KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF ARCHITECTURE AND PLANNING

FACULTY OF ARCHITECTURE AND BUILDING TECHNOLOGY

DEPARTMENT OF ARCHITECTURE

TITLE:

SAWDUST AND WOOD SHAVINGS PROCESSING FACTORY - SOKOBAN, KUMASI

BY

OWUSU-ANSAH NICHOLAS KWABENA

B.Sc. ARCHITECTURE

MAY, 2009

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A DESIGN THESIS REPORT SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF

POST-GRADUATE DIPLOMA IN ARCHITECTURE

FACULTY OF ARCHITECTURE AND BUILDING TECHNOLOGY

COLLEGE OF ARCHITECTURE AND PLANNING

MAY, 2009

DECLARATION

I hereby declare that this thesis report has been undertaken solely by me, except for portions where references and acknowledgement have duly been given, and not a duplicate work. It has resulted from thorough research and logical analysis and synthesis under department staff supervision.

....

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(STUDENT)

SEPTEMBER 18, 2009

(DATE)

I hereby declare that this work is an original research undertaken by my student and has been conducted under my supervision.

....

MR. CHARLES ESSEL

(SUPERVISOR)

18TH SEPT. 2009

(DATE)

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PROF. G. W. K. INTSIFUL

(HEAD OF DEPARTMENT)

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(DATE)

DEDICATION

This design thesis is dedicated first and foremost to the Almighty God for his protection and guidance through my six years of architecture education and stay in this department.

Again, to my parents for their utmost dedication to my education and my overall wellbeing throughout my entire life on this earth as well as my entire family.

Also, my sincere gratitude goes to my friends both on campus and beyond for their immense contribution one way or the other in my education and life on this university campus.

Lastly, my sincerest appreciation goes to my supervisor for his selfless contribution to making this design thesis a success and also shaping my understanding of design for all the years I have been under his tutelage.

ACKNOWLEDGEMENT

I will want to first and foremost express my profound gratitude to the Almighty God for his protection and guidance through my six years of architecture education and stay in this department.

Again, my heart goes out to my supervisor, Mr. Charles Essel for the knowledge he has imparted to me throughout my architecture education and his selfless contribution to shaping and making this design thesis a success.

Mr. Samuel O. Afram, my year master cannot be left out of this list for his dedicated service to the class and most especially his inspirational messages during our stay with him. I salute you, sir.

My immeasurable appreciation goes to my family for their support, love, advice and encouragement through my entire education life up to date. May God bless you all, protect you and give you all long life to reap what you have sown. Thank you.

And to all who have one or the other contributed to the success of the project. To you I say blessings and thanks a million.

Finally, to my colleagues who formed the studio club for their immense help and encouragement for making this come out a success. I am grateful to you all.

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CHAPTER ONE

1.0 OVERVIEW

Wood waste is produced in all phases of the manufacture of wood products in the wood industry from logging to primary conversion (sawmilling) and secondary conversion (plywood production) as well as during storage of finished product. With the industry still thriving and more factories springing up, waste production will also increase based on the total mill efficiency of the industry.

Total mill efficiency in 1999 was estimated as 39% (39% of the log input volume was converted to saleable wood products) with sawmilling being the least efficient within the industry – 34% (WINDS, 2001). According to WINDS, 2001, it is estimated that total log harvest in 1999 was 3.72 million cubic metres as compared to the prescribed annual allowable cut (AAC) of 1.0 million cubic metres by the Forestry Commission. It is also estimated in 2001 that there will be an upward milling capacity of 5.1 million cubic metres per annum (WINDS, 2001).

With the recovery rate of the industry being very low a large amount of waste is introduced into the system. The types of waste usually produced include barks, sawdust, shavings, slabs and edges. They are basically grouped as solids (bark, shavings, off-cuts, slabs and edges) and sawdust with compositions of 79% and 21% respectively. Of the various residues generated in sawmills by volume the bark constitutes 10%, sawdust and slabs and edges are 21% and 69% respectively. The largest amount of waste is produced in the log yard followed by sawmills. It is estimated that in Ghana the sawdust generated in the mills alone is about 97,000 tons a year.

Utilization of these waste produced in the industry is very much low with a large amount either burnt or sold to be used as firewood. Sawdust, among the various categories, is rarely used and creates environmental hazards (not readily degraded by fungi and insects unlike other organic materials) besides being a fire hazard. A percentage of the solid residues like off-cuts and slabs are used by the mills in their boilers whilst the rest is sold as firewood. The tertiary sub-sector processes some of the solid residues, but the largest part of these volumes is used as energy substitutes, for example in bakeries (WINDS, 2001). According to a joint UNDP/World Bank sawmill utilization study 66% of the total residue production is concentrated within an 8km radius in the Kumasi area; Takoradi – 9%; Mim – 9%; Akim Oda – 5%; 11% is scattered among other locations. The feasibility and viability of utilizing wood waste commercially depends on the type, volume of the waste and location of sawmill. Possible end products from the processing of these wood residues include fuel briquette, particle board, chip board, fibre board, wood pellets charcoal, block board, etc.

Management of these residues produced has always been a constant headache for the various firms in the industry. They have no laid down procedure for disposing of the waste generated. They as well do not possess the technology to process the waste generated into other saleable product to earn the companies additional revenue. They resort to burning which creates environmental hazards. Beside it creating environmental hazards they can destroy property if proper care is taking in the process. Examples such situations can be found at the woodworking industry at Anloga, a suburb of Kumasi. In the search of proper ways to eliminate the waste as well as its attendant risks, the processing of the wood residues into saleable wood products lead me to choosing this topic of sawdust and wood shavings processing which is to be sited at the Sokoban Wood Village, Kumasi.

1.1 Problem statement

Management of waste in general in the country has always left nothing to write home about and as such this particular case of wood waste from the woodworking industry is therefore no exception. The waste management policies of the country have time and time again been a white paper something sitting in the offices of waste management authorities.

The woodworking industries in the country have no proper technology to take care of the waste they generate from their activities. The means by which the industries dispose of their waste end up polluting the environment. Environmental degradation is also a phenomenon every country which seeks to protect it flora and fauna frowns on.

The waste (e.g. sawdust) produced by these woodworking companies are not readily degraded by fungi and insects even though it is an organic material. These waste materials do not only pose as environmental hazards but a fire hazard as well. The method used in their disposal (burning) most at times leaves much to be desired by destroying property and lives as well. A typical case happened in last year (2008) at the Anloga woodworking industry in where the burning the sawdust spread to their sheds at night causing them to lose property worth millions of Ghana Cedis. The dumping of sawdust at the banks of the river in this same place (Anloga) is almost blocking the waterways at certain points destroying the river.

This phenomenon of environmental pollution and destruction of flora and fauna in my estimation must be stopped and proper measures put in place to take care of the waste which I am sure most well-meaning Ghanaians would agree with me. This leads me to my aim of eliminating the waste generated in this industry which poses these threats to our environment and lives as well as property.

1.2 Objectives

The objectives for this project include:

- Complete elimination of waste generated by the woodworking industry
- Put to an end the threat the waste generated pose to environment through their improper disposal methods.
- Turn these waste so called into saleable wood products and
- Help these woodworking companies generate additional revenue through the sale of the waste they produce
- Create employment avenues for a lot of the youth in the country by the setting of this processing factory in the city.

1.3 Justification

This project or subject is justified by the fact that it seeks to the complete elimination of waste generated by the industry which are not readily degradable and pose threat to our environment. Again the eventual elimination of the destruction to flora and fauna is also a plus to this project which by all certainty would not be doubted by any well-meaning citizen of this country. Not only is this project going to reduce or completely eradicate the threat to our flora and fauna but generate additional revenue to these woodworking companies. In this way they will keep their waste properly in order to generate revenue from their sale.

The recovery rate of timber will also come close to 100% efficiency as every part of log input will be converted into saleable wood products. Nothing would be left as waste by the inception of this factory to process the residues generated. New products would be introduced into market cutting down on if not stop our importation of similar products into the country from the developed world.

Additionally more employment would be created by the establishment of this factory right from the collection of waste from the source to the eventual workers on the production floor and its associated workers. By these and more other benefits this project is very much justified and would be supported by all.

1.4 Scope

A processing factory that would cover the production of

- Particle boards
- Sawdust briquette

And other associated products

The plant would have:

- Administrative block
- Raw materials storage
- Production floor
- Warehousing
- Welfare unit
- Research unit
- Staff and customer parking
- Ancillary facilities

1.5 Client

Private investors

1.5.1 Client brief

- Administration
- Production block
- Ancillary facilities
- Security
- Parking (staff and customers)

1.6 Research methodology

This explains the processes through which relevant data was gathered, as well as the limitations and the organizational structure of the study.

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CHAPTER TWO

LITERATURE REVIEW

2.0 OVERVIEW

The purpose of this chapter is to provide support for the study. It is to review the literature related to the subject of the study as well as provide the theoretical framework/conceptual base of the study. The chapter will focus on the following sub-headings:

- The timber industry
- Timber waste generation
- Waste management
- Waste distribution
- Waste utilization

2.1 The Timber or Wood Industry in Ghana

The timber industry is one the most significant industries in the world over most especially the forest areas including Ghana employing a good number of Ghanaians. The industry depends on the several timber species found in our forests.

The industry however, is said have started when there was the need for timber to be used as railway sleepers during the construction of railway lines in the country. The first of its kind is said to have been established in a village known as Gyankrom in the Western region around 1903. Since then more of such companies have been established across the country dealing in different activities and products of which some produce for export and others for the local market. There are now about 554 companies in the industry as at 2004 of which a great chunk of them are found in the forest areas of the country. The Ashanti region has the greatest number of the companies in the country.

The industry is structured primarily by the kind of activity or operation engaged in -: primary (logging); secondary (saw milling, ply milling, veneer milling) and tertiary (furniture, furnishing, doors, etc). The production pattern at the primary level have been checkered due to a lot of factors of which some are the use of obsolete machines, improper logging methods. The recovery rate for timber by sawmilling industries has been always on the low side. The total mill efficiency in 1999 was estimated at 39% (meaning 39% of log input volume was actually converted into saleable wood products with the remainder going down as waste. In 2004, the total mill efficiency was 34% and the industry achieved 40% recovery rate in 2007.

2.1.1 Waste Production

From the operations of the various sectors of the industry (logging through to the storage of the finished product) waste is produced. The different sectors of the industry generate wastes which are in different compositions by way of volumes and types. The types of waste usually produced include barks, slabs, off-cuts, shavings, sawdust, etc and they come in different volumes. The residues are basically classified as solids (barks, off-cuts, slabs and edges, shavings) and sawdust. The solid residue accounts for about 79% of the waste generated in the industry whilst sawdust accounts for 21%. The largest volume of waste is produced at the log yard and it is closely followed by the saw mills. It is estimated that for every log harvested about 65% of it goes down as the waste whilst the remaining 35% is converted into saleable wood products for both the local and international markets. The compositions of the waste in volumes are bark (10%), sawdust (21%) slabs and edges (69%). The pie chart below shows the compositions of the various types of waste generated in the saw mills.

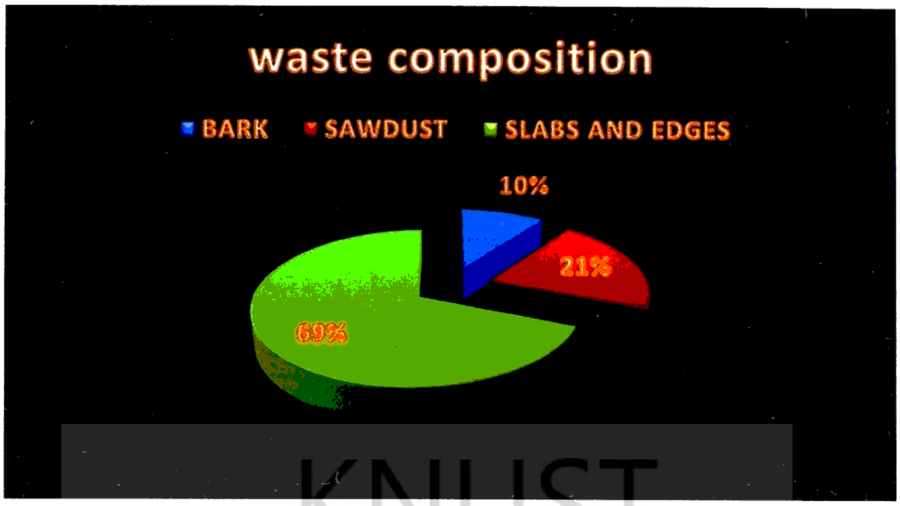

Fig. 1 showing the types of waste and their compositions

A typical waste generation of a sawmill company in Kumasi (LLL)

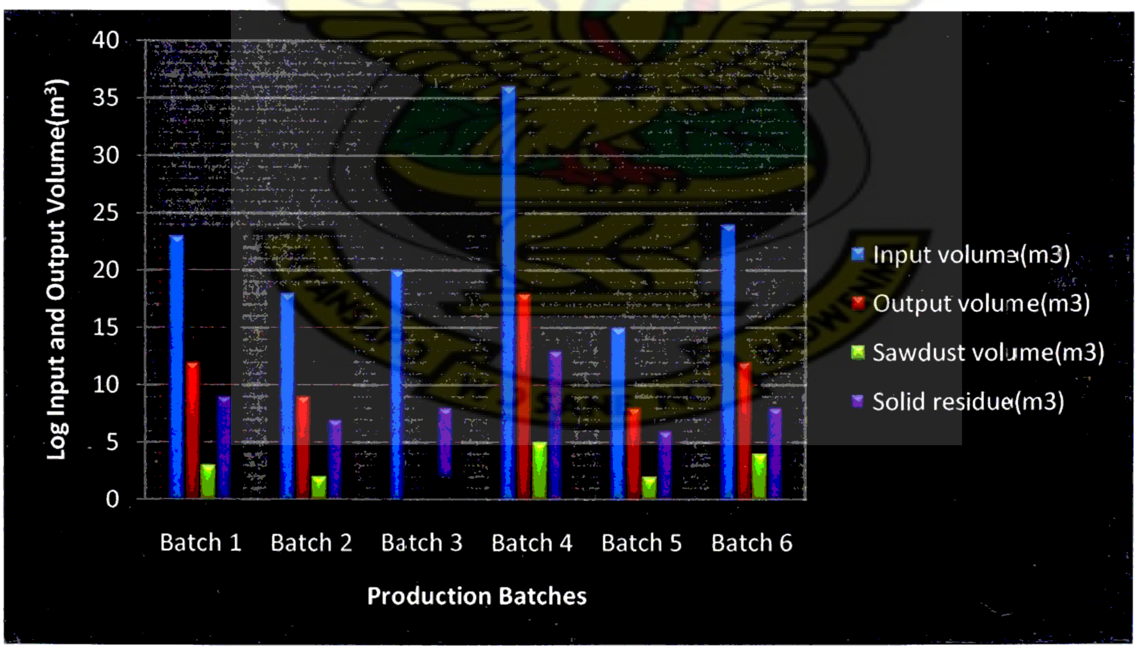

Fig. 2 showing the waste generation of a sawmill company in Kumasi

For every batch of log input there is an output of about 50%. The waste generated is grouped into two: solids and sawdust which also forms about 50% of the log input volume of every batch

2.1.2 Management of waste produced

Managing waste has always and continues to be a headache of this country in general and waste management policies of the country have time and time again been a white paper something sitting in the offices our waste management authorities.

The country has had a hard time dealing with the waste generated in the country whether it being organic or inorganic. The situation is not anything different from what happens at the wood industry which also generates a good volume of waste from their various operations. Most of the companies in the industry do not have any proper way of dealing with the waste generated. They do not also possess the technology needed to recycle and add value to the waste generated and as such resort to burning which is hazardous to the environment. Most of them dump along our waterways thereby blocking the flow of the stream or river and polluting it as a result. Though sawdust is an organic material it is not readily degradable and such dumping it along the waterways causes' environmental degradation.

As most of the companies do not possess the technological know-how to process the waste they either sell the part of the solids to the bakeries for use as firewood and they also use the rest as fuel for their boilers. The sawdust is either burnt or sold to poultry farmers. Of late though some of the companies are processing some of their solid waste into parquet flooring and other products such as machete handles, ceiling brush handles, ladles, etc.

2.1.3 Waste Distribution

With most of the companies found in the forest belt of the country a significant percentage of the residue generated are located in these areas. Among these areas there are places with greater volume of waste generated.

According to a joint UNDP/World Bank sawmill waste utilization study, 66% of the total residue production is concentrated within an 8km radius in the Kumasi area; Takoradi and Mim accounts for 9% each; 5% is found in the Akim Oda area with the remaining 11% scattered amongst other locations around the country.

With a greater percentage of the residue generated located within an 8km radius in the Kumasi area justifies the sitting of the factory in Sokoban, Kumasi which also have a lot of these companies been sited.

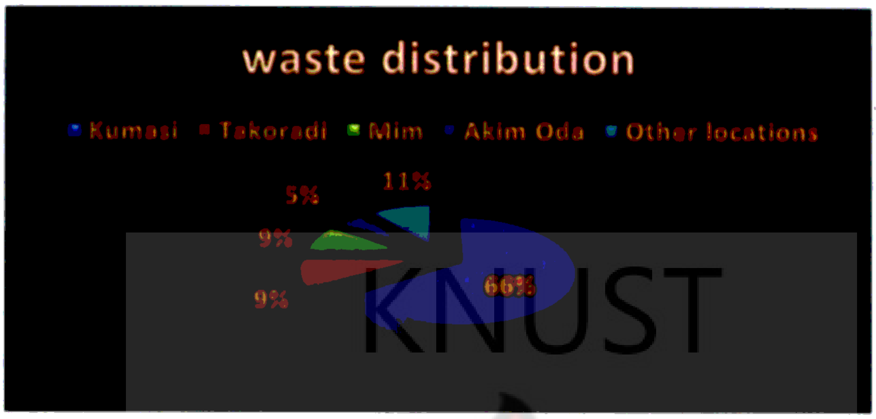

Fig. 3 showing distribution of waste among the production areas

2.2 History of recycling in Ghana

Clean and environmentally sound technologies are promoted through activities, which ensure that industries meet national environmental standards and at the same time promote the more efficient use of resources. Under the auspices of the Ministry of Environment and Science, a Waste Management Stock Exchange is to be established as a means of identifying and making waste available to other consumers who need such waste materials for their production activities. Through this arrangement, another company for its own production activities could, for instance, identify wastes generated by that company for use. This should help in reducing the quantities and types of waste generated in the country.

