having higher roof line and vice versa. This brings in daylighting and ventilation which are paramount in factory design.

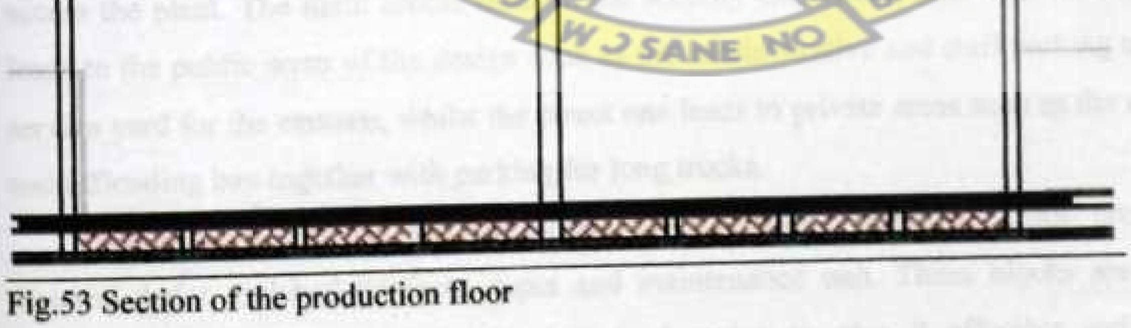


Fig.53 Section of the production floor

Fig.54 3D impression

4.8 THE DESIGN

The Plastic Recycling Plant went through an evolutionary process by considering the various studies undertaken without neglecting the design philosophy and concepts.

(I) Block Plan

There is one main access to the site which was in good condition and as such was used to access the plant. The main access leads to the security checkpoint after which a turn to the left leads to the public areas of the design such as the administrative and staff parking together with service yard for the canteen, whilst the direct one leads to private areas such as the main loading and offloading bay together with parking for long trucks.

The entire facility has six main blocks; administration, canteen and clinic, production, raw material depot, finished products depot and maintenance unit. These blocks are linked with covered walkways interspersed with soft landscaping to give it effective and harmonious functional flow pattern.

(II) Plans

The plan utilizes a 1.5m grid modulation system with column spacing of 4.5 m x 5m for the administration and other ancillary facilities but the longest span reaching up to 9m for the production floor due to varying machine sizes.

The main point of call for customers is the administration from where they can be ushered to the production unit, the various depots or the canteen as they are all interlinked with covered walkways.

Workers enter the facility either from the staff parking or the bus stop after which administrative workers access the main administration from the entrance foyer. Factory workers go through the main entrance to the changing room after which they clock-in. During break, they use the same entrance to access the canteen and in case of emergency, the clock-in point is used to access the clinic. There is a well landscaped courtyard between the production unit and the canteen with shaded seating areas which provides a conducive atmosphere for workers to relax and refresh themselves during break time.

Administrative workers access the main production unit at both lower and upper flows through a covered walkway to promote effective supervision. The production unit is linked with the raw material and finished product depot as well as the maintenance unit, promoting fluidity in production.

At the south western part of the site are the service facilities such as the step down transformer, standby generator and the water treatment and storage unit.

(III) Structure/Form

The main administration is characterised by two level structure linked to a mezzanine floor of the production unit which has a double volume. The remaining facility has is characterised by one level structure.

Concrete columns and beams are well connected to form a rigid frame to support the steel truss roof support as well as the aluminium barrel roof. There is a break in the curved roof form where necessary to admit light and provide adequate ventilation into the spaces such as the production unit.

(IV) Views

A landscaped lawn can be viewed from the various units of the facility, from the main parking to the courtyard and linkages between the units along with a well designed walkway. By virtue of the topography there are clear views into almost all the units of the facility.

(V) Capacity

The plant will produce between 500kg/h to 1000kg/h depending on the availability of raw material and demand for finished products. This will be undertaken by 75 workers with 40 being mainly factory floor workers with the rest working in various units of the plant. Workers will be employed mainly from the Kumasi metropolitan area for easy accessibility to the plant.

(VI) Circulation

To make circulation in the facility easy, staircases, walkways and ramps have been provided.

