SUGAR-CANE PROCESSING FACTORY, LAFIAGI
(Fire Safety and Control in Sugar Industries)

By:

SULAIMAN, A. D. T, (B. Sc. Hons.)

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DEDICATION

To the architectural profession and the Lafiagites in general.

DECLARATION

I, Sulaiman, A. D. T., declared that this thesis has been written by my person and it is a record of my research work. It has not been accepted in any previous application for a higher Degree. All quotations are distinguished by quotation marks and the sources of information are specifically acknowledged by means of references, notes and footnotes.

12/5/94

SULAIMAN, A. D. T.

CERTIFICATION

This thesis entitled SUGAR-CANE PROCESSING FACTORY, LAFIAGI, by SULAIMAN, A. D. T. meets the regulations governing the award of the Degree of Master of Science in Architecture of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

(Name and Signature) — Date 20.5.94.
Chairman, Supervisory Committee

(Name and Signature) — Date 12/05/94
Member, Supervisory Committee

(Name and Signature) — Date 12-5-94
Member, Supervisory Committee

(Name and Signature) — Date
Head of Department

(Name and Signature) — Date 31/3/95
Dean, Post Graduate School

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ABSTRACT

During the early ages, cane was taken as a mere garden plant, meant for family chewing. But later, there was development whereby cane can be refined into sugar crystals.

This was first done in Persia about A.D. 500, later the Arabian influence established the art of refining sugar in Egypt, and since then, there has been development of sugar industry world over.

The history of sugar industry in Nigeria has little in record owing to the fact that it has very short life span.

Sugar-cane which is the only source of sugar in Nigeria, was introduced to the country in the 19th century during the slave trade, and it was just in the early 20th century that sugar industry developed in the country.

Since then, there has been a number of cane plantations, which are more than the number/capacities of sugar factories in the country.

Meanwhile, the waste or the fibre from the cane (Bagasse) is used in the boiler house as fuel and the fire safety controls and design considerations are also looked into in details.

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CHAPTER ONE

1.0 INTRODUCTION

Growing or cultivation and consumption of cane has come a long way since early ages when it was taken as a mere garden plant for family chewing to the present time where so many sugar-cane plantations are found feeding the few sugar-cane processing factories in the country.

1.1 The Thesis

The text of this thesis shall cover the historical trend in the development of industrial architecture, the history of sugar-cane cultivation and the production process of the refined sugar. Hence, this thesis shall be divided into chapters to treat in details the planting, production and factory planning to suit the sugar industry, in addition to fire safety measures.

1.2 Motivation

The motivation of this thesis arises from the concern an Architect should have for this country, this topic was chosen in a bid to contribute in a little way in solving the enormous problems facing the sugar industry in Nigeria.

For instance, in Lafiagi where the project is proposed to be cited, there are very large cane plantations where over 40% of its annual project is normally wasted due to lack of cane processing factory near the plantation, and poor means of transporting the raw-materials to the nearby or the requiring sugar factories and the shortage of cane pr essing factories.

Thus, proper selection of site for the proposed factory is to take care of the annual wastage, transportation problem, to create employment opportunities for the elites of this country and the people of Lafiagi in particular and to reduce the quantity of sugar being imported into the country.

1.3 Aims

i. Improving the present conditions of sugar-cane processing factories.

ii. Reduce the quantity of sugar being imported to this country.

iii. To provide employment for the people of the area.

iv. To select a site near the source of raw-materials.

v. To solve the problem of transporting raw-materials and the finished products.

1.4 Objectives

The thesis shall seek to:

i. Use the capacity of the factory to minimize wastage.

ii. Separate heavy traffic (heavy trucks) from light ones (cars, bicycles and pedestrians).

iii. Identify the administrative capacity needed for effective accommodation and efficient service suitable for the factory workers.

iv. Plan the factory in such a way as to reduce considerably the rate of fire spread and ricks.

1.5 Scope

The scope of this thesis shall entail the provision of administrative core, production hall, ancillary facilities, storage facilities and maintenance area, effective road network, most especially the loading and the off-loading bays. Provision is also to be made for future expansion, measures to raw-material source and general orientation of the factory complex.

1.6 Methodology

Having established the problems, aims, objectives and scope of study, the next thing to do is to narrate how the study is to be conducted. The procedure, data collection techniques, statistical tools for analysis and interpretation of data used in this thesis do not deviate from normal practice of researches of this type.

The primary and secondary information is got from the following sources:

Field surveys, adaptation from past relevant write-ups, review of various books, oral interview, journals and magazines on sugar and sugar industries.

Quite a number of sugar-cane processing factories were visited to see, study and analyze their production process and problems associated with them.

1.7 Historical Trend in Development of Industrial Architecture

Origin of Industries could be traced to the beginning of Industrial revolution. This means that industries may be

said to have evolved when mechanical labour was substituted for manual labour at the inception of Industrial revolution.

In the change from machine tools to machines, machinery was used to produce great quantity of products quickly and cheaply. There are three generally agreed periods of Industrial revolution:

1750 - 1830

1830 - 1871

1871 - date.

The first period saw the beginning and development of machines. In the second period of Industrial revolution, mechanization was consolidated in many parts of Europe. From 1871 to date, industrialization has undergone a lot of changes from simple steam powered engines to atomic power plants.

Preceding the industrialization was the mechanilist period. In this period, commerce and trade were the most important. This period was characterized by growth of foreign markets, individuals becoming richer and this led to the establishment of large industrial concern which meant an end to the guild restrictions. Textiles, coal, iron and steel and steam engines were developed.

Factory designs were geared towards mass production. It should be noted that before this time, "Industries" were parts of the home: but with the advent of machine, the name became too small to accommodate the machines. This called for

specialized buildings to accommodate the machines. This marked the beginning of formal industrial architecture.

Peter Behrens (1868-1940) was one of the architects that developed a form of architectural thoughts that answered the demands of industrialized society. He designed and built turbine factory between 1908 and 1909 in Berlin. This became what some historians called the "Industrial temple." It served as an expression of monumentality to European architecture.

Walter Gropius and Adolf Meyer designed and built the Eagos factory in 1911. This building was a stepping stone in the steel and glass construction.

Simple task performance in industrial building, emerged. But the consequences of industrialization was many of which the following were the most important:

1. Emergence of the industrial class or the capitalist class.
2. Over production of goods.
3. Improvement in transportation and communication.
4. Rural-Urban migration.
5. Population explosion.
6. Emergence of class society:-

   consolidation of he bourgeoisie distinct social unit. The early industrial architecture was more oriented, because of brutal working conditions, child labour, no

proper ventilation, heating, sanitary facilities, health and comfort of the workers were not considered.

1.8 Citing of Industries

Before citing an industry, feasibility study has to be carried out. There are many factors which influence the location of industries:

1. Availability of raw materials.
2. Labour - whether skilled or unskilled.
3. Availability of ready market for the finished products.
4. Site location in relation to the city in terms of commuter services, prevailing winds, level of air pollution and water pollution.
5. Physical features - quality of soil, terrain, (flat, sloppy, steep), sewage and industrial waste disposal.
6. Technology, machinery, type and quality of production energy supply.
7. Shape of site.

1.8.1 Planning the Industry

It is necessary when planning an industry to zone the complex for minimization of construction expenses, maximization of profit and production output. The architect,therefore, has the obligation to meet the above requirements through good planning. Proper zoning and utilization of site should be done to be able to achieve this.

There are three main objects located in common areas:

a. Production, storage building and plants.

b. Energetic transportation and installation of all sorts.

c. Social, administrative and cultural building laboratories and service objects.