The country's steel and paper industries, and to some extent the plastic industry, are engaged in programmes of recycling wastes. A number of small-scale aluminium fabrication companies have been assisted to improve on their production systems. Though these programmes were initially meant to address the environmental problems associated with their operations, the improved production systems also led to improved efficiency in the use of materials and reduction in waste from the industries. All programmes for the management of waste relate only to waste generated within the country. The country does not permit the importation of waste for processing or disposal.

The issue of waste management has become a subject for research in many stakeholder institutions. The management of plastic waste is receiving attention. Some technologies have been developed to assist recycling of waste. A number of small-scale plastic waste recycling plants have been set up in the Greater Accra Region. There are plans to set up similar ones in other metropolitan, municipal and urban areas of the country.

The management of other solid and hazardous waste is also being researched at the Ghana Atomic Energy Commission and the Center for Scientific and Industrial Research (CSIR). Exogenous technologies are also being studied for their appropriate adoption and transfer for local use. The following are the recycling arrangements and the amounts the industries are able to recycle

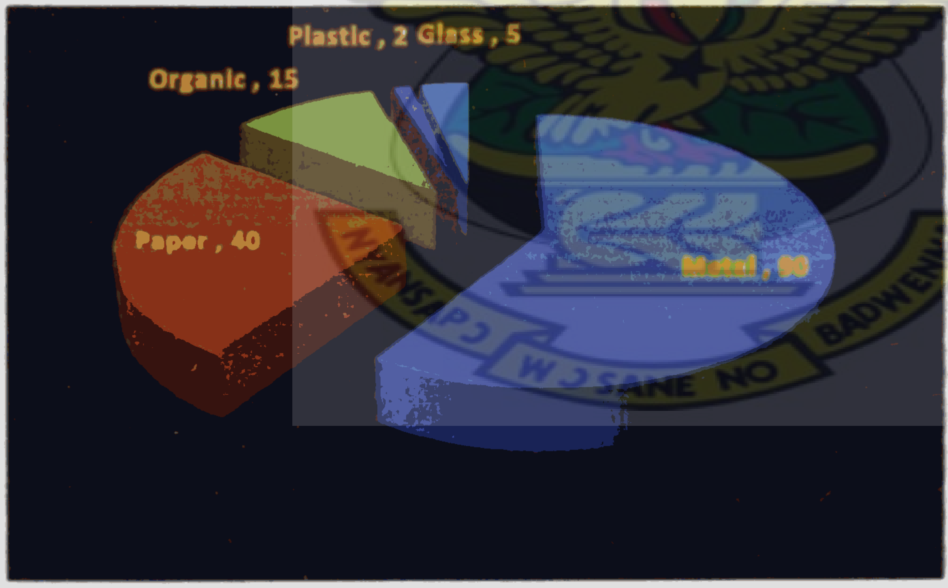

Fig 4 Waste recycling in Accra-Source: WMD (August 2004)

2.3 Waste Utilization

Waste becomes waste only when nothing can be recovered from it. In July 2002, the French regulations on the elimination of waste came into force. They forbid the dumping of non-"ultimate waste" This waste cannot be used again in anyway meaning it is neither recoverable nor reusable, unlike sawdust and waste wood. The recovery of waste has become very important to several countries in the world and they are making every effort possible to reuse the waste produced in the country in recent times, most especially wood waste. The utilization of waste consists of "reuse, recycling or any other action aiming to obtain, from waste, reusable materials or energy".

The residue generated at the saw mills and log yards has both economic and social benefits which when exploited would help the country immensely. These benefits can be realized only by adding value to what is termed as waste. By adding value we mean putting it through a process which produces a new and useful product from the waste. A diversity of products such as chip board, particle board, fibre board, pellets, briquettes, etc can be obtained from the processing of wood waste. Again energy can be obtained from wood waste. What was disposed of in the past is now recovered as a valuable fuel: sawdust, wood chips and shavings are a great sustainable source of energy – provided they are pressed into briquettes. Companies operating in the various sectors of the timber industry are therefore well advised to find an optimised method to turn their sawdust and chips into something more valuable.

2.3.1 Energy from Wood Waste

In most developing countries wood and charcoal are the predominant fuels for preparation of food to maintain the quality of life that encompasses the majority of citizens. In many developing countries wood fuels are also important for small and medium size industries. Moreover, energy from wood continues to be important in industrial countries. In the USA biomass including waste wood and alcohol from corn provided about 3.3% of total energy consumption in 2000. This was more than was provided by conventional hydroelectric power and more than other forms of renewable energy. Wood energy is consumed in a variety of forms that include fireplace lengths, chunk wood, chips, sawdust and shavings, black liquor from pulp manufacture, pellets, and fireplace logs, briquettes, charcoal, gasified wood fuel, and liquefied wood fuel. Wood provides warmth and comfort to homes through burning in fireplaces and automated heating systems. And even in industrial countries wood is used for cooking where it is burned in specially designed stoves for convenience or on grilles to bring out special flavors. Wood fuel is important to commercial wood manufacturing facilities where waste wood can be disposed and used profitably for energy at the same time. In areas where wood from logging and manufacturing is abundant other industries such as brick making and cement manufacture also benefit from sales of wood fuel. In some South American countries wood charcoal provides the fuel for smelters in manufacturing steel. Some major considerations in using wood for fuel are environmental impact, economics, convenience, reliability, and simplicity. On balance, wood is an environmentally benign fuel. It tends to be more economic than some other fuels, but may be less convenient.

Chips and Sawdust: Chips and sawdust are more common types of particulate wood fuel. There are some special combustors that can burn green (unseasoned) sawdust, but it is usually necessary that chips and sawdust be fairly dry. Chips are dried in special dryers that may use wood or fossil fuels to generate heat. Sometimes dry sawdust and chips are available at secondary wood manufacturing plants such as furniture plants. Dry sawdust can be a very desirable fuel for use in special combustors that burn particles in suspension. In such cases grates are not necessary. Chips are advantageous for handling and storing. They can be used effectively in automated stoker applications.

Shavings: Shavings are produced when lumber is planed or molded or spun off from logs that are peeled. Since shavings are usually produced in the processing of dry lumber they make good fuel. Green shavings from applications such as rounding logs for log home construction may be further processed by chipping and drying.

Pellets: Wood pellets are becoming increasingly popular. They are made by compression milling small wood particles such as sawdust. When pellets are made from clean wood with little bark, the ash content is low. Pellets are sold at retail outlets in 18 kg (40pound) sacks. They handle and store easily. They should be kept dry to prevent disintegration, and to avoid risk of mold and decay. Sometimes pellets for cooking are made from woods with special flavors that can be used in barbecuing, directly or with charcoal or gas, for conveying this flavoring to meat or poultry. However, the most common use of pellet fuel is for heating with modern and convenient pellet stoves. Some of these stoves burn pellets with 85% efficiency and have automatic ignition, feed, and control systems.

Manufactured Fireplace Logs and Briquettes: Manufactured fireplace logs (firelogs) are made from waste wood to provide open-hearth warmth and ambience with clean fuel. Wood briquettes are similar products of smaller length that are used as barbecue fuel or industrial stoker fuel. There are two types of firelogs or fuel logs; one type is made with the addition of around 50% wax. The other type is all wood. In the USA wax-type logs are more popular, but the all-wood type is more popular throughout the rest of the world. Wax-type logs burn with fewer gaseous emissions to the air, but they do emit carbon compounds from nonrenewable fuel that lead to an increased greenhouse effect. All wood logs do not emit non recyclable carbon. All-wood logs are made in machines that apply pressure with screws or pistons. The heat developed in the process is sufficient to cause the lignin in the wood to flow and act as a binder for the particulate wood waste. Many machines to make fireplace logs are designed to take advantage of the heat generated by high pressure and do not use supplementary heat. Other machines have extrusion cylinders that are externally heated to temperatures between 180°C and 300°C. Electrical resistance coils provide heating, and after the manufacturing process starts a temperature control setting permits operation at an optimum temperature level. The heating process slightly carbonizes the surfaces of the logs or briquettes and gives them a dark brown color. Heating may also contribute to better particle adhesion and less friction in the extrusion process. Briquettes are made in the same ways as all-wood logs, but the log lengths from the machines are cut into thin disks. In developing countries brick making presses have been adapted for briquetteing. In these cases pressures are lower and inexpensive adhesives are used as binders. The wax-sawdust firelog manufacturing process is not used for producing briquettes, only for fireplace logs. Wax sawdust logs are composed of about 40-60% wax with the remaining portion being sawdust. The heat content of wax-sawdust logs is higher than all-wood logs. Compared to wood, which has a high heating value of about 20 MJ kg–1 (8500 Btu lb–1), wax-sawdust logs have a heat content of 36.4MJkg–1 (15700 Btu lb–1).

2.4 The Briquette

The compressed wood briquette is a fuel of high performance intended for heating complementing or replacing traditional wooden logs. The briquette's very low moisture content combined with its high density makes it a quite advantageous fuel. Briquettes have been made for more than 20 years all over the world.

In Europe, some of our neighbours are big producers of briquettes. The Eastern countries supply Germany, Austria and Switzerland (where demand is greater than production). Italy and Spain also have experienced a very strong development of briquette productions.

In developing countries, the compression process allows the use of all sorts of wood by-products and the supply to the local populations of a means of heating which also can beused for cooking food.

2.4.1 Techniques of manufacture

The manufacture of briquettes requires a specific press. Three technologies exist:

- ❖ Hydraulic press: used mainly for small outputs from 50 to 300 kg/hour. Its low purchasing cost and its ease of use make it the most profitable tool for joinery workshops where the volumes of treatment of sawdust and chips do not require continuous running of the press;
- ❖ Inertia press: this technique is especially used for larger installations and for an industrial production. The capacities are superior to 300 kg/hour. The final quality of these briquettes is altogether superior (higher density and a regularity that allows an easier automation of packaging).
- ❖ "Screw" press: this technology is similar to extrusion. Its use is not widespread because of the small number of manufacturers and the important problems of wear of the screws. However, technically the quality of the briquette produced is most advantageous. Today we are still at the stage of prototypes, and the distribution of this type of machine remains commercially confidential. Depending on the technology, briquettes can have various forms: Cylindrical of various diameters and lengths, parallel piped, hexagonal most commonly. To simplify, it can be

said that for production of less than 250 kg/hour with intermittent running, hydraulics should be the first choice and mechanical techniques used for production beyond that.

Fig 5 Photo 1-Briquette press Cimaj, capacity o f 900 kg/hour.

2.4.2 Who makes briquettes?

The application of the regulations concerning the utilization of waste imposes a search for solutions for the wood industry. The industry of the second processing of wood is particularly concerned by this type of production. In , the briquette requires a dry material, no matter which method is used. The moisture content must be below 12% in every case. The manufacture of briquettes allows first of all an important reduction in the storage volumes of sawdust and chips, energy utilization being from a certain point of view an additional advantage. Numerous small joinery workshops have opted for this solution: stockpiling in summer in the form of briquettes and heating the workshops in the winter with these briquettes. For bigger joinery workshops, often only the excess sawdust and chips that is not utilized as raw material by the industry, is used for compression and resold locally or used on the premises. Recently, one observes the emergence of regional production of briquettes, made by specialized companies, from the waste that they collect from small joinery workshops. Although there are no statistics in this domain, the market for briquettes can be estimated at about 10 000 tons sold a year. Sales are constantly increasing as the market is still in its infancy. As a point of comparison, the Czech Republic has more than 40 known manufacturers. If one considers an average of 500 tons per producer (there producer (there are indeed big producers of several thousand tons) it makes more than twice as much for a country less than half the size of France.

2.5 Production Process of Briquette

After the raw materials are received and sifted the following processes continues:

- **Size Reduction**

For good briquetting, materials must be reduced to very small size. Size reduction is done by the chipper for waste wood and then the resultant chips are reduced further in a grinder or hammer-mill type crusher.

- **Screening**

After the materials are ground and mixed, then they must be screened for size quality. This will remove those particles that are too large so they can be then returned to the grinder for regrinding before being added to the production line again.

- **Drying**

The dryness of the raw material for briquetting must be held at a uniform level. Briquette raw materials' dryness must be held around 12% moisture content. If the materials become too dry it will become too dusty and particles will not adhere to each other to form the briquettes. If the materials are too wet, they will fall apart as they dry after briquetting. If the moisture content of the raw materials is less than 12% you may spray it with water to get it to the desired dryness. If it is greater than 12%, you will need to use a dryer to bring it to the desired consistency.

- **Conveying**

Product raw materials have to be conveyed from the grinder to the screen, from the screen to the dryer and then to the storage bin that feeds the compressor. Once the materials are in the storage unit that feeds the compressor, they must be conveyed to the compressor. Once the briquettes are formed they must be conveyed from the compressor.

- **Blowing**

In some systems, raw materials are blown up into the storage chamber for feeding to the chip compressor.

- **Briquetting**

A screw type compression machine is used for forming the briquettes. The briquettes are extruded with a hexagonal shape with an outside diameter of 60mm. The hole through the middle makes the briquette burn better. The length of the briquette can be controlled by the operator.

- **Cooling Briquettes**

After the FUEL BRIQUETTES are removed by the mill, the FUEL BRIQUETTES must be cooled. You need to strap them and stack them in small piles and put them in a shady section of room 3 that has been set aside for this. It is important that this area be kept cool and clean.

- **Strapping**

Briquettes are formed by compression which holds them together. However, they can deteriorate if allowed to be in a wet or damp place. Another source of breakage is careless piling of briquettes. Briquettes should be strapped with a strapping machine into small packets and then these packets should be strapped together into multiples of the small packets. Two pieces of strapping tape, preferably three should be used for safety and permanence.

- **Storage of Finished Briquettes**

Briquettes should be stored inside, in a dry place. The floor should not be allowed to get damp and no leaks should be in the roof of the building. Briquettes should be kept clean and dry prior to selling. Always sell the oldest briquettes and arrange the storage area so that you are always drawing from the oldest products in your stock.

- **Packaging Briquettes**

While strapping in small bundles in consumer sizes is the most profitable way to market your FUEL Briquettes, often you will want to sell to larger commercial buyers. They may want to buy in truck loads and may want them strapped to a pallet. You will need a forklift and large strapper if you want to sell this way. Additionally you will want a large shrink wrapping system if products are to be exported. It is vital to prevent moisture from entering into the briquettes.

- **Storage of Large Quantities of Briquettes**

Your product must be stored in a covered cool place so that they will not become damp while awaiting sales. It is very important to start with a storage area construction as soon as you begin planning to develop your FUEL BRIQUETTES manufacturing business. Bins can be constructed in the building in room 3 for this purpose. With a safe storage, you can produce large quantities of FUEL BRIQUETTES when raw materials are available, often during the harvest season and sell them later when prices rise after the season is over.

2.6 Pellets

The wood pellet is a high performance fuel intended for heating and for the production of hot water as a replacement for traditional fuels in specific equipment: stoves and boilers. The pellet's very low moisture content (6 -8 %) associated with its high density makes it an efficient fuel. The pellet was invented in the 1970's in the USA and it appeared in France in the 1980's. In Europe, the Scandinavian countries are very big producers: 700.000tons/year for Sweden, 250.000 for Denmark. Germany, Austria and Switzerland also experience a very strong increase of their production. Italy has, for its part, an exponential expanding production.

2.6.1 Techniques of manufacturing:

The manufacture of pellets requires the combination of several methods:

- drying is necessary for production from wet sawdust or chips
- grinding reduces the particle size (refining of the sawdust or the dried chips) to facilitate the pelleting process.
- the pellet press works by mechanically compressing the sawdust through a drilled ring die. The pressure, close to 200 bars, is exercised by means of two rollers. The viability of pelleting plants requires production of more than5000 tons/year. Numerous attempts have been made to develop small presses for the nascent markets but these attempts have never given complete satisfaction, the costs of maintenance being very high. According to need, pellets can have various diameters: 6 mm for pellet stoves, 8 to 10 mm for boilers and >12 mm for industrial applications.

2.6.2 Who makes pellets?

Complex industrial equipment (a pellet mill), today the production of wood pellets in France comes from three producers and represents a market of about 20.000 tons/year. The geographic situation of these three producers limits today the development of the market because of the high costs of transport. There are numerous projects to install pellet mills in the forest regions (example: Rhone - Alps, Landes, Provence – Alps- French Riviera). The industry of the first processing of wood supplies these manufacturers. The raw material is also marketed to the manufacturers of chip board. In Sweden, numerous installations use planning chips stemming from the industry of the second processing and avoid thus the operation of drying. The manufacture of pellets allows a reduction of volume by three. Energy utilization is the most frequently used plan of action. Other uses, such as for example litter for domestic animals, are also possible and taking place. Pelletisation of wood can be an additional activity for the manufacture of pellets of manure, urban water treatment sludge or fodder.

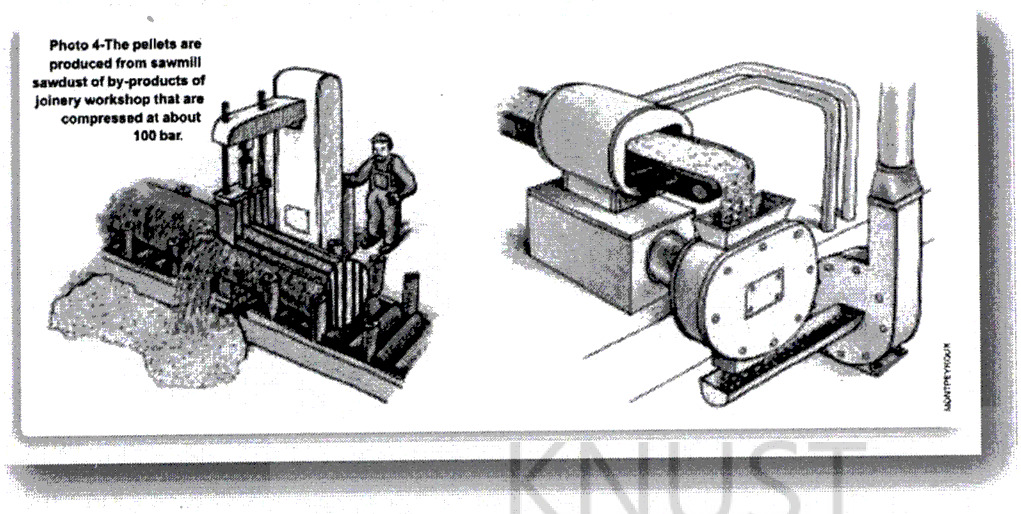

Fig 6 showing a pelletizing machine

2.7 Pellet Production Process

2.7.1 Raw material

Wood pellets are usually made from clean conifer sawdust and planer shavings. The wood must have been debarked prior to passing through sawmill. Sawdust of hardwoods can be mixed in with that of softwood, but successful production of hardwood pellets without binders is more difficult. If at all possible, dry sawdust and shavings (less than 15% moisture content) are used, because then the drying step can be skipped. If the sawdust is wetter, a drying process is needed before pellets can be pressed. Sometimes a small amount of wood chip is added during the drying process to increase the amount of feedstock; this is then pulverised in the hammer-mill.