(VII) Services

Electric power, water, telephone and Internet lines are basic amenities that cannot be avoided in the design. Secondary provision has been made in the area of electricity and water. Provision has been made in the form of a standby generator and overhead storage tank for electricity and water respectively.

(VIII) Ventilation

Ventilation has been looked at with the provision of courtyards and open spaces. Natural lighting has also been taken care of with the open spaces to bring light into the corridors and circulation areas. The structure was considered so that maximum use of every space could be achieved. For example, ceilings are used for services and walls and floors can be serviced depending on the type of construction done.

(IX) Elevations

The various façade of the entire facility has been well designed to carry through the philosophy of the design and as such has free flowing roof of curvilinear form. Order is strongly brought to view in the conscious effort made to demonstrate symmetry.

Wide overhangs characterize the various elevations which cast deep shadows thereby pronouncing the depth to balance the soaring heights of most of the facility such as the production unit.

Various wall textures are carefully employed to enhance the aesthetic quality of the scheme.

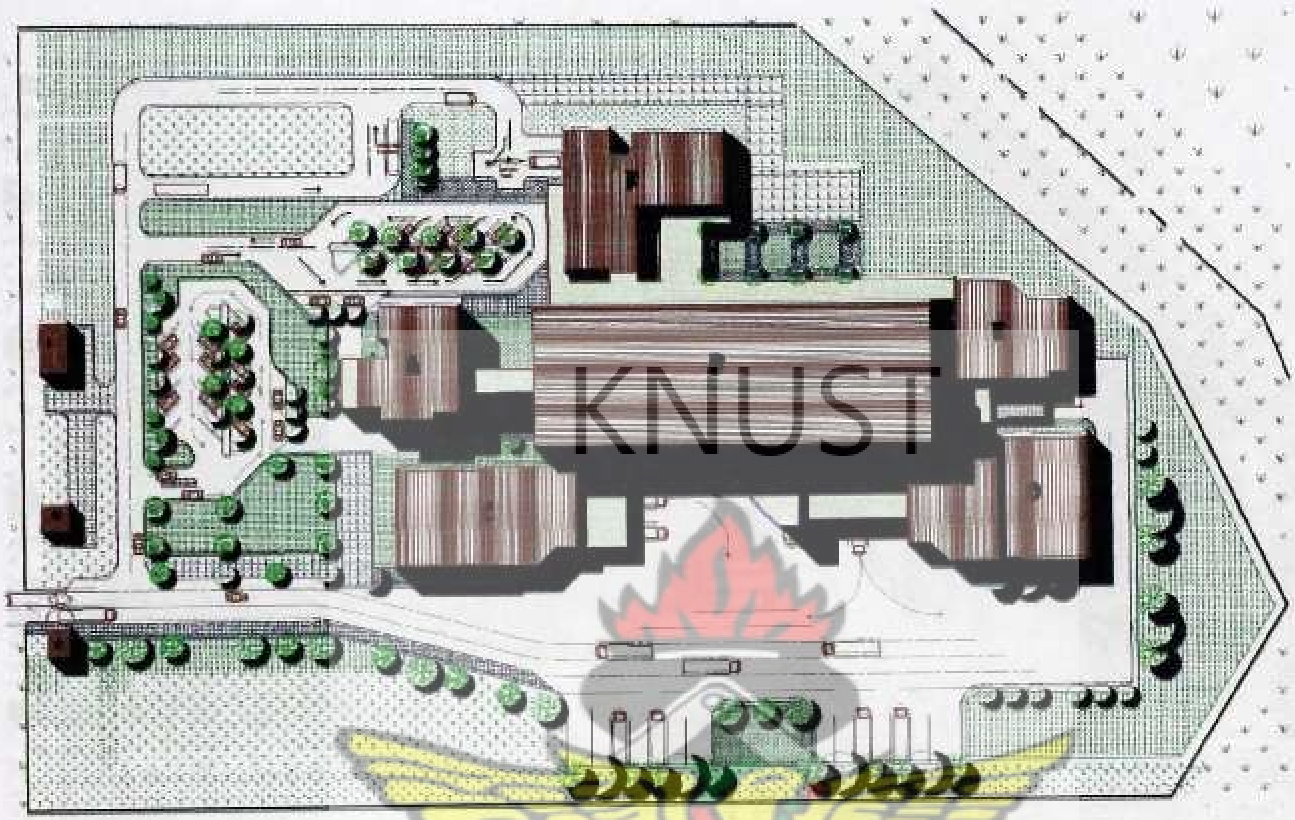


Fig.55 BLOCK PLAN

LEGEND

A – ADMINISTRATION BLOCK

B – PRODUCTION UNIT

C – FINISHED PRODUCTS DEPOT

D – RAW MATERIALS DEPOT

E – MAINTENANCE WORKSHOP

F – CANTEEN & CLINIC

G – SECURITY POST

H – STEP DOWN TRANSFORMER

I – SERVICES UNIT

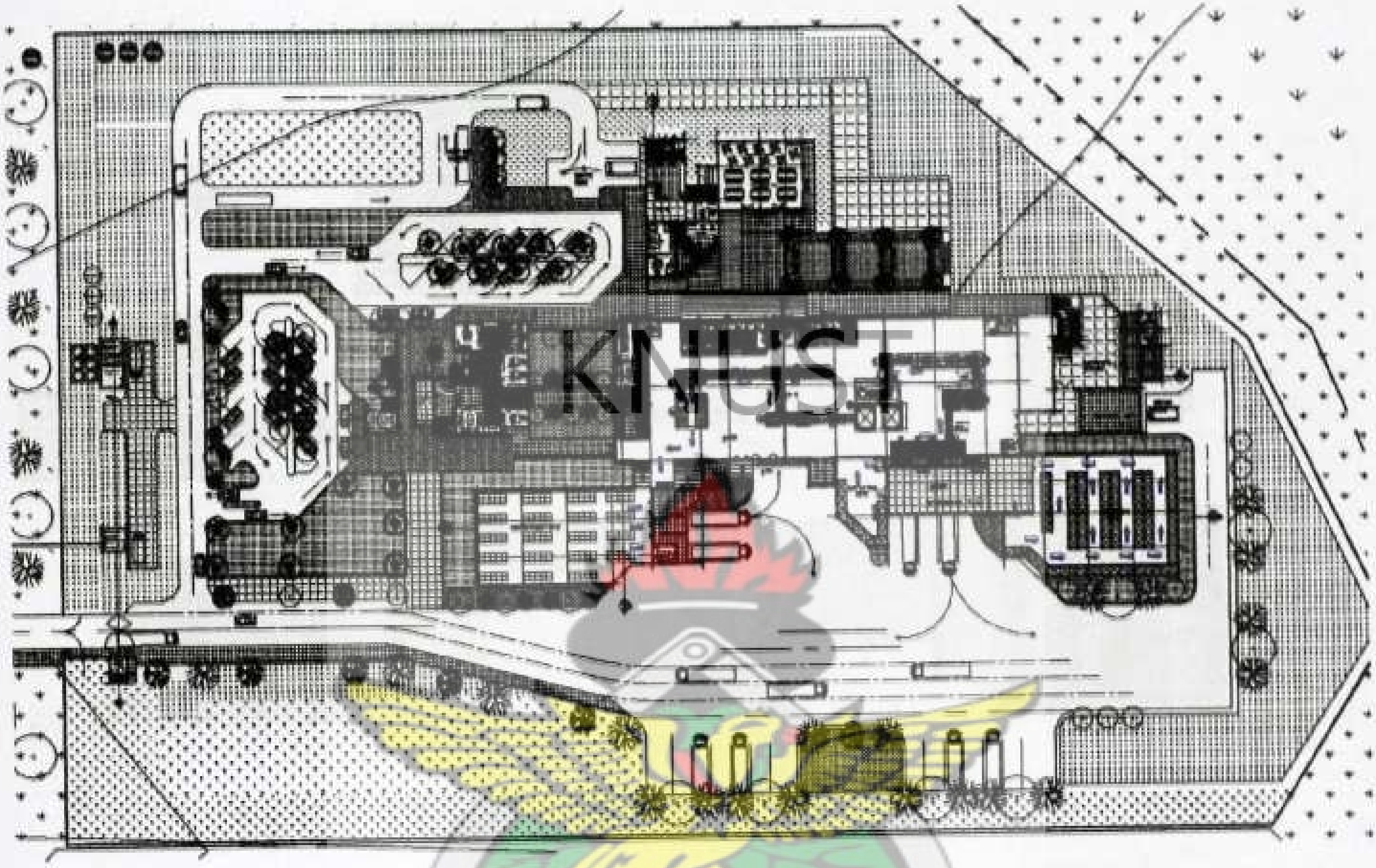


Fig.56 GROUND FLOOR PLAN

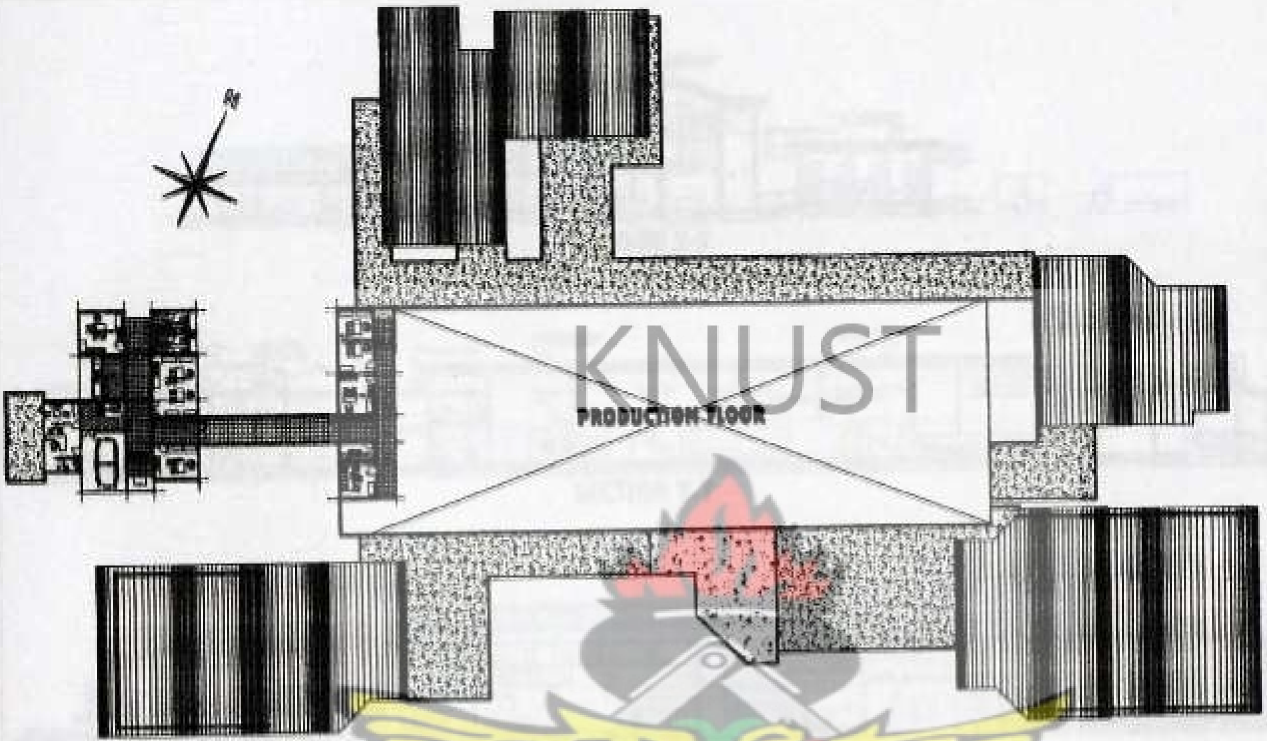


Fig.57 FIRST FLOOR PLAN

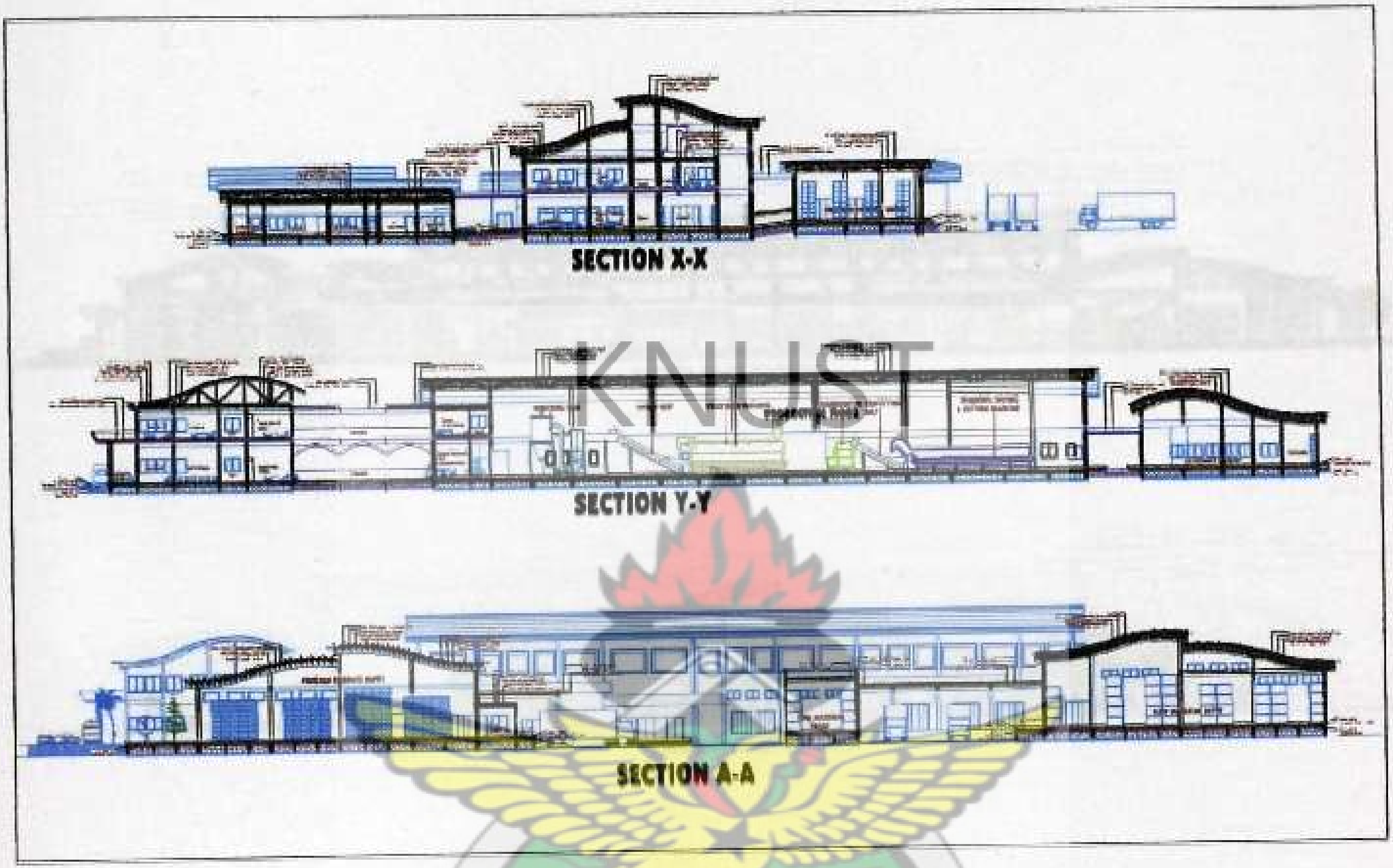