There are six different zones in the master plan of an industry:

1. Entrance - which depends on volume of traffic there are usually separate access for pedestrians and vehicles.
2. Transportation Zone - For vehicular off-loading and loading areas, parking areas, turning spaces are located in a place convenient enough to avoid congestion of traffic.
3. Production Area - Object concerned with the production and distribution of energy are placed close to the biggest energy devices and units and along transportation zone.
4. Ancillary Building - It is usually designed along with the main production hall because of their close relationship.
5. Storage - There should be divisional stores located close to the respective production halls and the main-store near the transportation zone.
6. Administrative Zone.

1.9 Architectural Contribution

Looking at the whole factory layout, and also from the site zoning which is based on rate of fire risk. The bagasse house, boiler house, and process hall are the most risky. The bagasse house is considered as one with highest fire risk as the bagasse which serves as fuel has a very high combustible rate with ignition temperature of 400-500oF1.

Owing to this fact, attempt has been made to reduce and to check fire spread from these areas. The bagasse house is constructed with steel stanchions as its superiority over other construction materials is not to be contested in this proposal, despite its poor fire-resisting properties. In trying to arrest this situation, that is, in trying to increase the fire resistance properties of steel, they are all protected with 2-layers of half inch Gypsum Board/membrane on the steel column surface thereby forming a deep air space around the walls, hence more time is required for the air space to heat up.

To further enhance fire resistivity of the entire structure, the walls of the bagasse house, boiler house and process hall are constructed of brick which are 8 inches (200mm) and hollow, possibly filled with perlite, hence provides up to four (4) hours fire resistance.

In addition to all these, chimneys which are also constructed of hollow bricks, are extended far enough above the building so that wind from any direction will not cause

any pressure against the upward exhaust flow of smoke and gases. Clearance for chimneys and vents that exhaust gases and smoke is fixed at 900mm (minimum).

NOTES

1. Egan, M. D. (1978) Concepts in Building Fire Safety Printed in U.S.A.

2. Group Report (1975), The Planning and Citing of Industries (unpublished), Department of Architecture, A.B.U., Zaria.

CHAPTER TWO

2.0 FEASIBILITY STUDIES

2.1 What is Sugar

Sugar is produced in the leaves of all known land plants by the process called photosynthesis - the capture of sunlight in combination of carbon dioxide (CO_2) and water (H_2O) in cells which contain chlorophyll. Oxygen (O_2) is given off in the process.

The same sugar that adds palatability to every meal is present in such familiar fruits as oranges, apple, grapes, bananas and pineapples, and in smaller amounts in vegetables.

However, since the sugar-cane and the sugar beet store sugar more abundantly than other plants, they have become the major sources of the world's supply.

The extraction and refining process merely separate non-sugars from the sugar made by nature in the plant. Whether obtained from sugar-cane, sugar beet, the date palm or the nectar of flowers, the substance is the one sugar sucrose.2

Refined sugar is one of the purest of known organic substances. It contains some 99.96 per cent of the sugar called sucrose by the chemists, to distinguish it from the related substances also known as sugar (e.g. maltose and lactose).

2.2 Source and Extent of Raw Material

Sugar-cane which is the major raw material of sugar factories, will be sourced locally, within Lafiagi

where the factory is to be cited and its environs as the number of size of sugar plantation in and around Lafiagi town will be enough to feed the industry at least for a long time to come.

The factory's sugar-cane needs will be supplied by the factory, plantation and the rest by the local farmers.

Hence, one can conclude that there will be no supply problems with subsequent expansion, as the plantation and local farmers will always increase their annual production.

2.3 History of Sugar in Nigeria

The Greeks and Romans knew the existence of sugar-cane and probably of crystallized sugar. "Derivatives of the sanskrit word Sakara3 survived in most existing languages, as in our word sugar." Neither the Bible, the Talmual, nor the Qur'an contains references to sugar or sugar-cane, although "honey" is common in all three of these religions authorities.

Sugar was introduced to Nigeria by the British colonialists, and was subsequently integrated by Nigerians. The use of sugar spread so fast that by 1955, Nigeria consumed 43,000 tonnes, all of which was imported.

This high and increasing demand for sugar prompted the Federal Government of Nigeria in 1956 to commission feasibility studies to identify areas suitable for commercial cultivation of sugar-cane and sugar production.

During the feasibility studies, Lafiagi, Shonga, Jebba all along the banks of River Niger, Isyin adjoining Ogun

River, Akure - Benin around Owena River, banks of River Kaduna on both sides of Zungeru/Bida road south of Wushishi and around Elele near Port-Harcourt were all identified as possible areas. Other areas were located after the initial studies, these areas are Numan in Taraba State and Mokwa in Niger State.

With the aid of these feasibility studies, it was then decided to develop the "Fadama" areas of the River Niger, thus, Bacita was selected as the sugar plantation and subsequently, sugar-cane processing factory.

In early 1958, the Federal Government established he "Nigeria sugar syndicate" to carry out detailed studies on sugar viability in Bacita, and as a follow up in 1961, the "Nigerian Sugar Company Limited" was incorporated. The country's first production of sugar was 4,900 tonnes in 1964/65 period, with an installed capacity of 40,000 of refined sugar per annum.

By 1992, about 5,600 hectares of sugar-cane have been planted and an average of 30,000 tons of sugar have been produced for the last twenty (20) years with production varying from a low figure of 16,400 tons in 1973/74 to a high of 35,084 in 1983/84.

After the establishment of the Bacita factory, and with the "Oil boom", demand for sugar grew so much that Bacita could not meet up, thus, new factories were then planned. Sugar factories were then proposed for Numan, Sunti, Lafiagi

and Hadejia. The Sunti and Lafiagi schemes, after years of starting, only have sugar-cane plantations later, the production of sugar-cane stared at Suni with the installation of the factory equipment, while that of Hadejia in Kano State is yet to take off.

All functioning sugar factories in Nigeria have a production process similar to that of Bacita, they all use mills for the extraction of juice from cane, as opposed to the new system of diffusion.

2.4 Planting, Growing and Harvesting of Sugar-Cane

Sugar-cane is a giant grass belonging to the genus saccharum. The so-called noble or native canes comprised all the cultivated crops throughout the tropical and semi-tropical regions of the globe, are one of species, S.officinarum.

Commercial sugar-cane is propagated by means of cuttings or whole stalks (seed cane), planted in furrows with a light covering of soil. Each bud is capable of producing a plant, and from each of these, several shoots or suckers grow, forming a clump or stool of canes.

In the tropics, short pieces containing two or three buds are planted, but in the sub-tropics, such as Louisiana, U.S.A., whole canes planted two abreast with a lap, as only about 25 per cent of the buds produce shoots after lying in the ground over the winter. See plate (2.1).

The ripening of cane depends on many factors, most important of which are the amount and distribution of the

rainfall. As the plant approaches maturity, the sucrose content of the stalks increased and the reducing sugars decreases. Maturity frequently evaluated from the sucrose or reducing sugars present in the standing cane which normally are between 2.5m - 3.5m high. See plate (2.2).

The length of the growing season before harvesting varies greatly, depending on the area. In some areas, climatic conditions require that cutting begin after 7 or 8 months growth while in other areas, an average of 10 to 12 months.

New plants, called ratoons, spring up from the stubble after the cane is harvested, producing a second crop, which in turn may give a third and fourth crop and so on. See page (2.3).

Hand Cutting

Hand cutting of cane is still the commonest mode of harvesting even in those countries where mechanization has advanced in other phases of field work. The stalks are cut to the ground with knives of the machete type, and topped just above the highest coloured joint. The leaves are also removed at the same time or before the stalk is cut by burning which is the commonest in Nigeria. See page (2.4). After cutting, they are then tied in small quantities before parking them into carts. See plates (2.5), (2.6) and (2.7).



Plate (2.2) 9 Months Old Sugar-Cane



Plate (2.3) 3 Weeks Old Sugar-Cane (Ratoons)



Plate (2.4) Burnt Sugar-Cane Ready for Manual Cutting/Harvesting

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Plate (2.5) Cut Pieces of Cane Arranged on Ridges

Hand-cut cane is much cleaner than that delivered by any type of machine harvesting yet devised, but increasing labour cost have intensified the search for suitable harvesting equipment.