Alternatively, where production of wood pellets directly from roundwood is envisaged, this will require additional debarking and chipping steps in the process, which can add significantly to cost. Since chips are many times the size of sawdust, a single pass through a hammer-mill might not be sufficient to obtain the required fine material for the pressing process; an additional pass through may be required. Chips dry at a slower rate than sawdust, so a much larger drying capacity is needed if roundwood is the wood supply for the pelleting plant.

2.7.2 Production steps

The production of wood pellets involves:

- reception and intermediate storage of the sawdust;
- drying and possibly intermediate storage again;
- screening for foreign materials such as stones and metal;
- hammer-milling and possibly intermediate storage;
- pressing of the pellets;
- cooling of the pellets;
- screening of fines;
- storage;
- bagging;
- loading out.

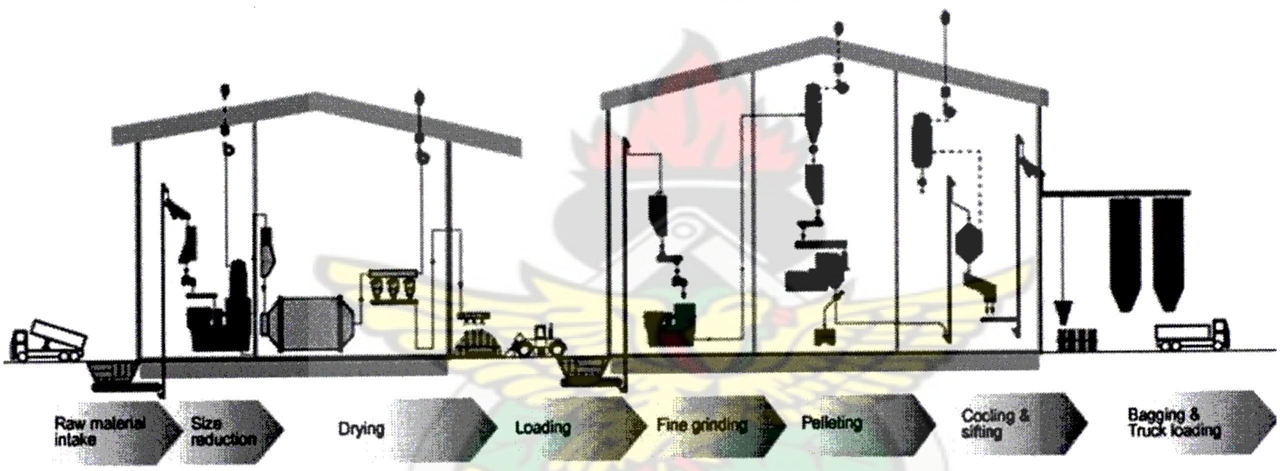

Fig. 7 shows a typical production flow for pelletizing

- **Reception**

At reception all sawdust coming in should be weighed on the weighbridge and samples taken to determine the moisture content. For storage it is preferable to separate wet and dry sawdust. Wet sawdust can be stored for a short period out in the open. The moisture content is not too badly affected if some rain falls on the base material, and wet sawdust does not blow about as easily. Dry sawdust should be stored indoors immediately to prevent the material getting wet. If the material is stored outside, the sawdust can blow about and create dust hazards. Very high levels of dust are encountered in buildings as dry sawdust is being unloaded. All personnel, including the delivery vehicle driver, should wear a P3 dust mask at all times during and after unloading. Vehicle windows should be kept closed while they are inside the building. In large plants that handle a lot of sawdust, under-pressure in the building is created to retain the dust inside. The exit gate from the building is equipped with an airbrush system that blows sawdust from the outside of the vehicles before they leave. In the reception building it is possible to mix the sawdust before it goes into the hammer-mill, so hardwood sawdust could be mixed in at this stage.

- **Drying**

The wet sawdust needs to be dried before hammer-milling as wet sawdust requires much more energy to reduce the particle size than when it is dry. There is also a significant risk of screens becoming clogged or smeared. Drying can either be done in a drum drier, a so-called flash drier that works with high temperatures, or on a flatbed drier, which works at a relatively low temperature. The first option is better suited for fine material, while coarse material needs a lower temperature. So, if chips are going to be mixed in, a flatbed drier is preferable. It is likely that the throughput capacity of the drier will be less than the rest of the system, so there should be a facility for intermediate storage of dried sawdust after the drier. The heat for the drier can be supplied by any kind of fuel, e.g. gas, oil or even biomass. The biomass boiler could use bark, wood chips, short rotation coppice or other wood waste that is not suitable for pellet production.

- **Screening**

Before the sawdust can be passed to the hammer-mill for homogenising, it has to be screened for stones, pieces of metal, plastic etc. Stone is usually removed by a stone trap, where the sawdust passes at speed over an opening. Sawdust should also be passsed over a magnet that removes metal objects. Foreign particles in the sawdust are likely to damage the press or could conceivably cause sparks in the hammer-mill, which might lead to a dust explosion.

- **Hammer-milling**

The homogenising of the sawdust to an even-sized feedstock for the pellet presses takes place in the hammer-mill. Here small lumps of wood, dead knots, etc. are pulverised, so that they can pass through the matrix of the presses. The mixing of the material is also completed here.

The hammer-mill should be equipped with a venting hatch to the outside of the building. If a dust explosion occurs, the membrane in the escape hatch will blow out and ventilate part of the pressure to the outside of the building. The opening of the vent on the outside of the building needs to be located at a sufficient height or cordoned off in a way that reduces the propensity for injury to any bystander or passer-by in the event of an explosion.Again, the hammer-mill will not necessarily have the same capacity as the presses, so there should be an intermediate store of hammer-milled material. This material is very fine and very dry, so precautions against fire should be taken. This part of the building should only be entered when wearing a face mask with a P3 dust filter.

- **Pellet pressing**

Many presses need the sawdust to be warmed up to 120- 130°C using dry steam. The heat makes the lignin in the wood become more plastic which helps to stick the particles together. The sawdust is extruded through a matrix and the pellets are cut off on the outside of the matrix.
The matrix can either be standing, with the pressure rollers moving on its inside, or can be lying down with the rollers moving over the matrix in a revolving fashion. The wood is pressed through the matrix under very high pressure. Vegetable oil is added to lubricate the last pellets at the end of a working period. The matrix will then slowly cool off with the lubricated pellets in the holes of the matrix. If this is not done, the last pellets may become stuck in the matrix, making it difficult to start the press again. The oil saturated pellets can be returned to the press again the next time it is due to be stopped. Usually the presses are kept operating overnight, because the matrix and the whole machine operate best at an elevated temperature. Many pellet plants operate from Monday morning until Friday afternoon on a continuous basis. This is another reason for having intermediate storage following drying and hammer-milling; otherwise the press can run out of raw material if it is in continuous operation for periods of up to five days.

- **Cooling**

Once the pellets leave the press, they are plastic and hot. During cooling, the pellets become rigid and lose moisture, so that the final moisture content after the cooler can be as low as 6%. They will take up moisture from the surrounding air and stabilize at a content of between 8 and 10%. After cooling the pellets are transported by conveyor belt to the storage shed, where they condition.

- **Packaging and delivery**

Pellets should be screened for fines before packaging or delivery. The fines can be returned to the production line. If the pellets are destined for the domestic market, many customers prefer to receive them in bags. These bags typically come in 12, 15 or 20 kg sizes. It is also possible to ship the pellets in one tonne bags or in bulk. The small bags are usually delivered on pallets of 960 kg or one tonne. These pallets are wrapped in plastic and can withstand moisture well. Small bags are, however, a better guarantor of quality, since the pellets are less subject to abrasion during delivery.

Pellets delivered in bulk can be transported by truck, tipped off at the receiving end, or be transported by a vacuum vehicle that sucks up the pellets in the factory and blows them into the silo at the receiving end. These trucks are also equipped with weigh cells so that they can measure the exact amount that is delivered. Pellets delivered by truck should always be dumped inside a building or in absolutely dry weather conditions as they will rapidly take up moisture, swell and disintegrate if exposed to water. The truck should always be carefully covered with a water-tight tarpaulin to keep rain out.

- **Storage**

During summer, the production of wood pellets probably exceeds the demand and the pellets may have to be stored for several months. The storage facility should be constructed of high concrete side walls that can withstand the pressure of the pellets. A cubic metre of pellets weighs around 650 kg, so if they are stored at a height of 5-6 m, a considerable pressure is exerted at the bottom of the pile. As stated, pellets easily disintegrate once they get wet, so it is very important that the building is water-tight, to prevent rain or condensation.

- **Quality control**

During production it is advisable to check pellet quality at least once a day. A sample is taken and fines are sieved out. The resulting sample is weighed and tested for durability in a durability tester. After tumbling the required number of revolutions, the pellets are screened again and weighed again. The amount of whole pellets should be in excess of 97.5% to classify as good grade wood pellets. A check should also be made for the amount of fines before the pellets leave the plant. At the final point in the production line the amount of fines in the goods should not exceed 1%. A declaration should be delivered with the pellets describing the raw material used, their durability and fines content, as well as their moisture content. If the figures are available, it is also useful to declare the energy and ash content.

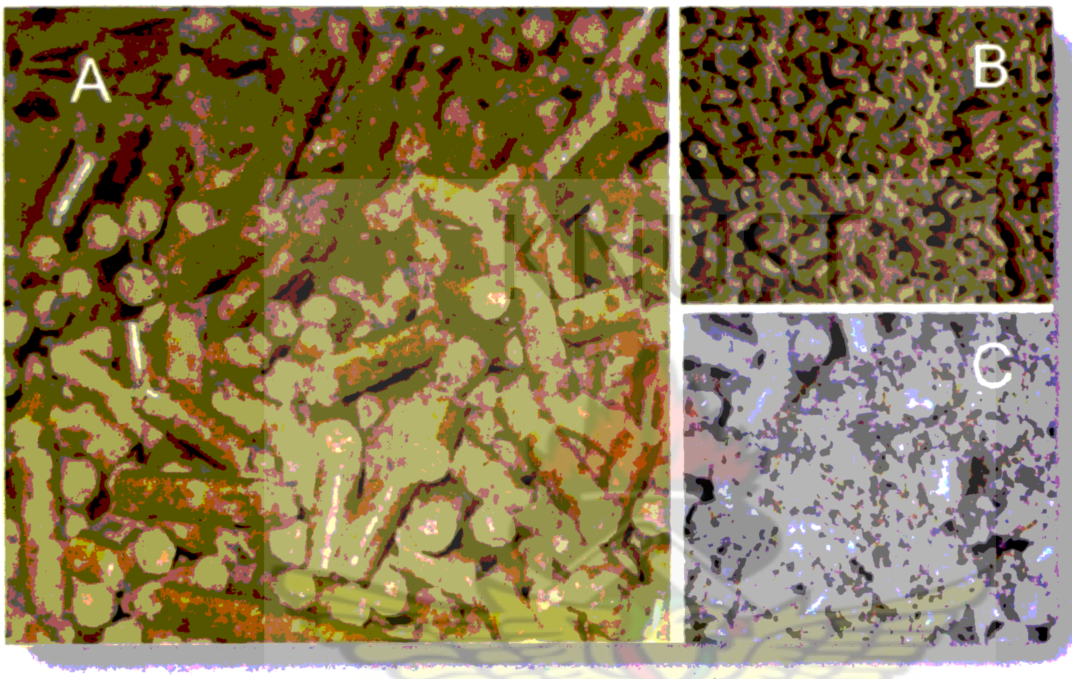

Fig. 8 (A) Good quality pellets; (B) medium quality pellets; (C) poor quality pellets.

2.8 The use of Pellets and Briquettes

Pellets are used essentially for domestic or collective heating. Briquettes can be used as self-supply for the heating of workshops, but most are intended for the heating of private homes.

Their main strong points are:

- Their shape and their conditioning which facilitate their storage and their use
- The flexibility of supply
- A clean, renewable and economic energy
- Decrease by 3 or 4 of the volume of storage
- Flexibility of deliveries adapted to the demand

- The perfect regularity of the quality ensures a control of the heating budget. Besides, briquettes do not require any specific installation and pellets make possible complete automation of combustion.

2.9 Chip Board

Gluing together wood particles with an adhesive, under heat and pressure makes chipboard. This creates a rigid board with a relatively smooth surface. Chipboard is available in different densities i.e. 25mm, 19mm, 8mm, 5mm and 3mm. One of the most common uses of chipboard is that it is the back piece, which provides stiffness on a scratch pad. Chipboard is the major input for the furniture industry and also used for kitchen tops and work surface. The raw materials required for the manufacture of chip board include wood particles (with different sizes), glue and laminated sheets (melamine).

2.9.1 Manufacturing Process

❖ **Chip & Flake Manufacturing**

Raw material blended for the production is a mixture of chips, shavings and saw dust. Chips, shaving and saw dust are taken from different heaps into the flaking line in certain pre- set proposition guarantees the mixing of different types of wood species. Chips and shavings are transported to Knife-Ring Flakers and the sawdust is taken to a wet chip silo.

❖ **Flake Drying & Drying Screening**

The flakes are dried in the drying department, which consists of individual dryers. There are one Buttner dryer and one Bison dryer. All two dryers are equipped with burner for using both oil and dust as fuel. Using 100% of dust as fuel is possible. The dried material is screened in 3 Pcs sifters (1 screen for each dryer). All screens are equipped for 3 fractions (core, surface and dust). It is an option for a second screening in Air Classifier.

❖ **Gluing Of Screened Flake**

The wooden practical flow is led from the particle silos, one for surface particles (the silos are not included in the delivery) via a horizontal Dozing Bin to a measuring unit in which the material flow is registered for the gluing system. The wooden particles are fed into a gluing drum, and further by belt conveyer to the forming stations. The screened and dried surface and core particles are separately glued in glue blending machines. There are two blending machines for core particles and one glue-blending machine for the surface particles. The Glue Preparation Department consists of mixing, dosing, metering tanks and pumps for supply of mixed glue to the Glue Blending machines. One mixture of glue for each layer can be prepared.

❖ **Forming & Press**

The forming stations consist of two units for the surface layer and one unit for the core layer. Forming is made on a Forming Belt Conveyor, which is the first part of 3 individual belt conveyors in front of the main press. The formed mat will be pre-pressed in a Roller Press with Belt. A Permanent Magnet and a Metal Detector is located before the pre- press. A trimming saw cuts the formed mat. The press is a multi–opening press with 10 levels in a frame construction and equipped with thermo oil heating, high- pressure hydraulics and system for automatic pressing without distance bars. The loading device with its tablet feeding system will ensure proper loading and unloading of the main press during same operation. The main press is heated with hot oil by a separate boiler. The boards are taken out of the unloading devices onto a belt conveyer with scale and through an automatic thickness meter with measure tolerance of 0.1 mm. The board weight and thickness will be registered before the board is fed to the cooling wheel.

❖ **Trimming Saws and Sanding Lines**

After the cooling wheel the boards are taken through a trimming saw for its longitudinal section before stacking on a Lifting Table. The stacked boards will be transported on a roller conveyer to the next Trimming Saw for the cross section of the board. The final size of the board is within the size of 2,400 – 2,500mm x 4,800 –5,200mm.This Trimming Saw and its feeding station with pusher is the first part of the Sanding Line Controls. The raw material in feed system, Knife-Ring Flakers, Dryers and Sifters are all controlled from a separate indoors control panel. The automatic control of the production line is based on PLC system. To guarantee maximum performance of the plant it is divided into functional sections, which are controlled by separate PLC units. The main process parameters are monitored on a terminal in the main control room in front of the main press.

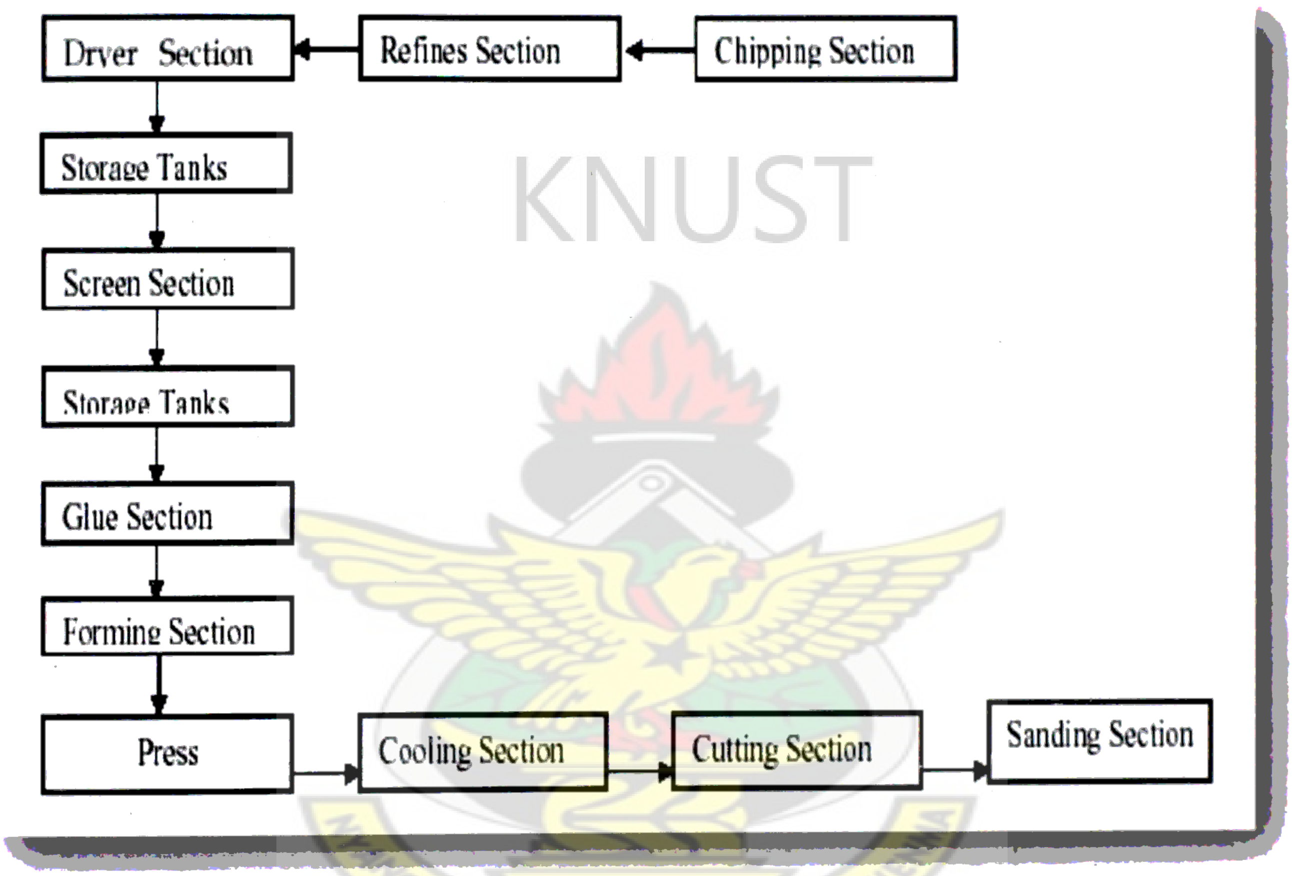

Fig 9 shows a typical production process for chipboard

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CHAPTER THREE

RESEARCH METHODOLOGY

3.0 OVERVIEW

This explains how the research is going to be carried out. It describes subjects/participants (respondents) of the study, the design, research instruments and procedures to be followed, including how the researcher will analyze data collected to test hypothesis or answer research question.