Fig.58 SECTIONS

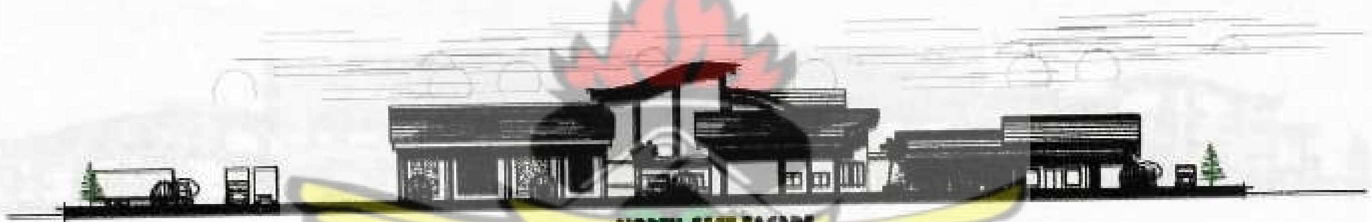


Fig.59 **ELEVATIONS**

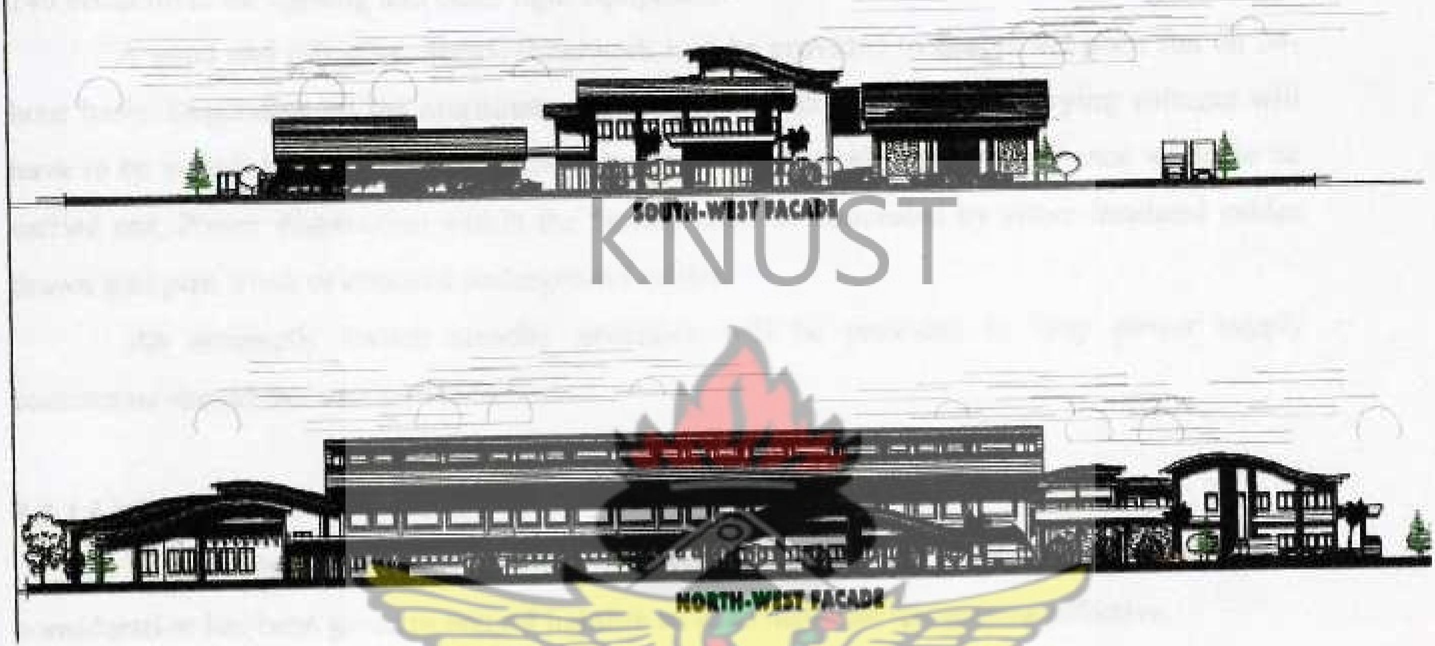


Fig.60 ELEVATIONS

4.9 SERVICES

4.9.0 ELECTRICITY

Electricity is provided to the plant at 11,000volts and this will be on 50Hz. A step down transformer will then step the voltage down to 415volts/50Hz for three (3) phase machinery and 240 volts/50Hz for lighting and other light equipment.