Machinery Harvesting

Harvesting machines have been used for more than 40 years, and the entire crops in these areas are cut by machine.

One of the earliest cane harvesters to be introduced was the thompson. See plate (2.8). The most recent model, mounted on a crawler tractor, cuts on raw of cane at a time.

After the harvesting have been done, cane loaders are then used to load canes into the carts as opposed to the manual method. See plate (2.9)

2.5 Economic Importance and Rural Utilization

Nigeria has the potentials to produce enough sugar to meet her local demand and even export some of it, if only the potentials are fully tapped and developed. If this is achieved, Nigeria would have save herself a lot of foreign exchange, and can even earn some by exporting sugar to the neighbouring countries.

With exportation of sugar by Nigeria, she can use it as a political weapon, just like America is using crops like wheat. Also, if the sugar industry is fully developed, it will provide direct employment to a lot of people.



PLATE (2.6) Tied and Assembled Pieces of Cane Ready for Loading



PLATE (2.7) Loading the Cane Into Carts

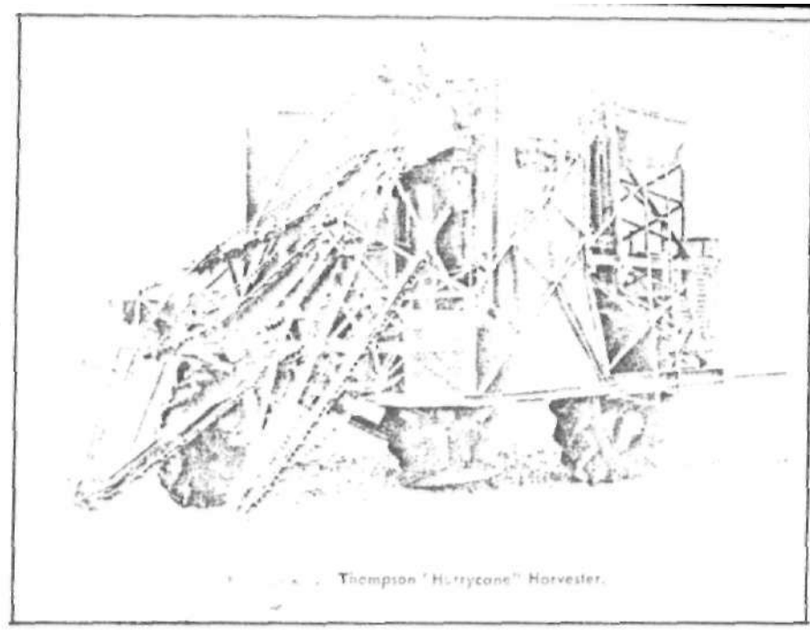


Plate (2.8) Thompson Harvesting Machine



Plate (2.9) Cane Loader

The Nigerian Sugar Company, Bacita presently provides employment for 3,000 permanent staff and 2,500 seasonal workers and over 50,000 Nigerians derive their livelihood from the company.4 Exportation of sugar will help in reducing Nigeria's over-dependence on oil as major source of revenue and thus helping to diversify the Nigerian economy.

Furthermore, an industry like the sugar industry is best cited near a good source of sugar-cane to reduce production costs, and this is usually in rural areas. Although it is almost invariably important to site sugar factories in rural areas, the Nigerian Government is trying to encourage rural industrialization by providing basic infrastructures like water, access roads and electricity in these areas, and also by its rural banking policies and tax reliefs for industries set up in these places.

Rural industrialization was evolved to help develop rural areas, reduces rural-urban migration and improving standards of living in rural areas. Advantages of rural industrialization are:

i. Provision of employment to the unemployed, thus improving their economic and social well being and to arrest rural-urban migration.

ii. Stimulate growth of service industries like increasing activities in the area of its location.

iii. Citing industries in rural areas will attract a very cheap labour and also easier to acquire land as compared to urban centres.

iv. Provision of clinics, roads, water, electricity and other amenities provided by the industry will go a long way to alleviate problems of rural inhabitant.

2.6 Demand and Pricing of Sugar

Nigeria and indeed the world over has a high demand for sugar in homes, offices and industries. Nigeria's sugar demand for 1988 was 800,000 tonnes and it is expected to increase to about 8.4 million tonnes in about 20 years. Unfortunately, Nigeria's total production of sugar from Bacita and Numan leaves an annual fall of over 95%. If all planned factories were to be active, in addition to existing ones, they will only meet about 10% of Nigeria's sugar demand.

The projected increase in demand from the present 6.5 kilograms per head to 50 kilograms per head is due to the projected increase of sugar usage in breweries, soft drinks, food canning, pharmaceuticals, bakeries, confectioneries and animal feed factories, this will further increase the price of sugar which has been improving on the average over the past year. Sugar was sold in the 1983/84 period for N553 per tonne, and by 1987/88 it was N1,375, which is a good price gain over a period of four years.

2.7 Production Capacity

The factory is expected to plant about 5,000 hectares of sugar-cane plantation and to produce about 30,000 tonnes of refined sugar annually, thus, the plantation will need to produce 300,000 tonnes of sugar-cane annually.

2.8 Major Inputs

Sugar-cane or sugar beet is the main input into sugar factories, but in this case, it is sugar-cane.

Bagasse (the residue obtained from crushing cane) is used as fuel for boiler in most cases, but other fuels like electricity can be used, only they are not as economical as bagasse.

Chemicals are used mainly during the process of clarification in these factories. The type of chemicals used depends on the clarification process employed, but the main ones used are lime CaO; sulphoric acid, H2So4 and carbon, C.

2.9 Market

Looking at the demand for sugar in Nigeria, only about 10% of the demand is met by the existing factories, which leaves about 90% of demand to be met by importation. But this figure can be reduced by increasing the local production with new factories, who are assured of a good local market and even Africa in general. See table (2.1) and (2.2) below.

Table 2.1

Nigeria's Sugar Market

Year	Local Production	Total Consumption	Importation	% Production on Consumption
1980	32.2	750.0	706.6	4.3
1981	43.2	900.0	864.3	3.8
1982	35.7	950.0	910.9	3.8
1983	39.1	900.0	883.6	4.3
1984	16.4	550.0	509.0	2.3
1985	44.0	600.0	542.0	6.8
1986	58.0	650.0	566.0	8.9
1987	84.0	829.5	745.5	10.0

SOURCE: Data compiled from International Sugar Organization, Savanah Sugar Company and Tate and Lyle (Nig.) Limited.

NOTE: All figures in thousands metric tonnes 1984 production affected by draught.

Table 2.2

Sugar Consumption in Selected African Countries in 1986

Country	Consumption (Thousand Tonnes)
Algeria	575.0
Cote D'Ivoire	125.0
Egypt	1,650.0
Ethiopia	159.0
Ghana	55.0
Kenya	420.0

Libya	190.0
Nigeria	650.0
Morocco	725.1
Senegal	70.9

SOURCE: International Sugar Organization. From Tables 1 and 2, it can be seen that there is a viable market for sugar.

2.10 By-Products of Sugar-Cane and Uses

2.10.1 Bagasse - Bagasse, the fibrous residue of the cane stalk after crushing and extraction of the juice, consists of water, fibres and relatively small quantities of soluble solids. In most factories, bagasse is used as fuel for boilers, but it can also be used for the manufacture of fibre board, paper and manure by ploughing it into cane fields.

2.10.2 Producer Gas - Bischof of Magdeburg, in Germany, is credited with having built the first gas producer in 1839.5 Producer gas is made by burning fuel to ash by means of a mixture of air and steam, the resulting gas being a mixture of burnt and combustible gases. Coke or coal are the fuel generally used, but soft fuels like wood, saw dust or bagasse have been successfully used in various countries.