- **Preliminary Survey**

A reconnaissance survey was conducted on the site and data gathered to ascertain the suitability and feasibility of the site.

- **Collection Of Data**

In order to obtain relevant and appropriate information for the project, primary and secondary means of data collection was conducted.

- **Structured Interview**

Architects, lectures, actors of wood industry as well as professionals and experts involved in the development of such a facility were consulted. Their contributions were well noted and used as the basis for the analysis and the design.

- **Bibliography**

- Information relevant to the project was obtained from books, journals, magazines and encyclopedias, internet and multimedia sources.
- Various search engines such as Yahoo, Hotmail, Goggle, Askkme, etc were employed to gather information from the internet.

❖ **Photography**

Pictures of the site were taken, analyzed and documented. In addition, pictures were retrieved from books, journals, internet to serve as a visual documentation for case, special and technical studies.

❖ Analysis Of Data

Information gathered following the procedure above, was first synthesized, analyzed and organized to arrive at the design.

❖ Limitation of study

- It was difficult acquiring official data on the amount of waste generated by the timber processing factories and other woodworking industries, getting access to similar facilities for case studies.
- The current information from the Forestry Commission could not be obtained since data on timber coming out of our forest were inaccurate and cannot be giving out.

3.1 CASE STUDY ONE

3.1.1 BMK PARTICLE BOARD, TAKORADI

This factory which is the only kind in the West African sub-region is located at Takoradi in the Western Region of Ghana. The factory shares the same yard with Prime Woods Products Limited. The factory is not a complex since all that exists is one huge structure with all the activities taking place within it. The building has all the various components required for the establishment of a particle board processing factory.

It makes a very good case study by virtue of tit being the only one of its kind in Ghana and West Africa as a whole.

Fig. 10 A picture of BMK and Prime Woods Products Limited

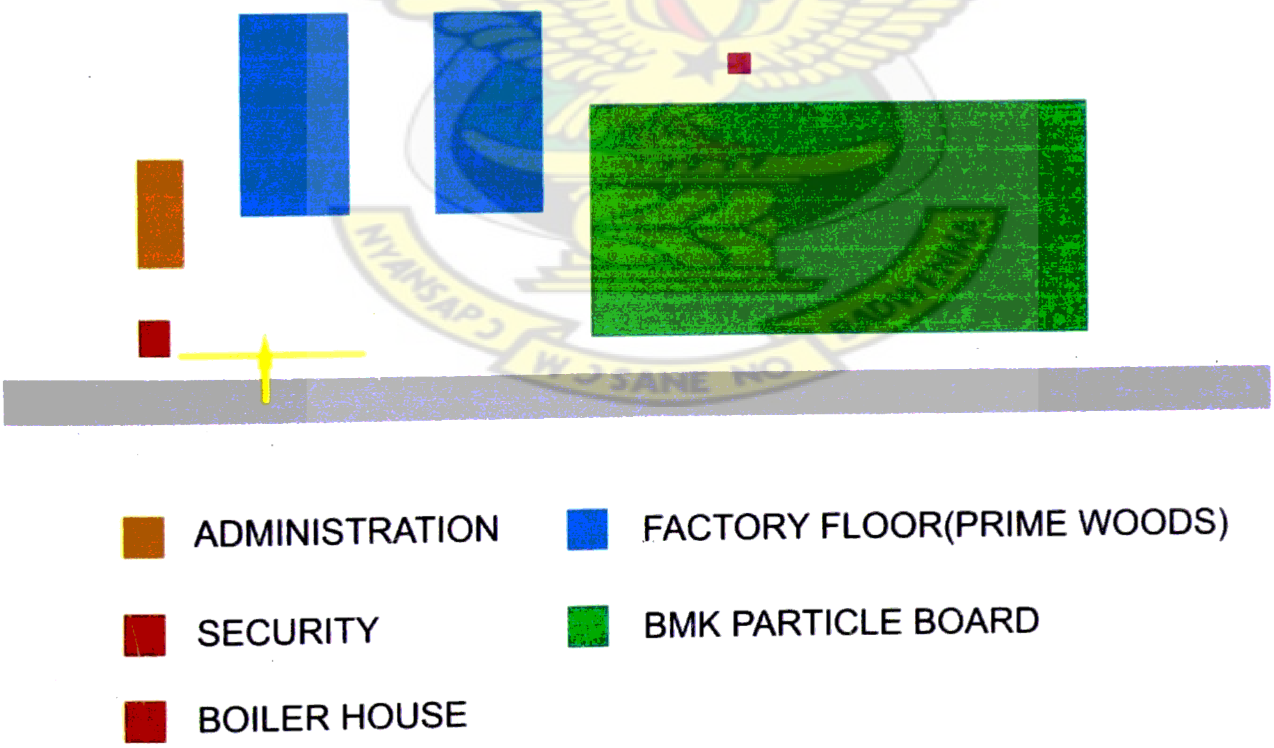


Fig 11 Schematic layout of site

3.1.2 General Approach

On entering the facility one meets the gate house (security) on the left with the administration and canteen behind it. The production floor for Prime Woods Products Limited is on the northern part of the yard which also is an open shed.

The structure on the eastern side of the yard is BMK Particle Board which is enclosed at all sides. The factory block houses all the components right from manager's office to finished products storage, which is rather unfortunate as the noise, dust and vibration is quite perceivable.

The good design feature here is the traffic and production flow on the structure. These two entities have been well laid.

3.1.3 Structural System

Walls: these are made of aluminium profile sheets welded to steel structural members which is painted with white emulsion paint.

Floors: floors are of reinforced concrete where heavy equipments sit. Criss-crossing the floor is covered drains and a network of electrical channels.

Ceiling: basically the roof serves as ceiling with Perspex introduced at various areas to augment the artificial lighting.

Windows: the building has very few windows except for the production area. As a result the place is always stuffy and uncomfortable inside.

Services: it comprises both vertical systems running along structural members and horizontal systems running with the floor slab.

Personal and Fire Safety: this very important aspect of factory design seems to have been played down since there was a marked absence of fire-fighting equipment and apparatus and personal safety measures encroachment to revolving parts. Ear plugs, nose masks and goggles seem markedly absent.

3.1.4 Justification for use as a case study

For the fact that it is the only of its kind in the country and the West African sub-region as a whole and the design feature which helps traffic and production flow.

- **Facilities available**

Delivery yard, car park (not enough), offices, boiler house, production floor, storage areas

- **Merits and Demerits**

The merits of the design include:

- Almost all the activities are housed in one huge structure which allows for good supervision of work by the management.
- The design feature employed which improves traffic and production flow in the structure.

Demerits include:

- High noise levels affecting the administrative section as well as the dust that fly around into the offices.
- Few windows openings on the structure making the inside of the structure almost all the time feeling stuffy and uncomfortable.

3.1.4 Conclusion

It can be concluded that the factory functions well for the purposes of particle board production as the dust should be contained. The introduction natural light through the roof is a plus that cannot be overlooked considering the depth of the building. The only thing is the housing of the administrative staff on the production floor looking at the noise levels and vibrations as well the dust. In all it served as a good case study material as it is the type in Ghana.

3.2 CASE STUDY TWO

3.3 FURNITURE FACTORY AT THETFORD, NORFOLK ENGLAND

The factory covers an area of about 3 acres (1.2ha) and is bounded on three sides by roads. The site has the self-contained offices and the production block positioned very close to each other on the western side to allow future expansion of the factory. This future extension would be carried out at the eastern portion of the site.

Fig.12 A Picture Of The Factory Showing The Offices And Showroom

3.3.1 General Approach

Offices, entrances and all delivery and dispatch positions have been situated at a low level yard at one side of the factory away from the area reserved for expansion. The office and showroom block, which can also be doubled by adding another floor, aligns with the short north side of the production block so that it conceals the yard against view from the London-Thetford main road.

The layout of the factory was based on the manufacturing processes. Initially the two raw materials – wood and metal follow separate paths before they meet semi-finished products at the sub assembly stage. Upholstery, varnish shop and final assembly section are aligned along an L-shaped corridor.

3.3.2 Structural Systems

The factory was erected in eight months. The choice of the structural design was governed by economic and flexibility considerations. Steel stanchions carry the main steel beams of 12m spans at 4.5m centres leaving a vertical clearance of 3.65m.

Spanning between the castellated beams are softwood joists carrying wooden panel tarred roof. Ventilators and roof light of translucent corrugated sheeting occupy one quarter of the floor area. The roof light at certain rooms have amber colour which filters the ultra violet rays which are detrimental to the wood. The beams are slightly inclined to aid in draining the roof through gutters along the edge above the column bays.

3.3.3 Justification for use as a case study

The structural system gives a good appreciation for the use of steel as vertical structural members and also the roofing members.

Facilities Available

Delivery yard, car park, offices, show room, timber shed, boiler house, wood finishing shop, accessories store and cabinet makers shop.

Merits and Demerits

The merits of the design include:

- Almost all the activities are housed under one roof
- A standardized structural module system has been used. This helps in expansion purposes and also speeds up construction.
- The production process dictating the layout of the structures is one strong merit of the design.

One major demerit is the external cladding of bricks which can pose difficulties in terms of expansion without recourse to structural demolition.

3.3.4 Conclusion

It can be concluded that factory functions well for the purposes of furniture production. The introduction of natural light through the roof is worthy of notice. Openings provided along the external classing are worthy of praise which help to ventilate the length and breadth of the factory.

3.4 The Production Process

The production of chipboard starts by sifting, screening and drying of the chips/sawdust. The flakes are glued and then transported to the forming and pressing section to be pressed after which it is cooled. It is further sent to the trimming and sanding section where the boards are cut to sizes and then arranged on pallets and stacked. The boards that would be coated are sent to the melamine section and after the process the boards are cut to sizes and stacked in the storage area awaiting transportation to the market.

The production process for wood pellets/briquettes also begins by sifting, screening and drying of the sawdust after which it is sent to the pelletizer to be formed. The pellets are packaged and stored awaiting transportation to the market.

CHIPBOARD MANUFACTURING PROCESS

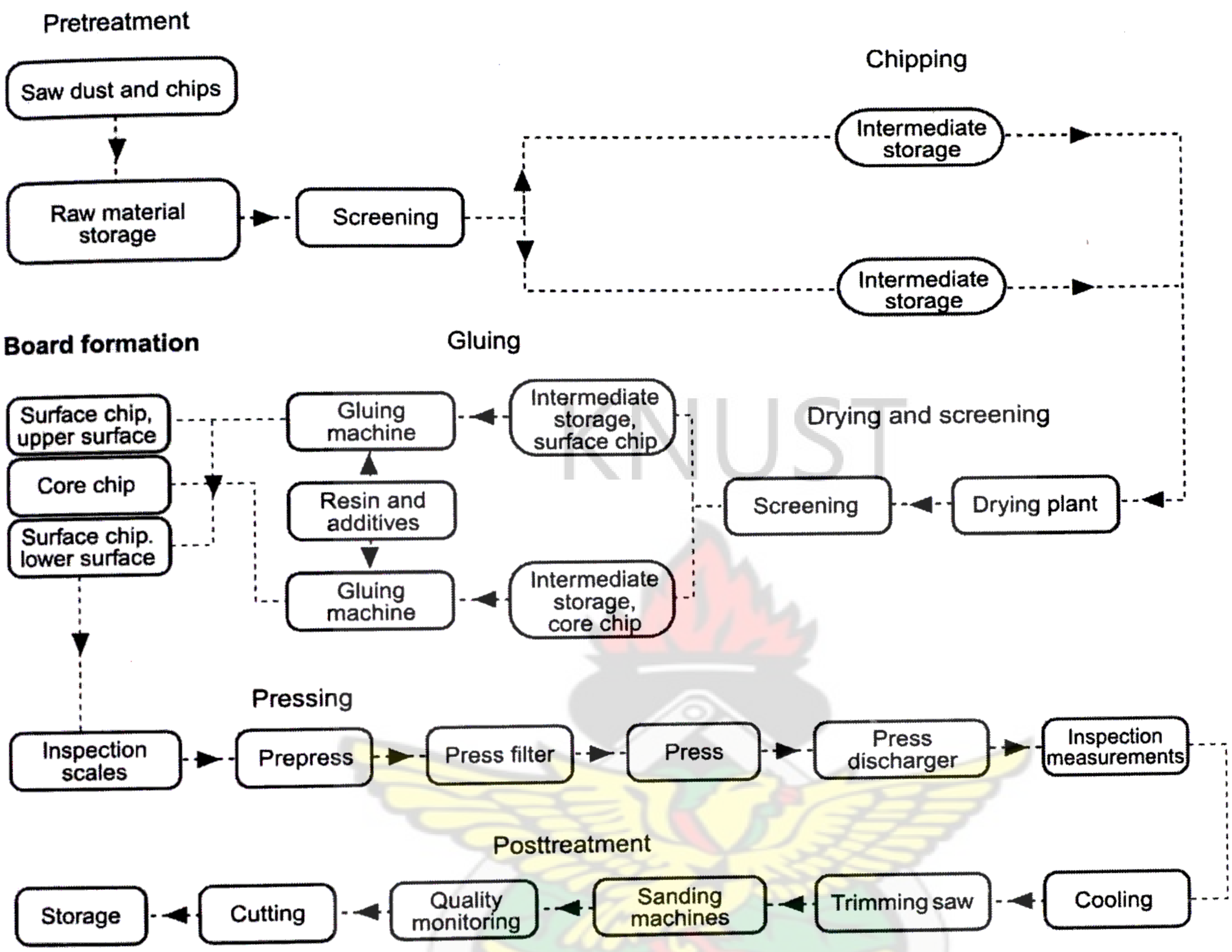


Fig. 13 shows chipboard production line

MANUFACTURING PROCESS FOR MELAMINE COATED BOARDS

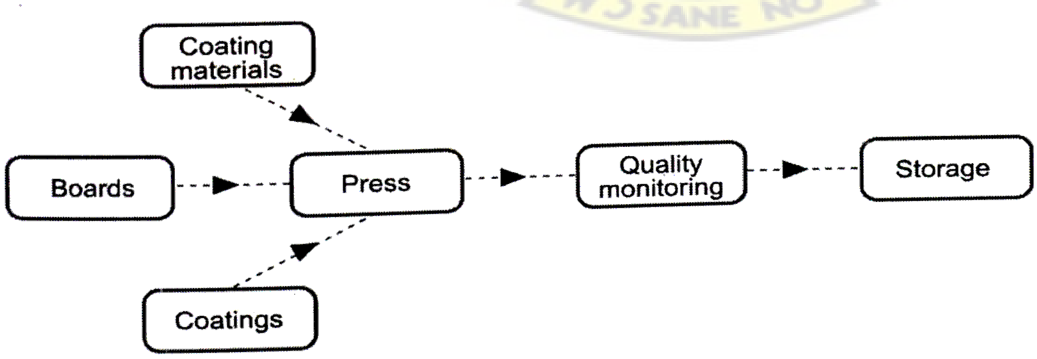


Fig. 14 shows melamine coated chip board production line

3.5 SPECIAL STUDIES

Machines and their sizes

chipper

height 2000mm
length 2500mm
width 800mm

hammermill

height 2000mm
length 2500mm
width 1200mm

pre-press machine

height 2500mm
length 4000mm
width 2000mm

sawdust model dryer

occupies an area about 20 sq. metres

cutting machine

height 1500mm
length 2500mm
width 500mm

oscillating machine

height 1000mm
length 1500mm
width 1500mm

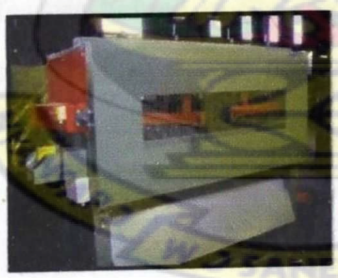
press machine

height 6500mm
length 4000mm
width 2500mm

conveyors

manufactured according specification from the client

wood shavings machine



height 1500mm
length 1500mm
width 600mm

sieves screener machine

height 1500mm
length 2000mm
width 1000mm

CHAPTER FOUR

FINDINGS AND DISCUSSIONS

4.0 Findings

This section deals with the information obtained from both the literature review and case studies that will influence the design proposals and recommendations. The things uncovered going through the research design include the following:

- Through the literature review, data on waste generation, distribution and utilization by the woodworking industry were found out which formed a strong basis for this design proposal.
- Through the studies of existing facilities related to the subject of study in one way or the other, structural systems, material application, roof systems employed, machine layout and other practices were found out which helped in making decisions concerning the design.
- The special studies conducted revealed the anthropometrics of the various machines required for the production processes. This helped in calculating the spatial requirements of the production block as well as other facilities involved.
- Segregation of activities was one major feature common to almost all the facilities chosen for case studies. This feature helped in the smooth running of these facilities and it is going to be an important part of my design proposal.

4.1 Site Selection and Analysis

4.1.1 Site Selection

The standards for the selection of a site for this kind of project depend on several factors including:

- Raw material sources and quantities;

- Ease of transportation (raw materials and finished products);
- Labour availability and
- Site accessibility

4.1.2 Site Location

The proposed site is located at Sokoban, a suburb of Kumasi in the Ashanti Region. It is bordered on the north by the Odum road and on the west by the Subin road. It is the stretch of land found at the eastern border of the Sokoban Wood Village.