A good and effective electrical network will be provided to enable the plant run on 24-hour basis. Depending on the machinery used, various electrical points at varying voltages will have to be established. This is to ensure easy location for repairs and maintenance works to be carried out. Power distribution within the factory shall be concealed by either insulated cables drawn into pipe trunk or armored underground cables.

An automatic switch standby generator will be provided to keep power supply continuous should there be power failure.

4.9.1 LIGHTING

The two major source of lighting has been employed in this design. A greater part of consideration has been given to natural lighting so as to make the design cost effective.

Due to the exterior finish used and the break in roof form, a lot of day light is effectively used. Day lighting in the interiors will be supplemented with artificial lighting. The offices, canteen and maintenance units would use natural lighting most of the time due to the working hour's duration

4.9.2 VENTILATION

Consideration has been made for both natural and artificial ventilation. The buildings will most of the time use natural ventilation. This was well maximized within the main factory floor through the use of honey comb walls and wider windows but supplemented with artificial ventilation to obtain the right working temperature for the machines and workers.

4.9.3 INFORMATION SYSTEM

The facility will be computer networked to facilitate documentation and transfer of information. CCTV cameras will be located at vantage points and will be monitored at the ICT room.

4.9.4 SECURITY CONTROL

This is aimed at reducing theft, monitor attitude to work and other unpleasant scenes. Security alarms and cameras will be introduced at vantage areas of the facility. In addition to this, security post at the entry points will be used to monitor the facility.

In totality there is a main control room where there is the provision of CCTV so that security checks can be easier. This is also to make communication among the security personnel effective, faster, easier, and co-errant.

4.9.5 FIRE FIGHTING PROVISION

Fire prevention rather than fighting has been carefully considered in the preliminary stages of the design and as such underground well insulated ducts were used in supplying electric power to various machines and units of the facility.

In fire fighting measures, areas susceptible to fire are well zoned from the others. Concrete roof cover linking various units prevents the spread of fire from one unit to the other. There is the provision of easy water sprinkles, which is activated on the detection of smoke.

Fire exit has been incorporated into open spaces and the exterior of the building for people to escape to safety in case of fire outbreaks. Fire resistant materials have been used in areas of fire escape together with water hose and fire extinguishers located at vantage areas of the facility.

Fire Hydrants have been externally provided at every 420sqm.

4.9.6 SECURITY LIGHTING

External and internal artificial lighting would be provided so as to boost the security of the place at night. These would be introduced in the facility, parking areas and the pedestrian circulation routes. Garden lamps will also be introduced to aid visibility at night

4.9.7 WATER SUPPLY

A water reservoir of 15000 gallons storage capacity (two weeks usage) will be located at the service unit of the facility on an erected steel support of adequate height to allow water to flow by gravity through two 100mm diameter PVC pipe line buried approximately 1.0 meter in the ground. Water would be tapped from this main line to service the various parts of the building.

Three boreholes will be dug and water from it will be fed to the water reservoir by the aid of pumps.

4.9.8 SURFACE DRAINAGE

Drainage has been provided to take care of sewage, soil waste, wastewater and rainwater. The sewage waste will be discharged into the designed septic tank at the services unit after which it would be emptied into the main sewage treatment unit of the landfill site about 500metres from the plant via a sewage truck in the short run and underground pipe in the long run.

Surface covered drains will be provided where appropriate. The covered drains are important to prevent flooding around the production, parking and maintenance areas in the event of heavy downpour of rain.

Waste water will be treated at the water treatment unit of the plant and then pumped back to be used in sanitary areas.

4.9.9 TELEPHONE

An efficient modern auto-direct exchange system shall be linked to the existing network to facilitate both national and international communication. The telephones will especially be supplied to the administration and then networked to the various units.

4.9.10 REFUSE DISPOSAL

To keep the entire plant clean, waste bins will be positioned at vantage points to prevent loitering. Proper and well planned waste management system required by Environmental Protection Agency will be seriously adhered to. Refuse collected will be dumped at the Dompoase landfill site.

4.9.11 LANDSCAPING

The plant has been well landscaped to minimize the effect and restore the natural vegetation destroyed or taken up by the design.