2.10.3 Fibrous Products - The following are some of the fibrous products from bagasse:

i. Pulp and Paper - The first patent taken for the production of paper from bagasse dates back to 1838 and was issued to Berry.6 It was also reported that

in 1844, bagasse was slipped to France for paper manufacture. From then on and especially after 1850, fairly frequent references can be found to bagasse as a paper-making material.

ii. Paper Board and Corrugated Board - The principal sources of corrugating board are hardwood pulps and straw pulps. Bagasse, in all essential respects, is a highly suitable material for the manufacture of corrugating board. Its fibre structure and high content give it an inherent advantage of rigidity, obviously a very important property for boxes and for the fluting of corrugated card-board.

iii. Fibre Board - Fibre board is a board generic term which encompasses sheet materials of widely varying densities manufactured from refined or partially refined wood fibres or other vegetable fibres. Bonding agents or other materials may be incorporated in the manufacture of these boards to increase strength, resistance to moisture, fire or decay, or to improve some other property.

iv. Hard-Board - The manufacture of hard-board from bagasse follows very closely that of insulation board up to the point where the wet sheet leaves the board machine. However, the pulp should have a faster draining rate than that for insulation board

and the refining should be more of the following agents: heat, pressure; humidity and catalyst.

2.10.4 Direct Utilization of Molasses

Molasses: When a massecuite is spun in a centrifugal machine, the sugar crystals are separated from the mother liquor termed "molasses." The final molasses is the liquid residue from which no more sugar can be removed.

The world production of molasses (cane and beet) had reached the value of 20,306,863 metric tons7 in 1967-68 and the import and export trade in molasses is important from the point of view of both tonnage and value.

The practice of applying molasses to cane soil as a fertilizer dates back to about 1850 and has been the subject of heated discussions, especially since the beginning of the 20th century.

Towards the end of the 19th century, in many tropical countries producing cane sugar, the slow replacement of animal by mechanical transport was taking place and there came a time when farmyard manure was decreasing and in organic fertilizers were not yet available, hence it was natural to think in terms of an organic fertilizer, that is, molasses, which was often but a cumbersome surplus on those sugar estates where the production of rum was limited.

As more and more became known about the rational utilization of in-organic fertilizers, the use of molasses in the cane fields decreased and would have probably disappeared

had it not been for the firmly rooted belief that organic matter per se has a definite value of molasses as improving crop yields.

Furthermore, the value of molasses as feed for livestock has been known since sugar was first manufactured. The most important characteristics of cane molasses as feed is its richness in carbohydrates, which occur mainly in the form of sugars. It also provides small amount of protein and a certain amount of non-sugars which have some nutrient value especially for ruminants.

NOTES

1. Contributed by Dr. John L. Hickson,
   Sugar Research Foundation, Inc. New York.

2. "Sugar as Food", N. Y. 2nd Ed., 1959, p. 10.

3. Bortha, I: Shakara, Pp. 7 (1965)

4. Fact sheet on the Nigerian Sugar Company Limited, Bacita.

5. Producer gas, publication No. 4, Arrow Press Limited,
   Watford, Herts, U.K. (1949)

6. Raw-Materials for more paper: Pulping process and
   procedures recommended for testing, FAO Forestry and
   Forest products studies, No. 16, FAO, Rome (1953).

7. By-products of Cane Industry by J. Maurice Paturau,
   Pp.137 (1969).

CHAPTER THREE

3.0 INTRODUCTION TO FIRE SAFETY DESIGN

Today, an increase in the responsibility of the designer for the fire safety of the occupants of a building is being experienced. There is a growing awareness that fire safety should be integrated with the initial design taking advantage of flexibility rather than recommendations applied at the end of a design process at the risk of distorting or disrupting the designer's original intention.

This should give the profession the opportunity to have a sound knowledge in fire safety and prevention measures thereby reducing the risk and possibility of fire outbreaks, ensuring the rapid evacuation of a building's occupants, and the eventual control of such a fire. Heat gains from lighting, machinery and process activities are of major significance. Special care must be taken in the design of such industries that are involved in the production, storage or usage of high flammable materials and toxic gases.

Fire control is a very important part of factory design. It influences the location of buildings on the site,process layouts, the choice of materials and the detailing of building elements. The architect's role is to ensure that the design of the factory conforms with the statutory requirement of saving life and with those of the insurers, i.e. to minimize losses. Fires are largely a result of carelessness and a lack of knowledge of the risks by the factory user. The designer

can help to minimize these risks by identifying potential hazards and making provisions accordingly.

3.1 Characteristics of Fire

Fire is the rapid oxidation of combustible material producing heat and light. In an accidental fire in a factory; this could result in extensive damage. There are three elements of fire viz: combustible material or fuel, and heat and oxygen. In the absence of any of one of these elements, a fire cannot occur. Hence,the prevention of fire is governed by the exclusion of any one of these elements from the presence of the other two.

The goals of fire safety design include:

i. Preventive design.

ii. Rapid detection and accurate location of a fire.

iii. Fast, safe and unhindered escape of the personnel which includes containing the fire, local extinguishing, smoke venting and preventing the collapse of the building.

Virtually none of the industries is safe from occupational fire hazards. It is worthwhile therefore to take all possible precautions with fire safety systems, even if the building is considered expendable by the owner. Fires have three main cases:

i. Natural Origin

ii. Accidental Origin

iii. Incendiary Origin.

Natural fire could be as a result of the action of lightening, hence the need to instal a lightening conductor to prevent fire, from static electricity or from concentration of the rays of the sun on very combustible material. Accidental fires are those caused by error, possibly by overheating of equipment and explosion, during the course of work. On the other hand, incendiary fires are those created with deliberate intent. These are acts of sabotage or arson by deviant persons.

3.2 Fire Prevention Design Consideration

3.2.1 Site Planning as a Control Tool - Generally, there are four characteristics of successful planning:

i. The promotion of accessibility. In this case, the accessibility fire fighting trucks and aid to and from location of the fire.

ii. The employment of resources as economically as possible.

iii. The separation of compatible land uses from each other association of compatible or mutually helpful uses.

iv. The carrying out of all development in as visually pleasing a manner as possible.

Of these characteristics, that which is of considerable concern to the fire conscious designer is the separating of incompatible land uses. In design, wind direction should be considered when locating fire risk functions within the site.

Such functions should be placed at the leeward side of the site so that eventual fires are not blown over towards the rest of the complex by the prevailing winds.

In addition, there should be the provision of access roads for fire fighting appliances which should provide room for the effective manouvre of fire fighting appliances during emergency situations. Spatial separation of buildings is another important factor in effective site planning which reduces the dangerous effect of fire propagation by radiation and provides sufficient allowance for fire fighting operations at proper angles of inclination. However, this spatial separation is not directly proportional to the heights of adjacent buildings since it would be improper to provide undue spaces between adjacent buildings in the complex.

3.2.2 Structural Materials and Fire Resistance - In the early days of the industrial revolution, factories and warehouses were constructed with timber floors and roof. Incessant fires occurred because the predominant sources of light and heat were oil lamps and open fires. The most devastating of such fires was that which occurred in the month of October, 1871 in Chicago. Subsequent reconstruction commenced, this time with a great emphasis on genuine fire proof construction.

With the introduction of the steel truss, it was thought that damage to building by fires would be greatly lessened. It turned out that steel roofs collapsed quickly as timber

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under fire. Finally, it was discovered that when a roof steel truss is protected by concrete, the risk of structural collapse was greatly reduced. This introduced the concept of structural fire protection, which involves a design process which ensures that building elements such as walls, columns, beams, floors and roofs are designed with specific materials or combination of materials which meet minimum fire endurance ratings.