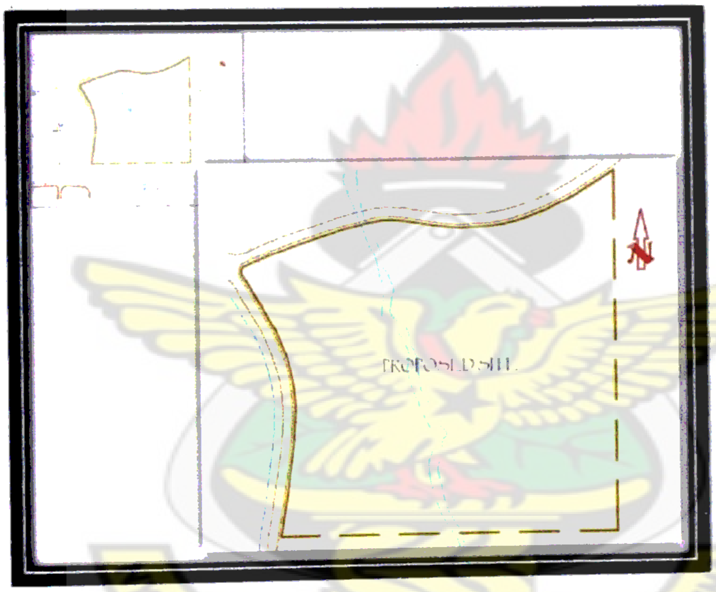


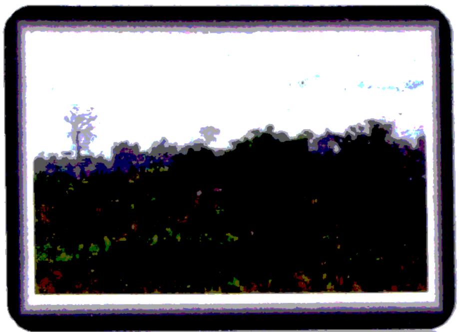
Fig. 16 showing proposed site

4.1.3 Site Description

Looking at the topography of the site from the site map and the contours on it gives an indication of a gentle sloping land towards the river but on the contrary, what pertains on the actual site is quite a different story: the nature of the landscape is one of an almost flat land. This is due to the sand winning activities on the site. There is a very gentle slope towards the river, Subin from the west. The site covers an area of 180000 square metres.

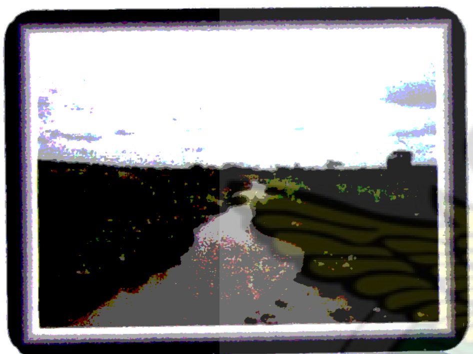
Site Ecology: the site is inhabited by human settlers, plants, crabs, birds and reptiles

Vegetation: the plant life existing on the site includes:



(a) Predominanatly grass

(b) Predominanatly trees and shrubs



(c) Predominanatly water plants along river banks (d)

Fig. 17(a, b, c and d) shows plant life on the site

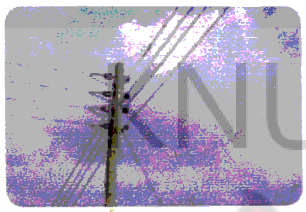
Climate and weather:

- temperature ranges between 21°C and 32°C
- annual rainfall vary from 1500mm to 2000mm
- relative humidity remains high at about 75% for most essential parts of the day
- wind velocities are typically low but strong winds during rainstorms

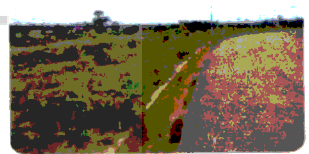
Infrastructure and Services:

- existence of electricity from the national grid
- existing telecommunication lines
- water supply from GWCL
- presence of storm drains
- well developed road and railway network.

(a)

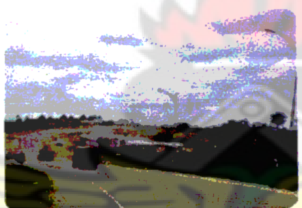


(b)



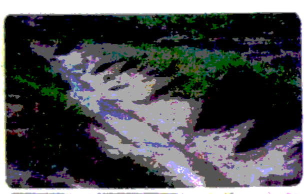
(c)

(d)



(e)

(f)



(g)

Fig. 18 (a, b, c, d, e, f and g) shows the infrastructure present on the sent

Topography:

- the land slopes gently into river from both sides (section D – D)
- the land is relatively flat from north to the south
- site has sand deposits which is being win for construction
- there is a drop of about 800mm from east to the west boundary

4.2 Peripheral Study

The site has a lot of industrial activities taking place very close to it or some metres away while other industrial buildings and activities can be found in the horizon. These industrial activities would consciously or unconsciously have an effect on the proposed site for the factory. The design typology and styles employed by these factories flanking the site would also affect the proposed factory. The residential buildings close by will also have an effect as well as proposed residential commercial development to serve the Wood Village.

Such of the activities and factories include:

- Sokoban Wood Village (west of site)
- New residential developments (east of site)
- Kaasi industrial area seen in the horizon (north of site)
- Vegetable farming (along the river)
- The Training Centre (Kumasi Wood Estate Limited)

Fig.19 Sokoban Wood Village

Fig. 20 Other industrial activities

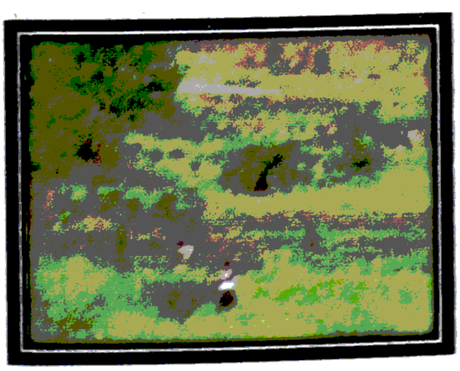


Fig. 21 vegetable along river

Fig. 22 Wood working activities

Fig. 23 residential development

Fig. 24 training centre (KWEL)

4.3 SWOT Analysis

4.3.1 Strengths

The strength of the selected site includes the following:

- Gently sloping nature of the land from the east to the west border
- The almost flat nature of the site from the north to the south
- Presence of the water body on the site
- The existence of the railway line
- Views to and from the site
- The area of land available

4.3.2 Weaknesses

The weaknesses on the site include the following:

- Sand wining activity on the site
- Soil type on the site
- Possible flooding of the site by the river in times of heavy rain storms
- Railway line passing through the site limits the possibility of accessing the site from the end.

4.3.3 Opportunities

Some of the opportunities include:

- Proximity to the wood village
- Proximity to other woodworking industries and other factories
- Nearness to the Sokoban township
- Vegetable farming close to the site

4.3.4 Threats

The threats around the site include:

- Grazing of animals around the site
- Sand wining activities around the site

4.4 Site Justification

This site was chosen over the others based on the following:

- Land area available for the intended project
- The gently sloping nature of the land (good for a factory setting)
- The presence of the water body on the site (to be tapped for the factory use)
- Presence of the railway line on the site (for a comparatively cheaper means of transportation of both raw materials and finished goods)
- The site's proximity to the Sokoban Wood Village and other woodworking factories (to provide cheaper source of raw materials)
- Views to and from the site are very good.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter is the concluding part of this research activity which tries to propound solutions and recommendations to solve the problem. The chapter will also deal with the design proposal recommended to tackle waste menace in detail after selecting a possible site for this project.

5.1 Design Philosophy and concept

Industrial designs follow certain principles and are very much technical and not just anything can be done which puts the designer in a straight jacket sort of thing. What you put where is purely determined by these principles. Every line drawn and size allocated to any space is dictated by the production line used and the processes involved in the manufacture of the product as well the machines being used and their anthropometrics. I came up with the philosophy of ***"free flow in efficiency"*** bearing in mind how raw materials come in, the type of production line being employed, the number of processes involved in the production and how the finished products are packaged, stored and taken out to the market.

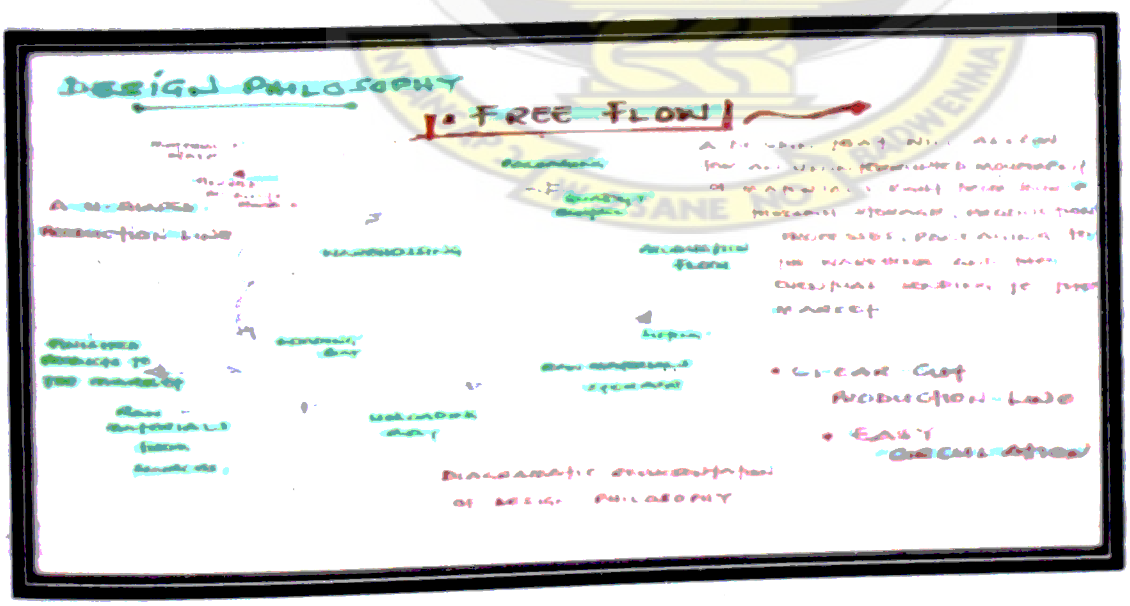


Fig. 25 A diagrammatic representation of design philosophy

To achieve my philosophy of "free flow in efficiency", the design should be such that it would allow for an uninterrupted movement of raw materials from the material storage through the production processes to packaging and the eventual transportation to the market. The production block therefore becomes the main point of focus and the structures there should be carefully located and co-ordinated to allow for an uninterrupted production process. The anthropometrics of the machines should also inform me about the how high the structures should go and again the temperature of the place should be considered in order to orient, number and size of windows to be employed.

5.1.1 Design Brief and Accommodation Schedule

ADMINISTRATION

SPACE	AREA (M^2)
[redacted]	
Reception	9.6
[redacted]	
Showroom	182.12
[redacted]	
Conference room	88.16
[redacted]	
Internet café	47.76
[redacted]	
Kitchenette	15.18
[redacted]	
Office - CEO	42.56
[redacted]	
Marketing manager	20.16
[redacted]	
Head of security	20.16
[redacted]	
Office (research)	20.16
[redacted]	
Store (research)	13.32
[redacted]	
Sanitary	24.4
[redacted]	
Total	**762.62**

CANTEEN

SPACE	AREA(m^2)
[redacted]	
Kitchen	43.12
[redacted]	
Pantry	8.88
[redacted]	
Dry store	4.35
[redacted]	
Bar	4.50
[redacted]	
Store (bar)	8.12
[redacted]	
Sanitary	8.12
[redacted]	

WELFARE DEPARTMENT

SPACE	AREA(m^2)
[redacted]	
Changing Room (female)	43.89
[redacted]	
Restroom	13.69
[redacted]	
Laundry	10.55
[redacted]	
Clock-in room	5.27
[redacted]	

MAINTENANCE DEPARTMENT

SPACE	AREA(m^2)

[redacted]	
Office (Engineer)	13.82
[redacted]	
Store (parts and tools)	52.75
[redacted]	

PRODUCTION BLOCK

SPACE	AREA(m^2)
[redacted]	
Raw Material Storage	964.18
[redacted]	
Packaging	147.14
[redacted]	
Office (Production Manager)	17.53
[redacted]	
Offloading platform	181.52
[redacted]	

ANCILLARY FACILITIES

SPACE	AREA(m^2)
[redacted]	
Security post (main entrance)	10.97
[redacted]	
Water Treatment plant	100
[redacted]	

5.2 Conceptual Site Planning

The site planning considered these factors:

- Types of raw materials being received and how are they brought in?
- Where and how are they stored?
- How are they sent to the production floor?
- The production line being employed

- The processes involved in the production
- How the finished products are packaged and stored?
- How they are sent to the market?
- The services required for the machines to function at full capacity
- How workers come in and customers as well
- Security for the place.

Option One

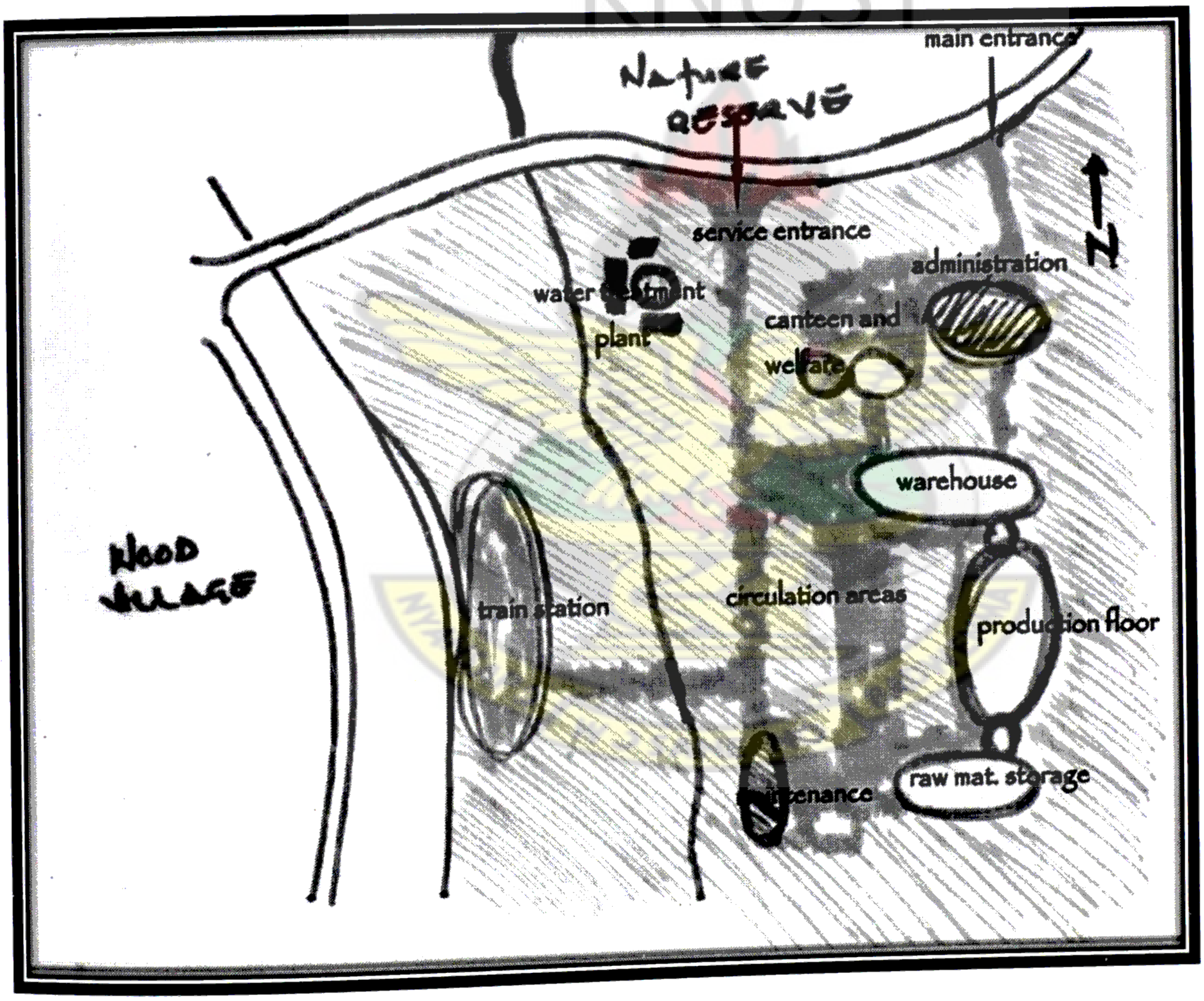


Fig. 26 Conceptual site planning, option one

This option comes with two entrances to the site, main entrance which is used by the workers at the administration and the customers and the service entrance for bringing in and taking out of goods. The juxtapositioning of the various blocks at the production zone tries to achieve some form of cohesiveness. The maintenance block is separated from the production block which breaks the cohesion. This option will be modified into option two as it is defeating my concept.