Decorative trees such as royal palm shall be lined along the major access ways to give a pleasing appearance to workers and visitors alike. Tough grass with low maintenance requirements together with dotted shrubs shall be used extensively. Trees are carefully selected to serve as windbreakers, sound breakers, dust breakers as well as the general enhancement of the place. Vegetation to be introduced shall not have vigorous roots.

Planting of trees close to junctions have been avoided so as to give a clear view of oncoming vehicles.

CHAPTER FIVE

5.1 PHASING

The project would be implemented in phases due to the high cost of the development. A phasing proposal has been considered for the construction of the plant as and when funds are available.

The plant would be constructed in three main phases; the construction of administration and production unit being the first phase, the construction of the raw material and finished products depot together with the canteen being the second phase. The third phase would comprise of ancillary facilities such as maintenance workshop, service units and landscaping.

With this plan put in place and well executed, the project would be constructed in five years.

5.2 ENVIRONMENTAL IMPACT ASSESSMENT

The recycling plant will use plastic waste to produce pellets for the plastic industry. The plant is expected to cover an area of 25acres and would be located at Dompoase, a suburb of Kumasi.

The plant will be well constructed and landscaped in accordance with good factory practices. The well tarred stretch of road leading to the site will be advantageous in accessing the site.

The buffer zone of about 500m has been created around the site to the nearest developed structure which is residential. It is expected that the plant will consequently have adverse effect on the environment such as noise, vibration etc

The general waste produced will be routed through the existing public drainage system. Chemicals or toxic waste will be disposed off by lay down regulations. All staff of the plant will be required to be in protective clothing during work periods. Security measures will be instituted to curtail the problem of unauthorized persons loitering around the facility.

5.3 COST ESTIMATE

The Approximate Estimation Method was used to calculate the cost of the facility to give the client an idea of the financial investment the project will need. The price per square meter for the construction of this project is currently quoted between 300-500 Ghana Cedis. To arrive at the estimated total cost, the total area of the design should be multiplied by the cost per square meter.

Unit	Total Area (m^2)	Cost (m^2)	Total Amount
ADMINISTRATION	800	500	400,000
CANTEEN	347	300	104,100
WAREHOUSE	1840	300	552,000
CLINIC	150	300	45,000
ANCILLARY FACILITY	1064	300	319,200
PRODUCTION FLOOR	1346	400	538,400
MAINTENANCE UNIT	501	300	150,300

TOTAL COST (Ghana Cedis) = **2,109,000**

5.4 CONCLUSION

The plastic recycling plant would be dedicated to the recycling of various plastic waste with varying product code particularly the once that cause a menace to the environment.

The facility is designed to meet the needs of all users of the facility in a harmonious atmosphere by the use of modern technology and machines which are environmentally friendly to users. Various units in the facility are well zoned to meet the requirement of varying users of the recycling plant, together with well designed landscaping to link these zoned units.

It is, therefore, hoped that the client and all concerned would come together to make this proposed project come into fruition within the shortest possible time.

BIBLIOGRAPHY

1. Allen, Edward and Iano, Joseph. Fundamentals of Building Construction Materials and methods, Second Edition. John & Sons, Inc, 1990.

2. Tutt, Patricia and Adler, David. New metric Handbook (Planning and Design data). Reed Educational and Professional Publishing Ltd, 1998.

3. Neufert, Ernst.Architects' Data. Second (International) English Edition. Blackwell Science Ltd, 1980.

4. Re Chiara etal, Joseph. Time Savers standards for Building Types, Third Edition. McGraw Hill, 1990.

5. Factories (Planning Design and Modernisation) – July and Drury

6. Industrial Buildings and Factories - F. Hancook

7. Refuse Recycling and recovery - John R. Holmes

8. Waste Disposal and Resource Recovery - Thanh, Lohani

9. An Overview of Solid Waste Management in the Kumasi Metropolis Area - Y.S. Lukman

10. Environmental Sanitation Review (1998) - Ambrose

11. The Economics of Waste (2002) - Porter, Richard C.

12. Why Do We Recycle?: Markets, Values, and Public Policy (1997) - Ackerman, Frank

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