Structural steel members can be fire-protected with membrane enclosures, for example, Mineral wool, gypsum board, spray-on materials like gypsum plaster and mineral wool fibres, magnesium oxychloride, inorganic coating sand concrete or brick encasements.

Poke through penetrations in floor slabs can be an unwanted path for the vertical spread of fire and smoke. These may be protected by packing the opening with mineral wool fibres or silicone elastomer foams, metal frame units, or fire-resistant adhesive tapes which are vinyl coated.

3.2.3 Ignition Sources - Potential ignition sources include smouldering combustion and flames for example, cigarettes and matches, hot surfaces, mechanical sparks, electrical sparks and electrostatic discharges. Operations that give rise to any of these must be strictly controlled in hazardous areas. Examples include welding and cutting, the use of electrical equipment, generation of static electricity and the presence of hot surfaces.

3.2.4 Segregation - Segregation places electrical fittings and apparatus outside the hazard areas and allows cables and ducts to be passed through air-tight seals. Segregation has the major advantage of allowing equipment to be handled and operated outside hazard zones, thereby reducing the risk of accidental ignition. Places may also be segregated because of their health hazards, for example, fume chambers where toxic gases are prepared.

3.2.5 Flammable Atmosphere - These are those in which a flammable gas, vapour, mist or spray or an explosible dust or fuel is mixed intimately with air within the limits of flammability. The act of ignition causes the flame to propagate spherically through the flammable atmosphere consuming the fuel and converting it into combustible products at high temperatures. If the gas is enclosed within a building structure, the increase in temperature is accompanied by a substantial increase in pressure which theoretically can measure up to 700 KN/M2, known as an explosion. No building can withstand such pressures from but careful planning and design can prevent such pressures from developing.

Sparks from electrostatic discharges or mechanical contact are high temperature particles produced by friction or impact and have sufficient energy to ignite a flammable atmosphere.

3.2.6 Explosion Control - Explosion relief ventilation allows explosion forces to be dissipated to the outside air

rather than being contained in the building, thus reducing damage in and around it. Such ventilation in a building is effected by creating large openings in the building envelope using weak or weakly fastened cladding which will be blown off at an early stage in the explosion, and thereby allowing excess pressure, flame and unburnt material; to escape into outside air. Preferably, the entire building envelope should be designated for use as explosion relief ventilators. The suppression of an explosion depends largely upon the very rapid release of chemicals into the propagating flame at a very early state of the explosion.

The subject of structural design in areas product to explosion is very complex and will normally require the services of structural consultants.

3.2.7 Ventilation - Efficient ventilation of hazard zones to remove inflammable gases and vapours in the atmosphere is an essential part of explosion prevention. Simple cross ventilation may be sufficient in low risk areas.

Heat ventilators, mechanically operated and located on the roof of the building, may be utilized in the presence of flammable materials which are lighter than air to increase ventilation rates. Where gases and vapours are considerably heavier than air, additional ventilation outlets should be mounted at low level to ensure that the air at that level is changed frequently.

A Laminar flow system is the ideal, whereby supply and extract grilles are equal to the cross-sectional area of the room to be ventilated.

3.4 Fire and Hazard Detection

In the event of a fire, early detection and alarm warnings are essential to prevent loss of life or harm of building occupants. If the time needed to detect fire ignition and warn the building occupants is reduced, a corresponding vital margin of safety for evacuation can be provided. An integrated alarm and defence system allows the fire to be contained before the arrival of the fire fighting authorities. Detection systems operate on one or more of the characteristics of smoke, heat and flame. Criteria for selection of detector system are:

i. The nature of the risks; flammable solids or liquids.

ii. The fire characteristics; clean burning like alcohol or smoky like plastics.

iii. Speed of fire growth.

iv. Potential loss.

Total reliance on an automatic alarm system is not acceptable. Alarm systems must also be fitted with manual controls.

The presence of flammable gases, mist or vapour or dust in the atmosphere may be identified by detectors. These work either on light dispersal and obscuration or on air sampling.

Detectors can be employed to produce audible or visible warnings, to shut down equipment which may present a hazard during emergencies (for example, to shut of electrical mains) and to activate emergency explosion prevention systems. Detectors are pre-set to operate below the lower level at which ignition might take place.

Areas that should be protected by smoke detectors include every part of the building. Detectors should be located mostly on ceilings or upper wall surfaces and in such a way as to consider the room air flow patterns from mechanical air distribution systems.

3.5 Fire Suppression Considerations

3.5.1 Fire Escape Routes - Rapid and safe evacuation depends on early warning of an outbreak of fire and the provision of clearly indicated escape routes. As a general rule, the following three conditions must be satisfied before escape route can be considered as adequate:

i. No occupant should need to go towards the fire in a bid to escape from same.

ii. All escape routes should be as short as possible, of adequate capacity and should lead to open air at ground level either directly or by way of a fire-resisting enclosure.

iii. Protected parts of the escape routes should not be exposed at any point to penetration by smoke or fire.

Under ideal situations, at least two escape routes leading in opposite directions should be available to every occupant. Escape corridors, stairways and exits should be sufficient in width and number to permit all the occupants of a building to leave quickly and without confusion in a maximum of about 4 minutes. Where space is restricted, ladders and spiral stairs may be provided as external means of escape for a limited number of able bodied people.

Fire drill notices or fire procedures should be displayed prominently all over an industrial complex, but no one is likely to pause to read this under the panic situation of a fire occurrence. Hence, factory workers should be adequately drilled on evacuation and suppression actions in the event of a fire.

3.5.2 Fire Control and Suppression - Eventual fires may be controlled either manually or by automatic suppression systems. Automatic fire fighting systems should be protected from the effects of pressure, projectiles and falling debris during an explosion. Water sprinklers are the most commonly used automatic suppression systems in industrial complexes. Sprinkler heads are activated at 68oC.

Supply pipelines should not be fitted to light weight overhead steel work as these often fail during an explosion and may fracture supply piping. Heavy gauge piping fixed to structural members will reduce the occurrence of damage and where possible, piping should be mounted behind heavy

structural members relative to the direction of any expected blast.

Portable equipment should also be provided so that small fires can be extinguished before the sprinkler system is activated. Hose reels provide excellent protection and the water should be automatically turned on when the house is extended. The maximum length of a house is 36.6m and no part of the floor should be more than 6m from the end of the nozzle. Portable extinguisher are required for every industrial property as a first measure.

3.5.3 Fire Points - These are groupings of fire-fighting equipment and should include an alarm, house reel, water extinguisher, special purpose extinguisher, fire bucket and a fire blanket. Where employed, they should not be more than 30m apart.

3.5.4 Hydrants - These are suitable for premises which are remotely located, so long as all parts of the building are within 60m of the hydrant.

3.5.5 Water Supply - Water supply for sprinkler systems must be automatic and have reliable flow and pressure. Such a supply must not be used for any other purpose and the capacity of such a storage should be calculated by the mechanical services consultant. Sprinkler heads may be concealed in suspended ceilings and are also available in decorative colours for use where the aesthetic quality of the final design is of paramount importance.

Water sprays also exists as extinguishing systems but the risk of electrical shock and damage to sensitive equipment weigh against it for specific uses. Petroleum products for example being lighter than water may simply become displaced and overflow to spread the fire. Other systems include foam systems, dry powder systems, carbon-dioxide and halo gas systems.

3.5.6 Smoke Control - When fire occurs, the attendant smoke presents what may sometimes be a greater hazard to life than the fire itself. Escape areas are best designed as smoke free zones and traditional methods for controlling the spread of fire and smoke in buildings have relied on the strategic use of fire resisting doors and partitions. While this is generally a successful preventive means, this method does not necessarily prevent the movement of smoke and toxic gases which are a prime threat to life.