Option Two

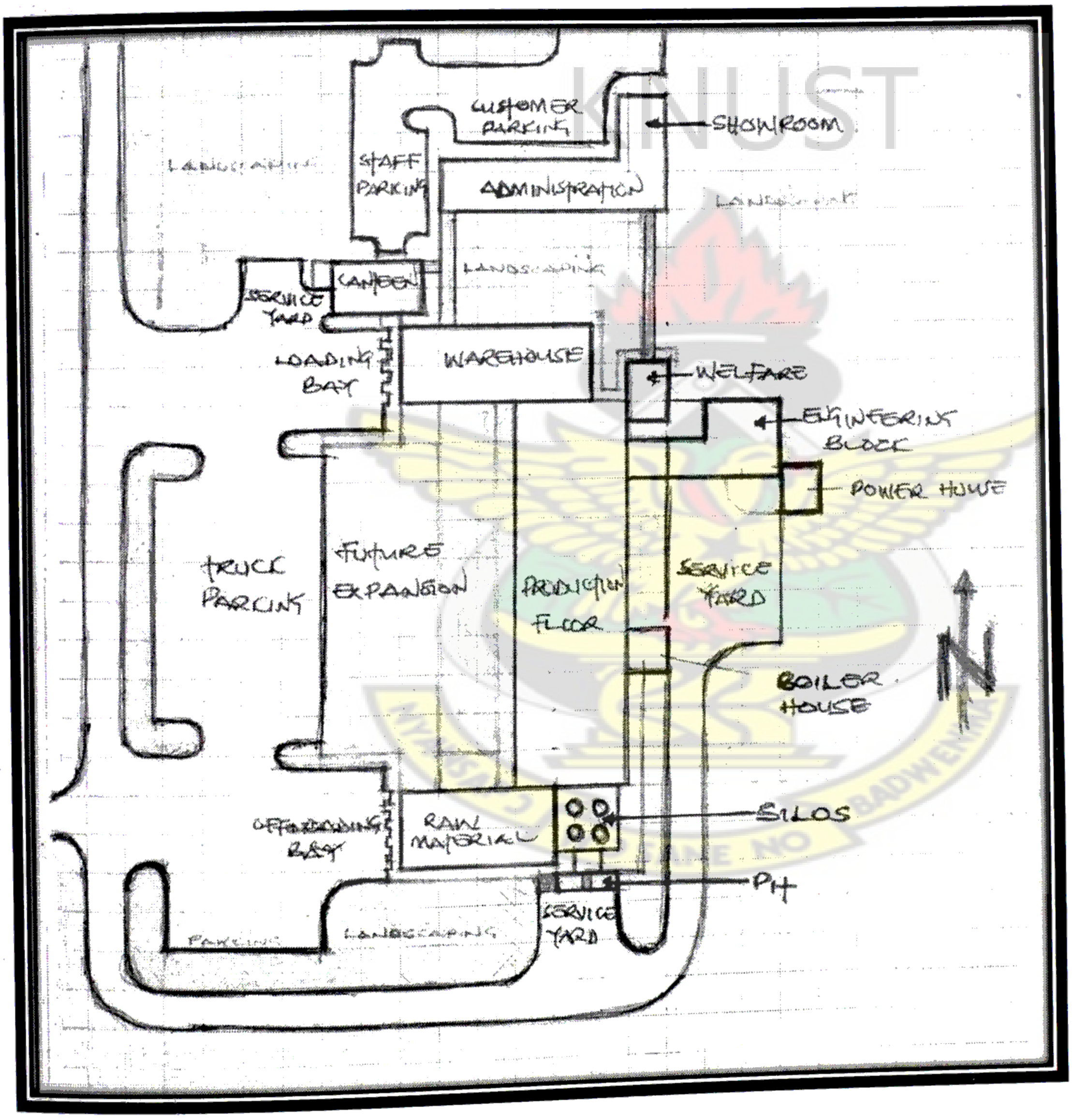


Fig. 27 Conceptual site planning, option two

This option has the same number of entrances as option one. The maintenance blocks as well as the welfare block have been attached to the production block achieving the cohesiveness needed to achieve the design philosophy. The administration and canteen block have also been linked by the use of covered walkways to help achieve the design philosophy. This is the option I have chosen but it is still subject to changes here and there.

5.3 The Design

As stated earlier, industrial designs follow certain principles and guidelines and are very much technical. Their form and planning considerations are purely dictated production processes and the type of machinery being used as well as the product being produced. How materials come in and the states in which they come also play important roles in the way offloading and loading bays are treated.

5.3.1 The block plan

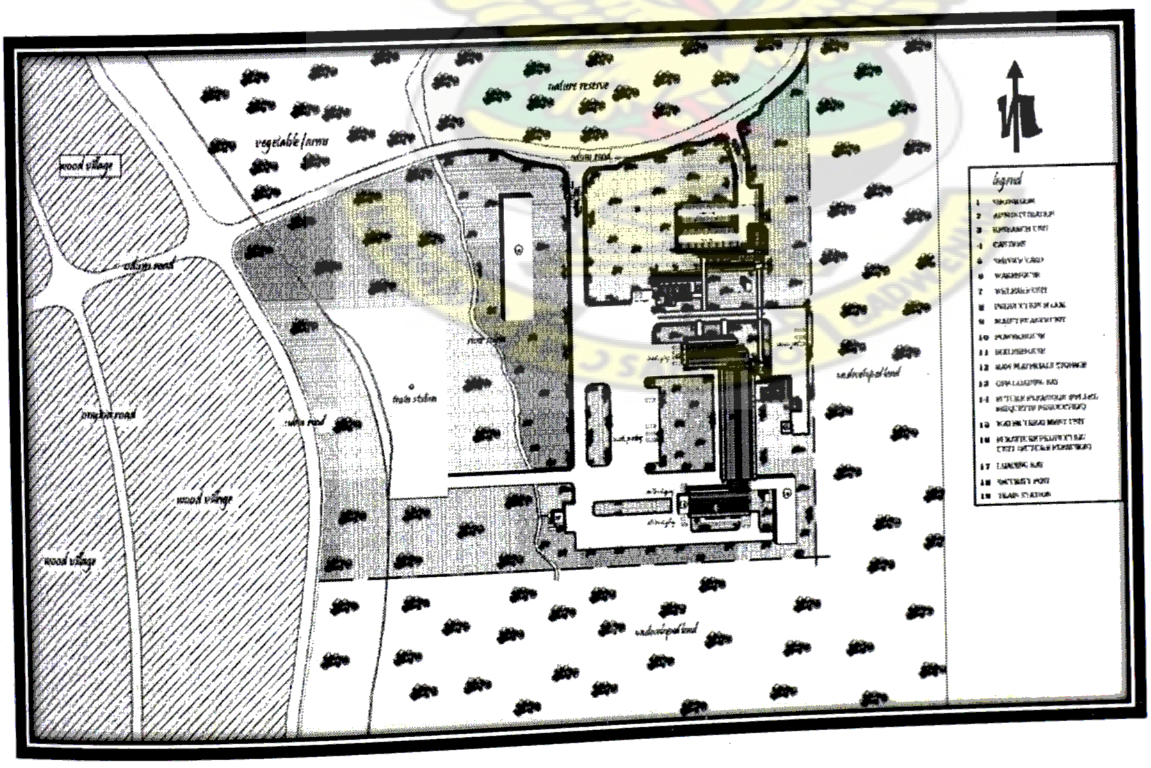


Fig. 28 Block plan

The block plan gives an idea as to how the various sectors of the facility are interconnected as well as the heights of the blocks. It again shows the facility in context and its location as well as the access routes to the site. The main accesses to the site are taking from the Odum road which is at northern side of the site. Both entrances are fully secured to check what or who comes and leaves the premises.

5.3.2 The layout

This also takes you into the various spaces allocated for each activity and how each space relates to the other

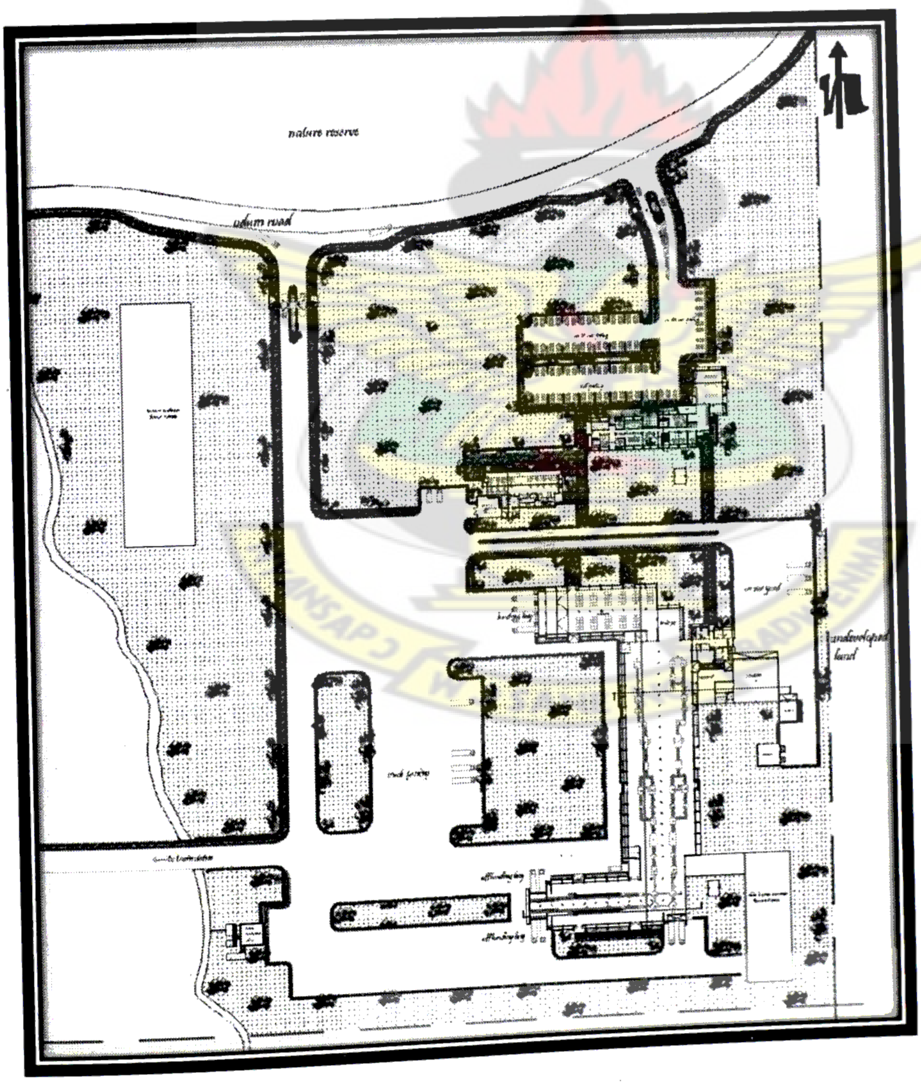


Fig. 29 Layout

The planning of the site was influenced mainly by the production process and the type of production line adopted. The way raw materials are received and in what form as well as the processes it goes through before it enters the production line informed me as to where to locate what to allow for efficiency in the production.

The various units of the production block were so positioned to aid the efficient running of the facility and to allow easy movement, convenience and cut down on distances to be travelled in accessing each of the units.

The welfare unit is attached to the production floor to help check worker movement in and out of the production area as it serves as the main entrance. The clocking area sits just before you enter the production area such that workers clock in before they enter after changing and sign out after the close of the day's activities. It will also help monitor any time a worker leaves the production area aside the mandatory break hours where every worker leaves the production area. Its position will also aid in short distances travelled in case of accident.

The maintenance unit is located in that machines can be serviced from there or easily moved there. Its location keeps it out of public view.

The site has been divided into two major sectors and these are the public areas (administration and canteen) and private areas (the production zone).

All efforts have been made to avoid conflicts between trucks and other vehicles that come to the factory. Service routes have been segregated from the entrance for other cars.

Safety precautions have been put in place to ensure safety on site. Firefighting equipment has been provided at vantage points to enable worker control fire before it gets out of hand. Escape routes have been factored into the design in times of fire or any other incident and as such all escape exits open into space where workers can run out to safety. All exit doors are wide enough to allow for three or people to run out at a go and they all swing outwards. Again efforts have been made to segregate fire prone areas in order to contain them in order to avoid spreading.

All the other blocks are well connected to the production block by the use of covered walkways which also defines the movement patterns on the site. All the parking areas are positioned to serve the purpose for which they are allocated well.

5.3.3 The Administration Block

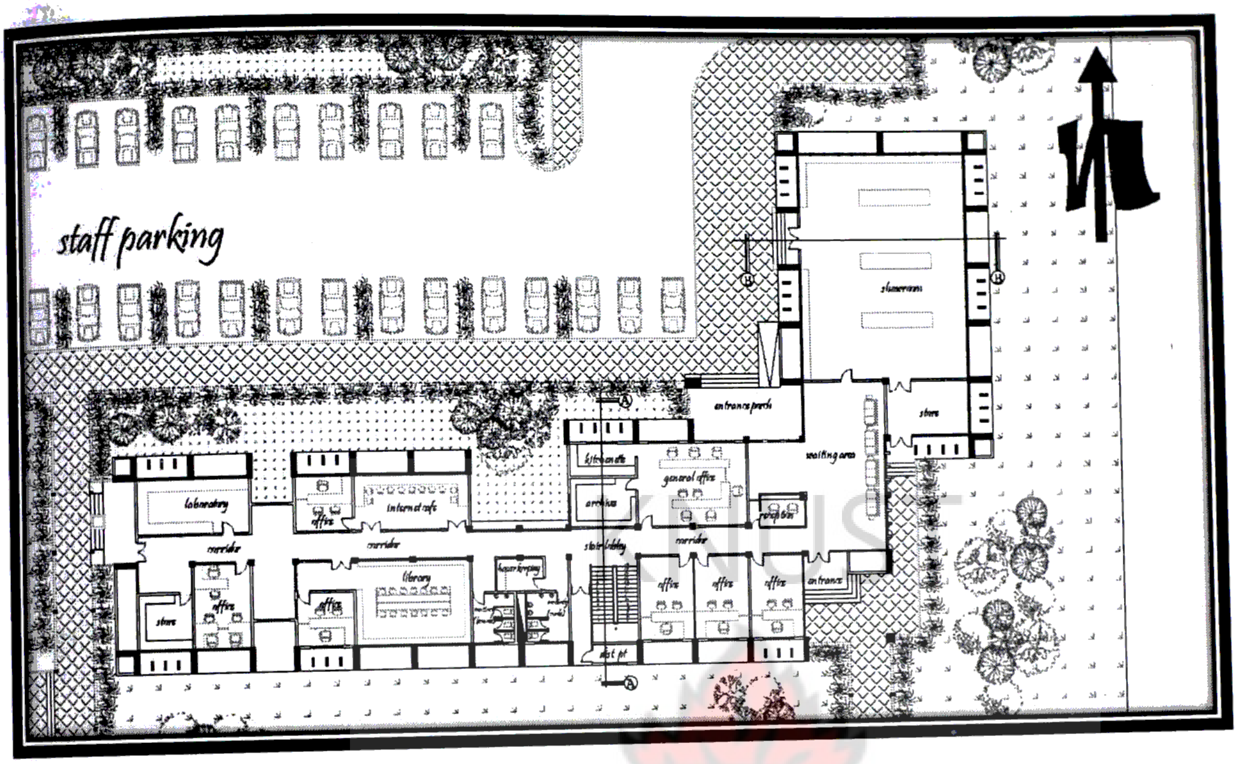


Fig 30 Ground Floor Plan (Administration)

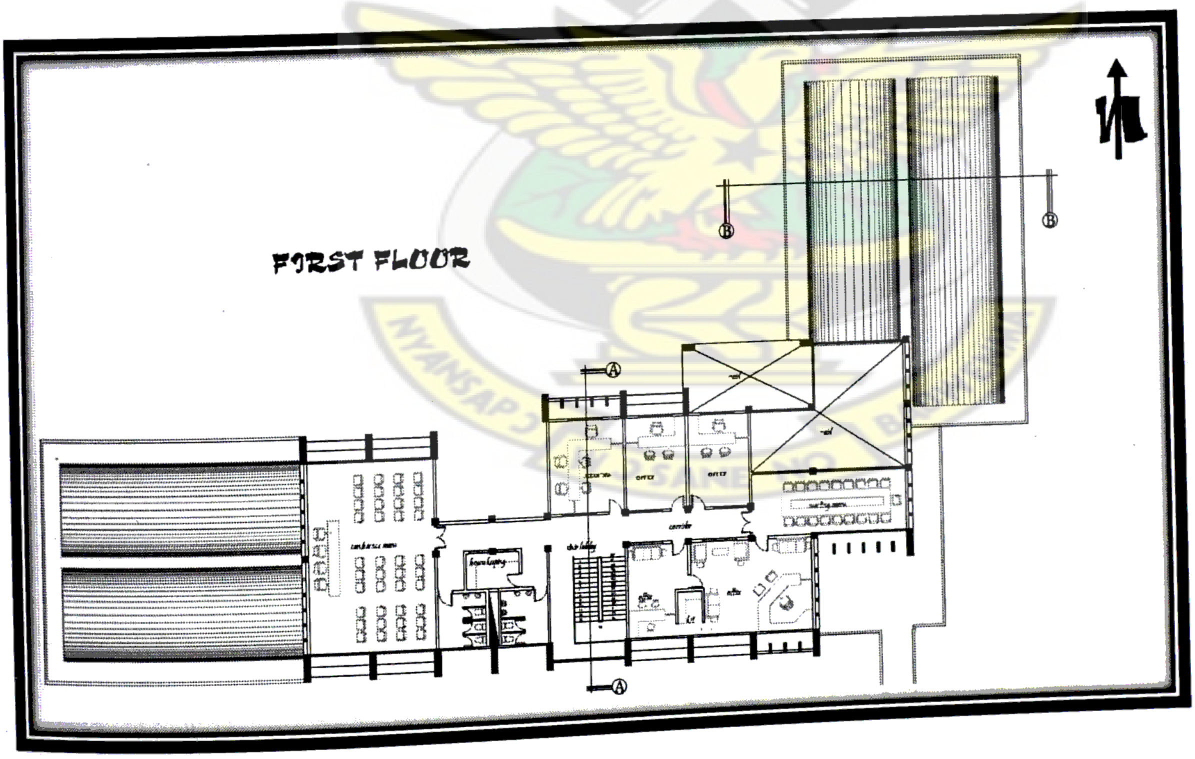
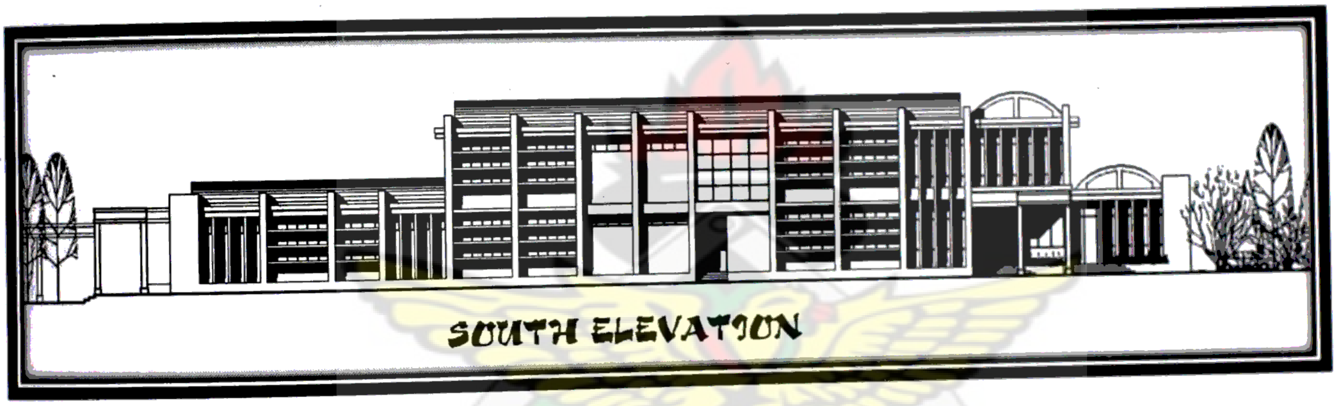


Fig. 31 First Floor Plan (Administration)

The block has three units brought together to form the administration block. The various units forming this block include; the administrative section which comprises of the ground and first floors, the showroom and the research section. The administrative section has offices for the administrative staff, kitchenette, archives, meeting room, conference room, reception, waiting area, washroom and a housekeeping. The research unit consists of a laboratory, internet café, library, office for the researchers, and store. The showroom sits along the pavement leading to the entrance lobby to aid visitors to have a view of the products available. This block is connected to the production block and the canteen by the use of covered walkways. This block sits closer to the main road than all the other blocks which mean its architecture should speak and stand out. The parking for customers are segregated and kept at the public areas.