3.6 Fire Precautions

Typical Example of Arrangements for Factories and Offices

Assessment - Because of the widely differing processes, substances and types of premises encountered in factories, the risk in the event of fire will vary drastically from one situation to another. In order to apply appropriate precautions, a building is placed into one of three categories or risk - "high", "normal" or "low" - depending upon the activities involved and the construction of the building.

i. Means of Escape:

The distance of travel for means of escape is the actual distance that has to be travelled between any point in a building and the nearest:

- final exit; or
- door to a stairway which is protected route; or
- a door in a compartment wall.

In workrooms with only one direction of escape, the permitted distance of travel within the workroom varies from 6m in high risk areas to 25m in low risk areas. For normal risk areas and offices, the distance is 12m. (See 'A' in table below).

Where escape from the workroom is possible in more than one direction, the permissible travel distance in factory workrooms are 12m, 25m and 35m for 'high', 'normal' and 'low' risk areas respectively. (See 'B' in table below).

The total permissible distance of travel to a place of safety varies from 12m in high risk areas with only one direction of escape to 60m in low risk areas with escape possible in more than one direction. (See table below).

Table 3.1 (a) and (b)

	Category of Risk	Distance of Travel Within Workroom	Total Distance of Travel
A.	Escape in one Direction Only	(M)	(M)
	Factories: High	6m	12m
	Normal	12m	25m
	Low	25m	45m
	Offices	12m	18m
B.	Escape in More Than one Direction	(M)	(M)
	Factories: High	12m	25m
	Normal	25m	45m
	Low	35m	60m
	Offices		45m

ii. Number, Width and Positioning of Room Exits

More than one exit from a room will be required if it is occupied by more than 60 persons or if the distance to be travelled from any point to the exit is more than the permitted distance of travel.

In factories, a wicket door in a larger door or a shutter is only satisfactory as a means of escape for 2 or 3 persons from a high risk area or 10 to 15 persons from normal or low risk areas and provided that certain dimensional criteria are satisfied.

The width of an exit should normally not be less than 750mm and where more than one exit is necessary, the total

width of all exits is determined by the number of persons likely to use them.

The contents of a room should be so arranged that adequate gangways and passageways are available.

iii. Corridors

The walls and partitions forming dead-end corridors and the doors into the corridor should be fire resisting. A main corridor should be at least 1m wide.

In office premises, corridors exceeding 45m in length should be sub-divided by fire resisting doors into lengths not exceeding 45m. In factories, this length is reduced to 30m.

iv. Stairways

In multi-storey buildings, there should, in general, be more than one independent stairway providing alternative means of escape from the upper floors. However, a single stairway maybe acceptable in certain limited cases.

In most cases, stairways must be separated from the remainder of the building by fire resisting construction and by fire resisting doors and escape routes must be so designed that a person does not need to pass through a stairway enclosure to reach an alternative escape route. A stairway should be at least 800mm wide.

Generally, a basement needs at least two stairways or other escape routes to safe places at ground level and where a stairway serving upper floors continues down to a basement,

fire resisting doors should be fitted at basement and ground floor level.

The following are NOT acceptable as means of escape:

- escalators;
- ramps steeper than 1 in 10;
- lifts and hoists;
- wall and floor hatches.

In special circumstances, lowering lines, portable and throw out type ladders may be used where only one person is involved; fixed ladders are only suitable for not more than 10 persons descending 9m or less. Escape routes should not normally be upwards.

v. Doors

A door used for means of escape should open in the direction of escape. Sliding doors may be acceptable in certain limited situations but not where the public is involved. Revolving doors are not acceptable.

All fire resisting doors should be fitted with positive action self-closing devices. Where it is necessary to hold these doors open, it must be by means of automatic fail-safe devices provided with a manual override.

In factories, loading doors, goods doors, shutters, up-and-over doors and windows are not generally acceptable for means of escape.

Door used for means of escape should be capable of being easily opened from the inside at all times when persons are in the building. They must be clearly labelled and kept clear.

vi. Exit and Directional Signs

Escape routes should be clearly sign posted including direction indication where necessary. Where the natural lighting is poor, the signs should be illuminated.

vii. Emergency Lighting

Emergency lighting to BS5266 Part I: 1975 should be provided where natural lighting is insufficient.

Fire Alarm System - In any factory or office building requiring a Fire Certificate, there must be an effective fire alarm system. The audible and any visual alarm signals should be distinctive and perceptible throughout the building. It must be properly maintained.

Electrical fire alarm systems should be of the release button type and so situated that no person need travel more than 30m to raise the alarm, and should conform with British Standard Code of Practice CP 1019: 1972.

Fire Fighting Equipment - All premises should be provided with appropriate means for fighting fire for use by persons in the building. Equipment should be placed in conspicuous positions, kept clear at all times and regularly serviced and maintained. The two types of fires in general that are most likely to occur are:

Class A Fires: Involving solid materials which burn with the formation of glowing embers, when water is the most effective extinguishing agent; and

Class B Fires: Involving flammable liquids when suitable extinguishing agents are foam, carbon dioxide, halon or powder.

The Home Office guides should be referred to for recommended minimum quantities of extinguishing materials.

Fire Instructions and Drills - All persons employed in buildings which require a Fire Certificate must RECEIVE INSTRUCTION AND TRAINING, PREFERABLY AT LEAST TWICE A YEAR, on their responsibilities and the actin they must take in the event of afire.

All employees should be aware of the location of fire fighting equipment and escape routes. Records should be made of all training and instructions given and a practice fire drill should be held at least once a year.

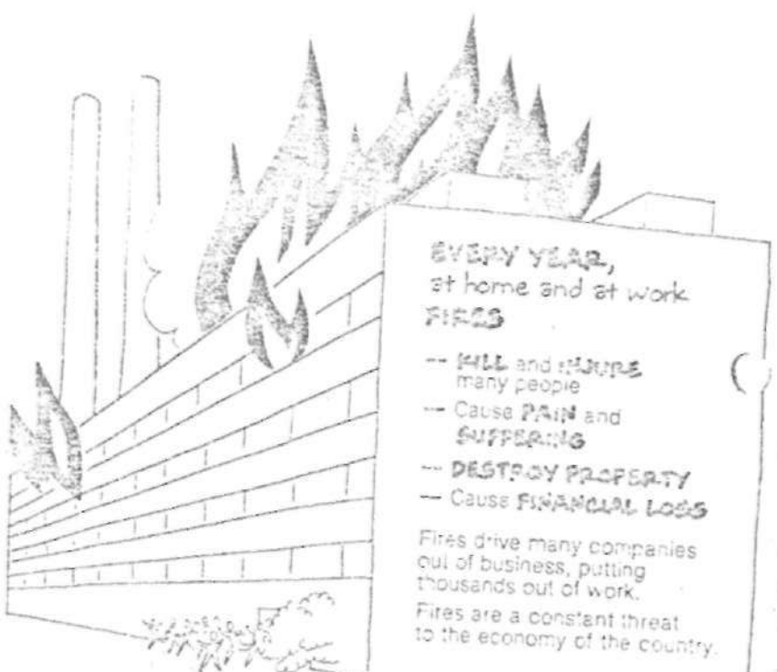
Fire Instruction Notices - At conspicuous positions in all parts of the building, printed notices should be posted stating, in precise terms, the essentials of the action to be taken upon discovering a fire or on hearing the alarm.

Disabled Persons - Special precaution and consideration must be given at all times to the problem of disabled persons.

A FIRE AT WORK

can send
- --your JOB
- --your INCOME
- --your HEALTH
- --even your LIFE

UP IN SMOKE!



EVERY YEAR,
at home and at work
FIRES

- -- KILL and INJURE many people
- -- Cause PAIN and SUFFERING
- -- DESTROY PROPERTY
- -- Cause FINANCIAL LOSS

Fires drive many companies out of business, putting thousands out of work.

Fires are a constant threat to the economy of the country.

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And yet...

ALMOST EVERY FIRE CAN BE PREVENTED!



MOST INDUSTRIAL FIRES ARE CAUSED BY--



- poor judgment
- human error
- ignorance
- failure to follow instructions.

That's why
FIRE PREVENTION IS YOUR JOB



Learn what you can do to help make your workplace **FIRESAFE.**

What CAUSES fires?

Most fires are caused by--



PEOPLE fail to guard against these COMMON HAZARDS

OPEN FLAME

Burners, dryers, incinerators, etc., not properly located or protected.



ELECTRICAL EQUIPMENT

Motors, switches, lights, wiring that overheat, short out.



FLAMMABLE LIQUIDS and CHEMICALS

Petrol, ethers, alcohol, sodium, potassium, etc. can be ignited by the smallest spark or static electricity.



SPONTANEOUS IGNITION

Slow build up of heat in piles of rags, dump waste.



FRICTION

Objects or materials rubbing against each other, for example, in poorly lubricated bearings.



SMOKING

Careless disposal of ashes, cigarette ends, matches.



HOT SURFACES

Combustibles placed too close to furnaces, flues, pipes, soldering irons, etc.



PORTABLE HEATERS

Gas furnaces, stoves, etc., too close to combustibles, poorly vented; left on by mistake.



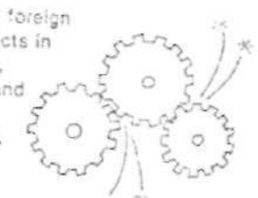
WELDING and CUTTING

without proper safety precautions. Should be done in a separate room if possible.



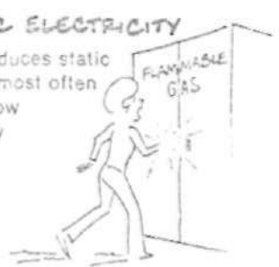
MECHANICAL SPARKS

Caused by foreign metal objects in machinery, dropping and bumping machinery.



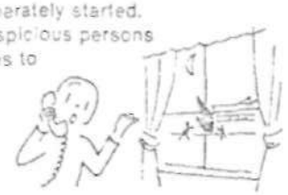
STATIC ELECTRICITY

that produces static sparks, most often in dry, low humidity areas.



ARSON

Fires deliberately started. Report suspicious persons or activities to security personnel promptly.



PREVENT FIRES BEFORE THEY START



-- by being SAFETY CONSCIOUS at all times!

FOLLOW INSTRUCTIONS

Perform your job as it should be done. Know and follow all required safety procedures; stay clear of prohibited areas. Don't cut corners.



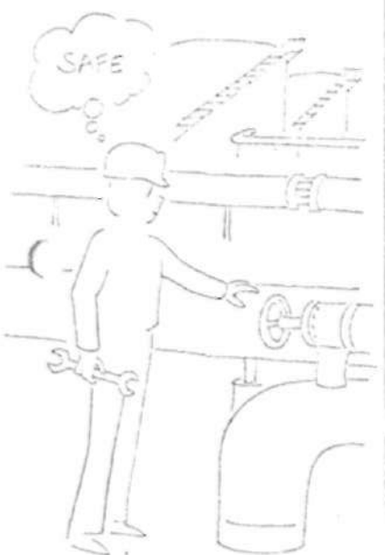
INSPECT EQUIPMENT

The EQUIPMENT and MACHINERY you use should be inspected regularly and thoroughly. All FIRE-FIGHTING EQUIPMENT should be checked regularly to be sure it's in top operating shape.



WORK SAFELY

Be aware of your work area. Always keep it tidy. Know what materials around you could ignite accidentally. Wear proper clothing and keep it clean. Handle and store dangerous materials with extreme care.



USE FLAMMABLES CAREFULLY

Handle them with extreme care. Use approved storage containers, properly earthed. Transport flammables carefully; avoid spills and drips; follow all accepted disposal procedures.



Report hazards

that you find at work.



Report

all unsafe conditions, such as dirty machinery, frayed wires, overloaded circuits, poor connections, spills, unprotected flammables, lack of firefighting equipment, poor ventilation, lack of ashtrays, unattended flames, clogged flues, pipes, messy rubbish areas.



Remedy

the dangerous situation yourself if it's something you've qualified to handle. Fix and clean machinery. Don't let it overheat. Move combustibles away from flames, hot surfaces. Repair leaking flammables, pipes, gas lines.



Make good housekeeping part of your daily routine.



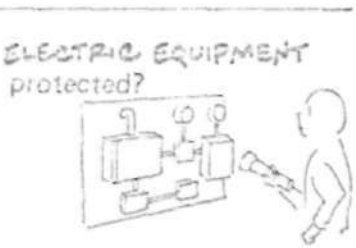












KNOW WHAT TO DO IN CASE OF FIRE!



- DON'T PANIC
- KEEP CALM!

❶ SOUND ALARM

Learn the location of nearest Fire Alarm Point. Follow instructions for raising the alarm.



❷ EVACUATE PEOPLE

Follow instructions for your building. Know evacuation procedures, primary and alternate escape routes.



KNOW YOUR FIRE DRILL.

3 BASIC INGREDIENTS of a fire ...take one away and FIRE STOPS!

AIR + HEAT + FUEL = FIRE!

(Cover - fire SMOTHERS)

(Drench with water -- fire COOLS)

(Shut off gas -- fire DIES OUT)

How to FIGHT small fires

Aim extinguisher or hose at BASE OF FIRE.



FLOOR FIRES
-- sweep from edge in.



WALL FIRES
-- sweep from bottom up.



ELECTRICAL FIRES
-- disconnect power source, if possible.

Use an extinguisher appropriate for what is burning.

But if fire gets bad ...
GET OUT! (close all doors behind you.)

MORE ABOUT FIGHTING FIRES

HOW TO FIGHT FIRES (cont'd):

For different kinds of FIRES...



WATER for:

ORDINARY COMBUSTIBLES

Fires burning in wood, cloth, paper, rubbish, rags, shavings, packing materials. Do not use on electrical equipment.

FOAM, DRY POWDER for:

FLAMMABLE LIQUIDS and GASES

Fires fuelled by petrol, oil, grease, paint, [illegible] s, propane, ethers.



CO2, HALON or DRY POWDER for:

ELECTRICAL EQUIPMENT

Fires occurring in motors, controls, wiring or involving the electrical current. Where possible, disconnect electrical supply and treat as appropriate for burning material.



DRY POWDER (special) for:

COMBUSTIBLE METALS

Fires in magnesium, titanium, zirconium, lithium, sodium, etc.

OTHER WAYS TO FIGHT A FIRE

DRENCH a fire with water from hose reel or fire bucket.



SMOTHER a fire with a blanket or sand.



BEAT out a fire with a shovel.



...there are different kinds of FIRE EXTINGUISHERS

Find out WHERE THEY ARE and HOW THEY WORK. Re-read instructions often so you'll be prepared to use every type. ... NOW, before a fire starts.

They may be coloured predominantly red, with a small colour code showing the type of extinguisher. Or, they may be coloured as not shown here.

FOAM — cream

- Works by SMOTHERING fire with blanket of foam.



HALON — green

- Works by SMOTHERING fire with gas.



DRY POWDER — pink

- TYPES: stored pressure; cartridge operated.
- Works by SMOTHERING fire with blanket of powder.



CO_2 (Carbon Dioxide) — black

- Works by SMOTHERING fire with gas.



WATER — red

- TYPES: stored pressure; cartridge.
- Works by COOLING fire.
- Do not use on electrical equipment.



KNOW THE LOCATION of emergency equipment in your work area.

FIRST AID KIT

Fast action can save a life. Know where to find stretcher, rolled blanket, too.



PLUS...

Ladder, axe, breathing equipment, etc.