(a)



(b)

(c)

(d)

Fig. 32 (a, b, c and d) Elevations for the Administration Block

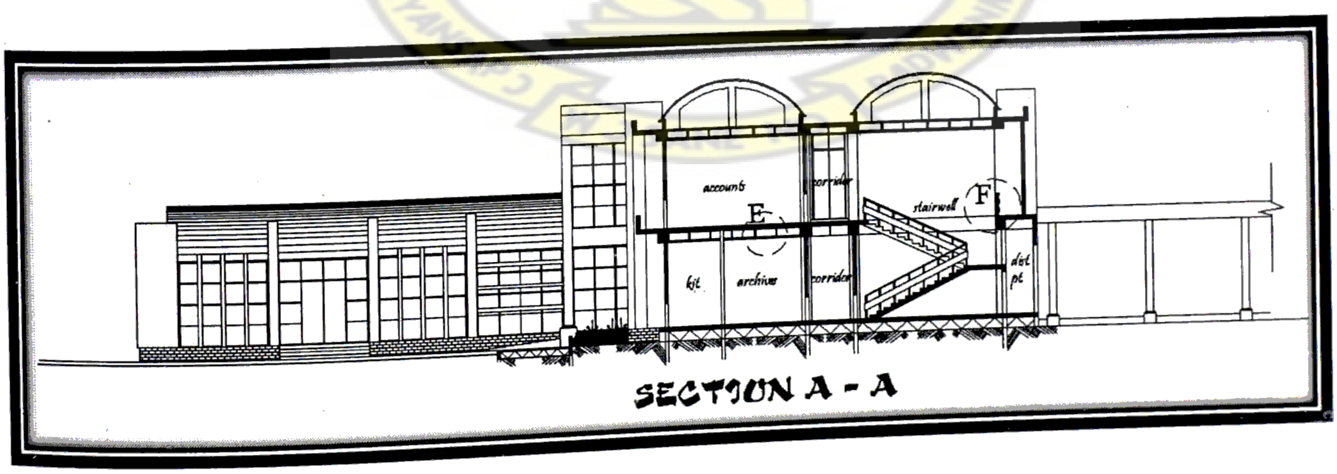


Fig. 36 Section (administration)

5.3.4 The Canteen

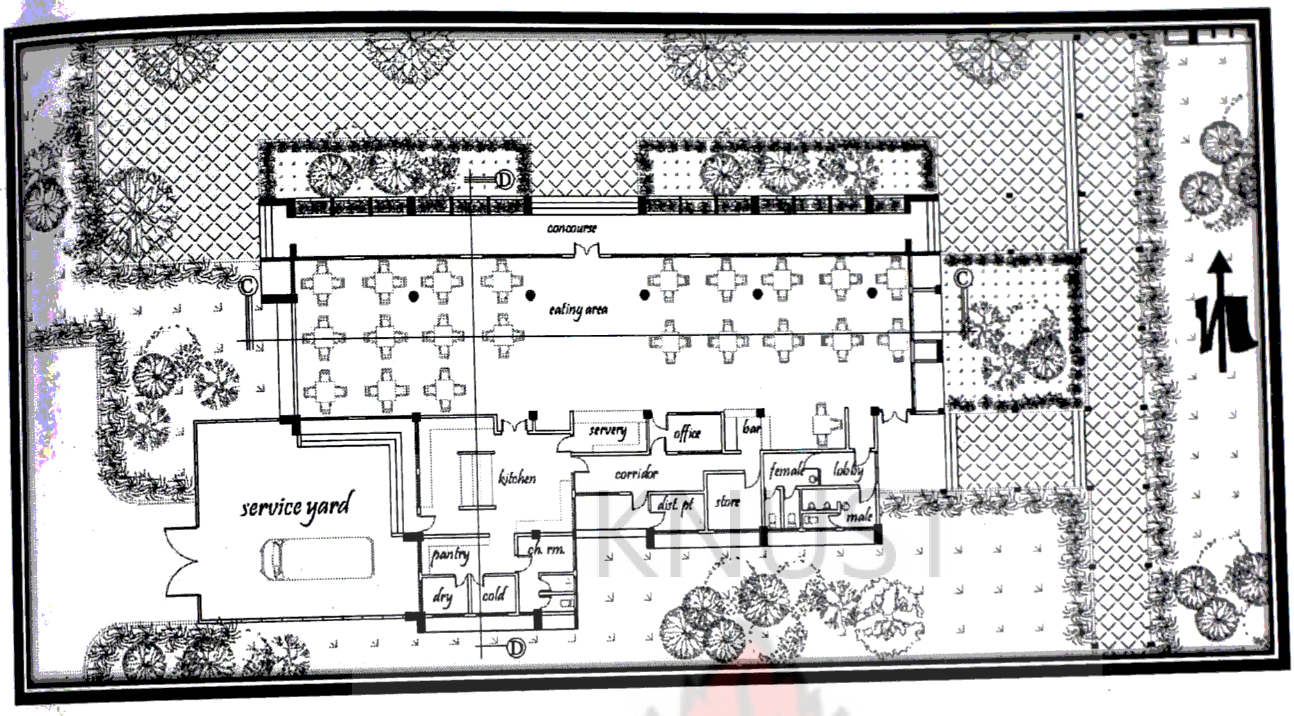


Fig. 33 Ground Floor Plan (Canteen)

The canteen is a subsidiary of the welfare unit and consists of the eating area, kitchen, pantry, dry and cold store, changing room, washroom, servery, bar, store (drinks) and outdoor sitting area for relaxation during break hours. It is connected to the administration with the use of covered walkway as well as the production block. It also has partially enclosed service yard.

(a)

(b)

(c)

(d)

Fig. 34 (a, b, c and d) Elevations for the Canteen

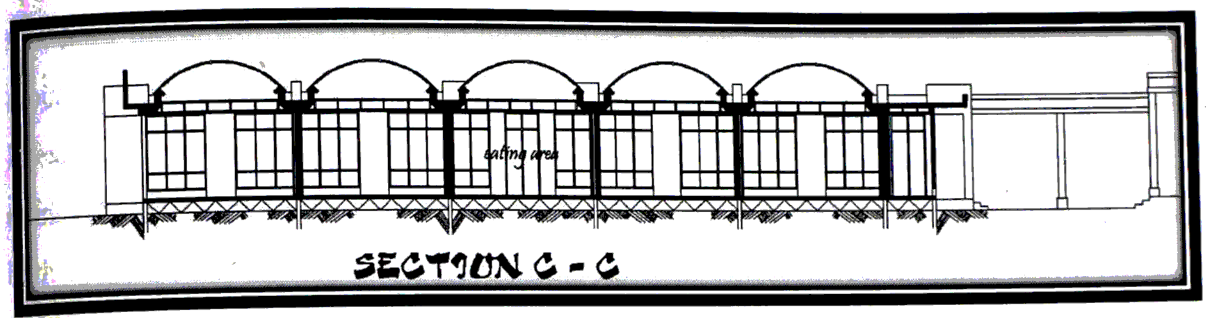


Fig.35 Section (Canteen)

5.3.5 The Production Block

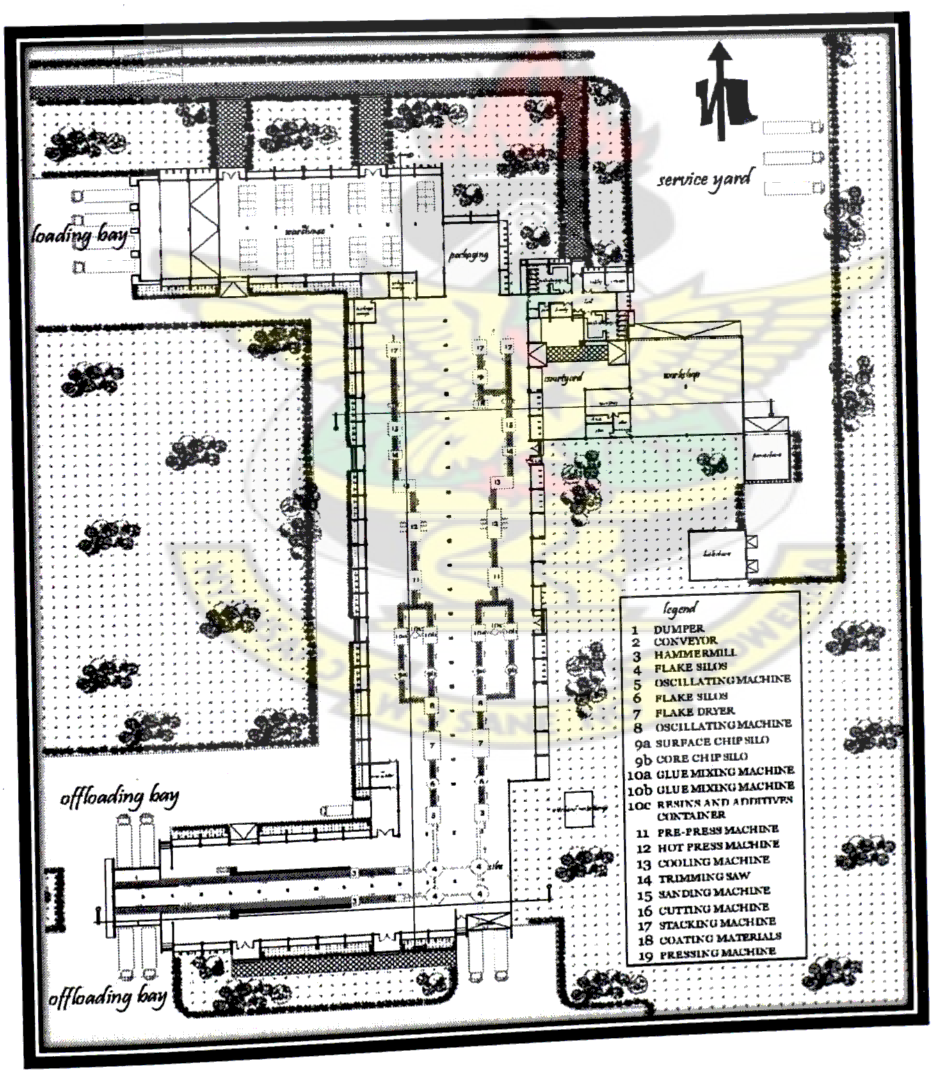


Fig. 37 Ground Floor Plan (Production Block)

The production block happens to be the most important structure on the site and every other facility exists because of this block. This block is a conglomeration of five or more major departments or units: (1) raw materials storage which consists of the offloading bay and the silos that hold the sawdust; (2) the production floor which also is the most single important space around which everything revolves. It is the pivot of the facility. It has space for the production lines, store for resins and additives, offices for the production manager and the quality control manager; (3) the welfare unit which contains the sick bay of first aid area, changing rooms for both male and female workers, washrooms for both sexes, laundry, janitor and a clocking area; (4) the engineering unit also consisting of the workshop, store for machines parts and other tools, offices for the head of engineering and parts manager, powerhouse and the boiler house; and (5) the warehouse which unit of this block which starts with the packaging section through the main storage space for the finished products to the loading bay where the products are transported to the market.

- **The Production Hall**

The production area occupies a substantial proportion of the total space and concentrated in them are the most expensive elements of the building and machines. As a result, there is the need to plan this area with maximum efficiency. There is the need to maintain the necessary working clearances to give maximum flexibility and convenience. Planning of production halls in factory design is a difficult task which an architect is confronted with since it requires the development of a layout to meet an exacting set of conditions and the integration of engineering services. It is therefore important that a layout of individual machinery to be considered in detail to arrive at a comprehensive solution to the problem of factory design. The total area of the production hall was arrived at after summing all the areas needed for all the equipment plus the circulation. Two parameters defined the floor area needed in the factory. First, the overall dimensions of the machine and secondly, the nominal dimensions of the materials to be processed and space for operator. Space for circulation while work is in progress is also considered.

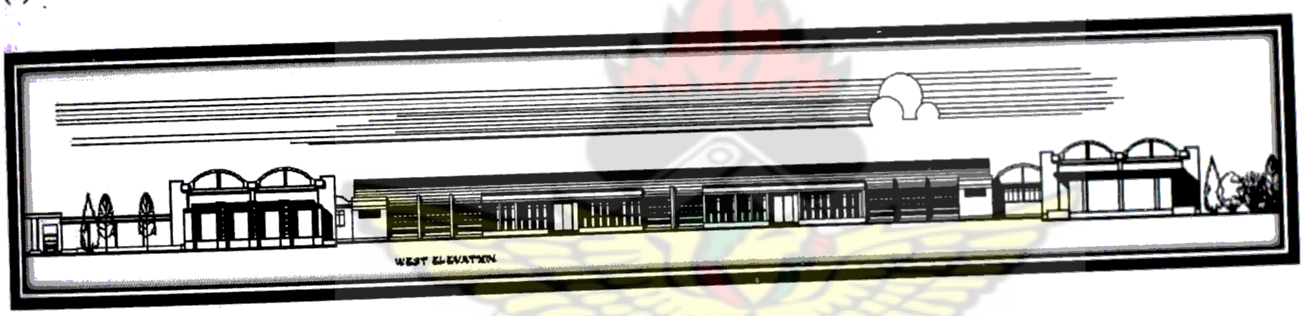
- **Maintenance unit**

The same considerations for the production hall were used for the maintenance unit. The repairs and servicing of machinery and general plant equipment in the factory would be undertaken in this area. Trucks, buses and other equipment shall be repaired in event of breakdown in or around the plant. The yard would also act as overnight parking for the trucks, store area for broken down machinery as well as carpentary, electrical plumbing services. Due to the nature of activities in this yard, the turning radii have been carefully worked out to ensure maximum circulation.

- **Warehouse**

This is where the finished products are kept in pallets ready for collection and distribution. It is has a direct connection with the production hall and has a good outlet for efficient handling of the finished product. Here, the room height is of utmost importance.

(a)



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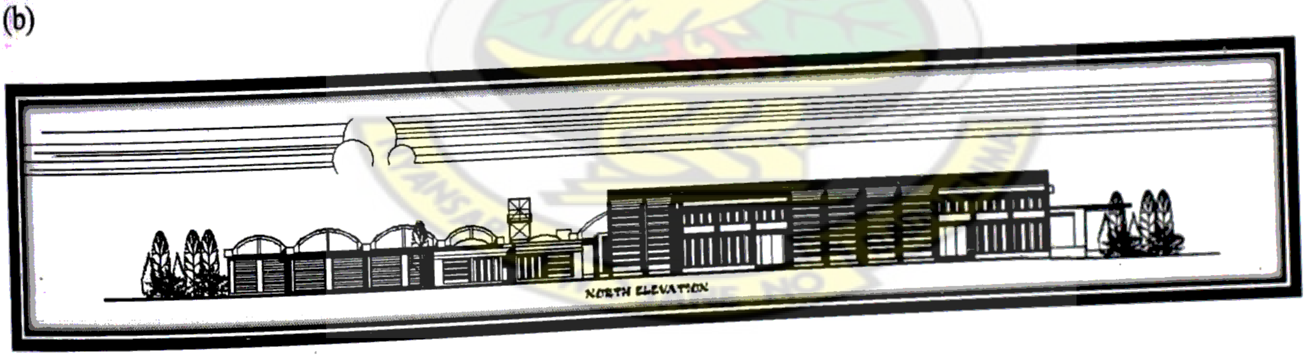
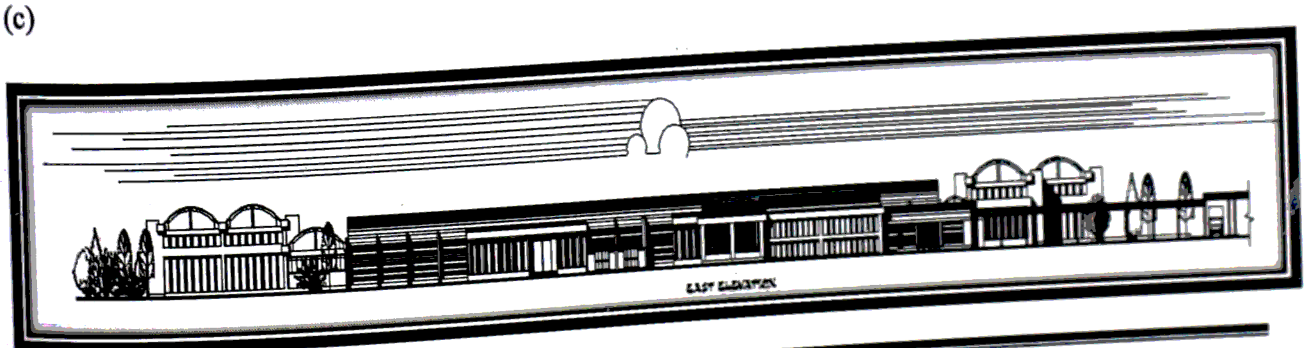


(c)



(d)

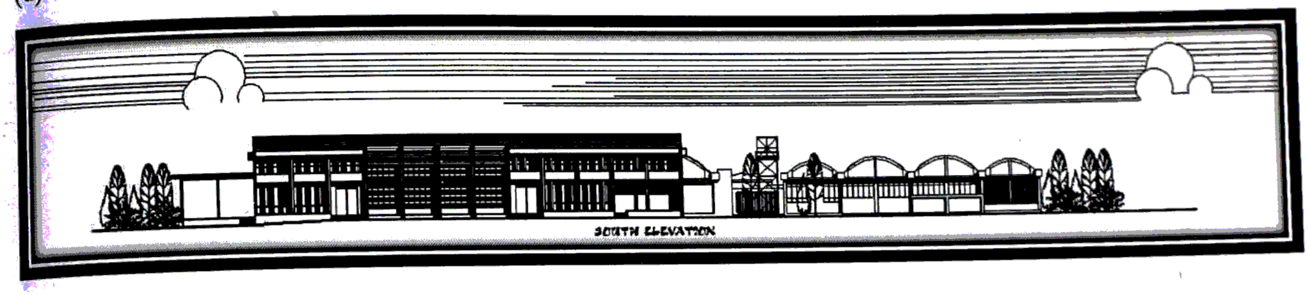
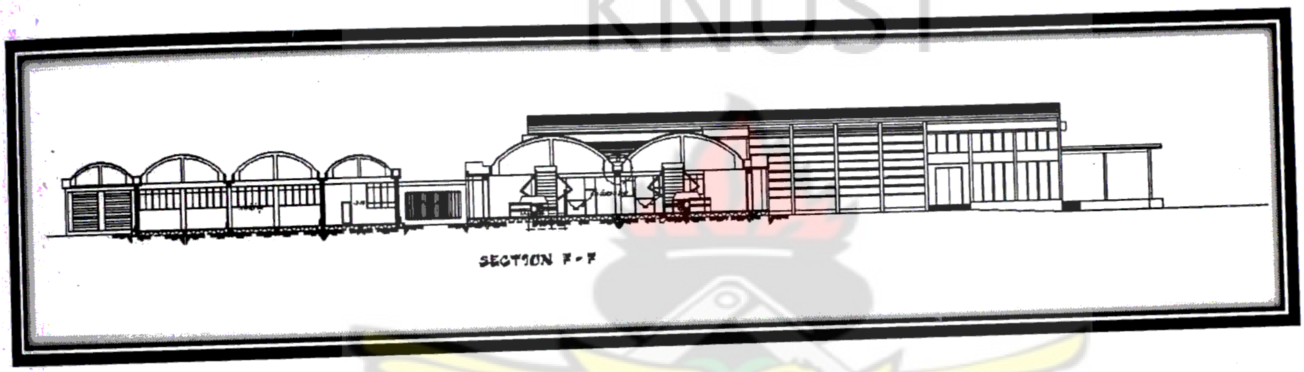


Fig. 38 (a, b, c and d) Elevations for the Production Block

(a)



(b)

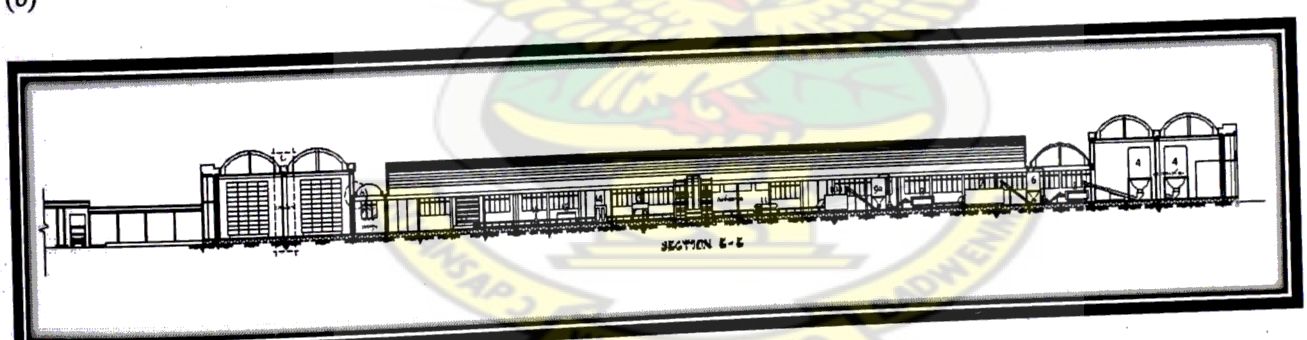
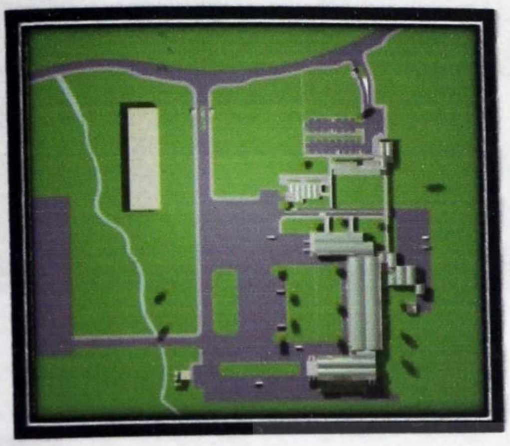


Fig. 39(a and b) Sections of the Production Block

5.4 Perspectives



a

b

Fig. 40 (a and b) aerial view of the whole site

a

b

c

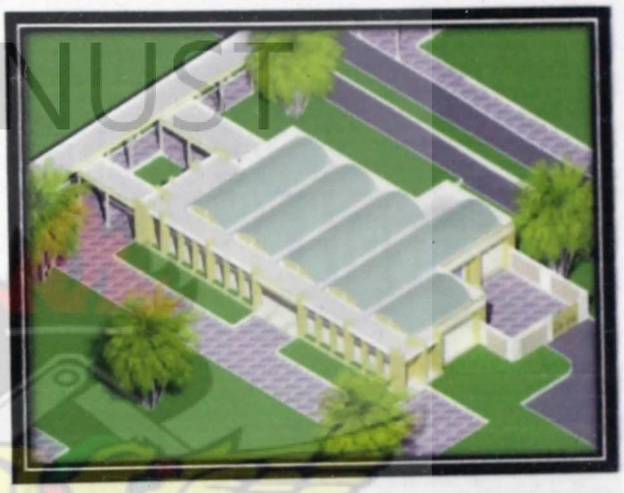
d

Fig. 41 (a, b, c and d) Perspective views of the administrative block

a

b

c



d

Fig. 42 (a, b, c and d) Perspective views of the canteen block

b

a

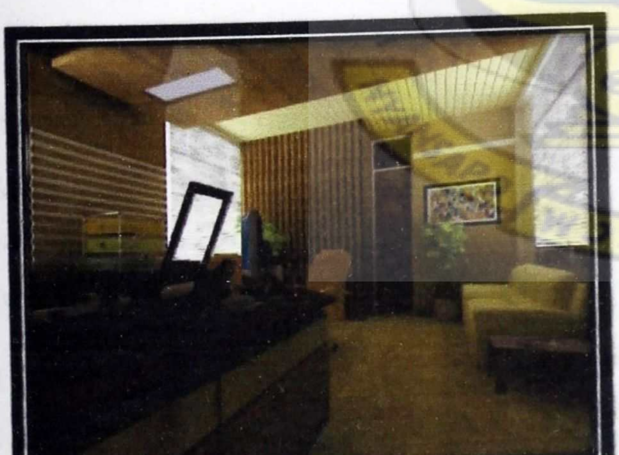
c

d

Fig. 43 (a, b, c and d) Perspective views of the production block

a

b



c

d

Fig. 44 (a, b, c and d) interior perspectives

5.5 Structure

All the buildings on the site employ the simple post and beam system to form the main structural frame with block work serving as the infilling. The walls then become non-load bearing. The roof system employed is the simple self-supporting barrel roof system usually used for industrial setups. Some portions of the roof are flat reinforced concrete roof which is drained by the use of pvc pipes along the columns into a reservoir which will then be recycled for use. The foundation system will be made brad pads because of the soil type on the site.

5.6 Materials

Substructure: it will be made of a high strength reinforced concrete to form the pile foundation and also for the floor slab. The strength of the concrete for the floor slab should be very high to be able to withstand the vibrations from the machines. Concrete strength should not be less than $35.00N/m^2$.

Superstructure: this will be basically made of block work as infill and rendered with cement-sand mortar as well as the structural members. Windows will be made of louvre blades.

Roofing: the roofing material will be a deep trough industrial aluminium arched panels fixed with 10mm diameter aluminium alloy hook bolts.

Finishes:

Production floor – the floor will be finished with a cement-sand screed with medium sized aggregates to help reduce if not prevent minor accidents by way of slipping. The walls will be finished with a 25mm thick mortar with fine aggregates and painted with textured white vinyl matte emulsion paint to help in the light distribution.

Raw Material Storage and Warehouse will have the same material properties as the production floor. The workshop and the powerhouse will also be the same.

Welfare unit – the floor will be finished with 300 x 300mm non-slip ceramic tiles. The walls of the washrooms will be made of 200 x 200mm white smooth ceramic wall tiles whilst any other wall will be finished with a 25mm thick cement-sand mortar with fine aggregates and painted with smooth white vinyl matte emulsion paint. The ceiling for all the spaces will be 600 x 600mm chipboard panels.

Canteen – the kitchen floor will be finished with a washed terrazzo. The changing room at the kitchen will be made of 300 x 300mm non-slip ceramic tiles while the wall will be 200 x 200mm white smooth ceramic wall tiles. The walls at the kitchen will be finished with 200 x 200mm white smooth ceramic wall tiles 600mm above the worktops. The rest of the walls will be painted with textured beige vinyl matte emulsion paint. The washroom at the public area will have the same properties as the washrooms in the welfare unit.

The floor of the eating area will be finished with non-slip ceramic tiles whilst the walls will be painted with textured white vinyl matte emulsion paint. The ceiling will be made of 600 x 600mm chipboard panels. All spaces in the canteen unit will have the same ceiling type.

Administration block – the floor of the reception and waiting areas will be finished with a 450 x 450mm polished porcelain tiles whilst the walls will be made of a 300 x 300mm black Zimbabwean polished wall tiles. The washroom's floor will be made of a 300 x 300mm non-slip porcelain tiles while the wall will be made of 200 x 200mm white smooth ceramic wall tiles up to the base of the high level window.

The floor of all the office spaces will be made of a 300 x 300mm porcelain tiles and walls painted with textured beige vinyl matte emulsion paint. The CEO's office will have the floor finished with woolen carpet and the walls finished with textured white vinyl matte emulsion paint. The floor of the library, internet café and laboratory will be finished with timber parquet flooring whilst the walls will be painted with textured beige vinyl emulsion paint. The corridors will be finished with polished terrazzo.

The showroom will also be finished with timber parquet flooring and walls made of textured white vinyl emulsion paint. The conference and meeting have their floors woolen carpeted and walls painted with textured white vinyl emulsion paint. The ceiling for all the spaces will be made of chipboard panels.

5.7 Services

- ***Electricity***

Electricity is provided to the factory at 11000 Volts and this will be on 50Hz. A step down transformer will then step the voltage down to 415 Volts/50Hz on a four phase supply system to the production areas and 240Volts/50Hz for lighting and other light equipment. There is the need to have a good electrical network since the plant is required to operate on a 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 of for repairs and maintenance works to be carried out. Power distribution within the factory shall be concealed by either insulated cables drawn into pipe trunking or armoured underground cables. An automatic switch standby generator will be provided should there be power failure, to keep power supply continuous.

- **Telephone and Internet Network**

An efficient modern auto-direct exchange system shall be linked to the existing network to facilitate both national and international communication.

- ***Lighting***

Natural light will be the major source of light for the production areas as well as the administration and as such large window openings are provided in the external envelope of the structure. All other units are to depend on natural light. This will be supplemented by a small percentage of artificial lighting.

- ***Ventilation***

Natural ventilation was also considered in the size of window opening and the level at which it should be placed to provide good enough air flow through the structure to help workers feel comfortable working. The window positioning allow for cross ventilation.

The offices will be provided with air-conditioners to supplement the ventilation situation of these spaces.

- ***Fire***

Doors with the required fire rating will be provided for high-risk areas. Fire hydrants will be provided at vantage points not more than 30m apart around the various blocks. Fire extinguishers, water sprinklers, fire alarms, smoke detectors will all be provided at vantage points in the various blocks. The road network and accesses should be such that fire tenders can access every side of the factory.

- ***Water Supply***

The main water supply for the facility will be tapped from the Ghana Water Company Limited (GWCL) pipeline along the Odum road. The water will be distributed to the various points of need. Again rainwater will be harvested and transported to the water treatment plant to be treated and pumped back to the overhead tanks located at certain points on the site. This water will be used for flushing, washing, watering plants, feeding the boilers, and for other uses. Water from the river running on the site will also be tapped and treated to augment the rainwater collected and the one from GWCL. In the rainwater collection, pvc pipes (75mm – 100mm diameter) will be connected to the roof gutters to bring down water to the receptacles at the ground level to be further transported to the treatment plant for processing.

- ***Drainage***

Surface covered drains will be provided where appropriate. The covered drains are important to prevent flooding in the event of heavy downpour.

- ***Landscaping***

The purpose of the landscaping is 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 routes to give a pleasing appearance to workers and visitors alike. Grass with low maintenance requirements together with shady trees and shrubs shall be used extensively. Again, trees shall be carefully selected and positioned to serve as wind breaks, sound absorbers, etc as well as for general beautification of the factory. Plants to be used should not have vigorous roots.

- ***Sewage Disposal***

Soil waste is conveyed through waste pipes from the sanitary areas and sent to the septic tank which is to be emptied at regular intervals.

5.8 Cost Estimation

The Approximate Estimation Method was used in calculating the cost of the facility.

Estimated Cost

FACILITY	TOTAL AREA (m^2)	COST (m^2)	TOTAL AMOUNT (GH CEDIS)
Administration	762.62	450	350,505.46
Canteen	457.84	450	206,028.00
Welfare Unit	157.64	450	70,938.00
Maintenance	458.30	450	206,238.00
Production Block	5292.89	550	6,135,471.61
Ancillary	197.17	450	8,872.65
Total	**7326.46**	**2800**	**6,978,053.72**

5.9 Phasing

Looking at the size and cost of the project would be implemented in phases. With this in mind, a phasing proposal plan has been considered for the construction of the plant as and when funds are available. In lieu of this, the factory will be constructed in a period of three years. Phase one comprises of the production hall, warehouse, raw material storage, administration, welfare unit, powerhouse, boiler house, security posts. Phase two comprises of the maintenance unit, canteen, research unit and the showroom. Phase three consists of the water treatment plant, pavement along the Odum road leading to the entrance of the facility. Phase four (4) represents the future expansion proposal (furniture production, pellet/briquette production).

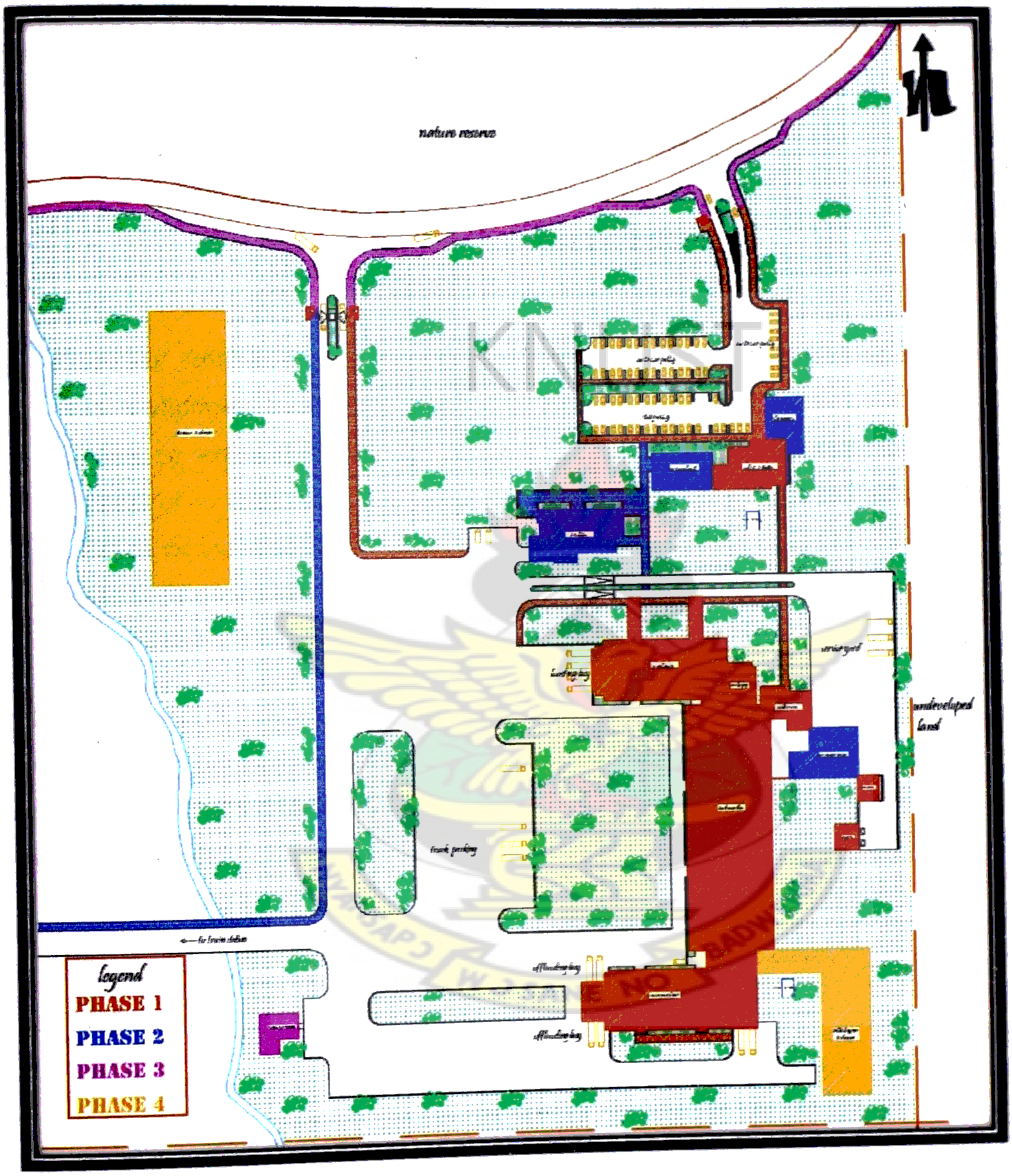


Fig. 45 Proposed Phasing Plan

5.10 Final Conclusion

Currently, the level of reusing the residue produced in the wood industry is very much insignificant as compared to the amount being generated per annum. As stated in the early chapters of this report, "waste becomes waste only when nothing can be recovered from it" and as such these residues generated are valuable resources that must be conserved and reused and not pollute the environment with it as has been happening all over the country especially the wood working industry at Anloga, Kumasi. These waste generated are being used extensively in the western world which is generating a lot of revenue for their economy. This thesis has been geared towards the following:

- Proposing possible ways of reusing waste generated by the woodworking industry in order to eliminate its hazardous effect on the environment and our lives.
- Coming up with a factory design proposal that will eventually eliminate the improper disposal of sawdust and other wood waste from sawmills without having an adverse effect on the environment.
- Coming up with a simple design which employs the necessary technology for carrying out the activity of processing the waste generated into saleable wood products.

It is hoped that this design proposal would contribute immensely towards the protection of the environment by absorbing the waste generated by the wood industry. Again, it is hoped that this design proposal will receive the necessary response from the appropriate quarters to rid the environment of waste.

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