Check your workplace against this



SITE SAFETY CHECKLIST

- ☐ RUBBISH -- no unnecessary accumulation.
- ☐ FLAMMABLES -- safely stored, contained; no breakages or spills.
- ☐ HOUSEKEEPING -- work area neat and tidy.
- ☐ WIRING -- good connections, earthed.
- ☐ MACHINERY -- clean, working properly.
- ☐ COMBUSTIBLES -- away from heat.
- ☐ SMOKING -- safe area, safe disposal.
- ☐ VENTILATION -- of waste, high fume areas.
- ☐ EXTINGUISHERS -- right ones, well marked.
- ☐ EXITS, PASSAGEWAYS -- clear, unobstructed.
- ☐ EVACUATION ALARM -- recognised by all.
- ☐ EVACUATION PROCEDURES -- practiced, known by all.

SO WHAT?

SO--

YOU'RE NOW THINKING ABOUT FIRE!



- KNOW how fires are caused.
- REPORT or repair unsafe conditions.
- PRACTICE good housekeeping.
- LEARN emergency procedures.

YOUR JOB AND YOUR LIFE MAY BE AT STAKE!

NOTES

1. Architectural Journals, Fire Protection, July, Volume 169, No. 10, March 7, Pp.499-502.

2. Architectural Journal, Fire Prevention, No. 99, 1973 August, Pp. 29-36.

3. Architectural Journal, July, Volume 156, No. 43, 1979 October 25, Pp. 939.954.

4. Arc. Abdulkarim Mas'ud, Services Note 1991/92. Session M. Sc. I.

5. Nigerian Tobacco Company Hand Book on Safety.

6. Group Assignment on Building Services, 1991/92, M. Sc. I

CHAPTER FOUR

4.0 CASE STUDIES

4.1 Nigerian Sugar Company Limited, Bacita

The Nigerian Sugar Company at Bacita is an indigenous, national company, managed and operated by Nigerians, using the vast natural resources of the country.

The company has good potential and a lot of benefits for the country. With history of feasibility studies dating back to 1956, the Nigerian Sugar Company is the first country's sugar manufacturer, and has always endeavoured, as a pioneer, to increase its production.

The company produces at present 36,000 tonnes of refined sugar annually, provides employment for 5 500 Nigerians, makes a sizeable saving in foreign exchange for the country, and has brought a major industry to an area where previous economic activity was confined to subsistence farming.

Truly, this is an industry of which Nigerians can be proud of.

The company is situated at Bacita, in Kwara State, 30 kilometres from Jebba. Almost 4,600 hectares of sugar-cane have been planted to date and total production of 35,084 tonnes was made in the 1973/74 cropping season. The possibility of further expansion is being investigated.

4.1.1 Facilities and Planning

Looking at the whole factory layout in perspective, one

will observe that the structures exist independent of each other and not all that linked together.

Basically, there are two gates leading into the factory area, one reserved for cane-carts and trucks supplying cane to the factory, while the other for visitors and customers.

Owing to the haphazard nature of planning the factory area, the entire layout seems more or less like an after thoughts even though it has a simple and functional layout. See fig. 4.1.

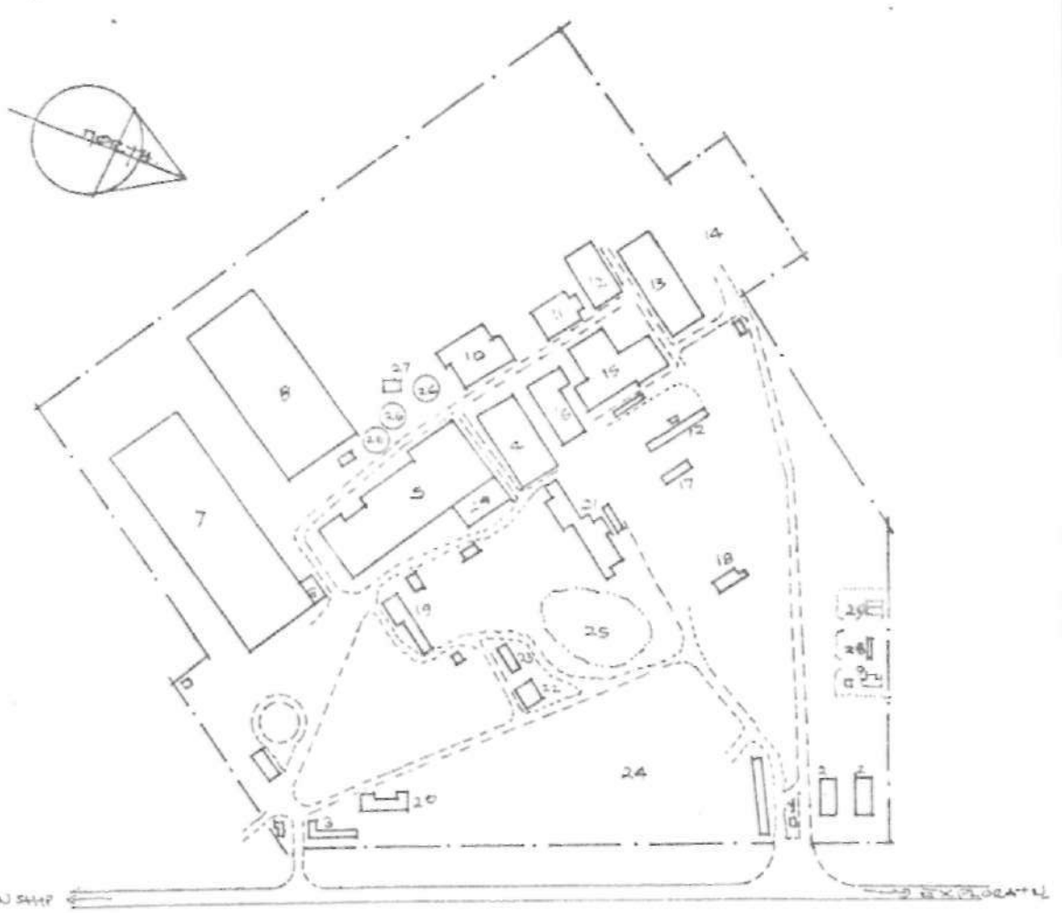
The double gate nearest to the plantation is used basically by cane carts and on entry along the non-defined route are irrigation, stores, fire and petrol stations leading to the field workshop is just near the cane yard. All repairs are done here in the workshop of two storey high steel framed shed without walls and floors, hence good natural ventilation and lighting but poor security for materials at the workshop.

As cane is fed into the inclined conveyor, it is transported into the mill house for extraction. See plates 5.1 and 5.2.

The machines in the mill house are heated in a storey steel framed building with steel floors and aluminum cladding as roofing walling.

The residue left after which the juice had been extracted, the bagasse is supplied by a conveyor to the bagasse house over the boiler house for it to get dried. See plate 5.3.

SITE LAYOUT



Legend

1 GATE HOUSE.
2 IRRIGATION STORE
3 SURVEY OFFICE
4 MILL HOUSE
5 PROCESS HOUSE
6 SUGAR HOPPER
7 BAGGED SUGAR STORE
8 SPRAY POUND
9 FIRE STATION
10 BOILER HOUSE
11 BAGASSE HOUSE
12 MAINTENANCE OFFICE
13 FIELD WORKSHOP
14 FIELD WORKSHOP YARD.
15 GENERAL STORE
16 FACTORY WORKSHOP
17 RADIO BASE
18 DIESEL TANK
19 FIELD TECHNOLOGY
20 FIELD OFFICE
21 SEVERAL STORE
22 CHEMICAL STORE
23 CHEMICAL CENTRAL
24 PLANT CONTROL YARD
25 FACTORY WASTE
26 MOLASSES TANKS
27 CARBON HOUSE
28 PETROL STATION
29 DIESEL TANK

Fig 4.1

NIGERIAN SUGAR COMPANY, BACITA.

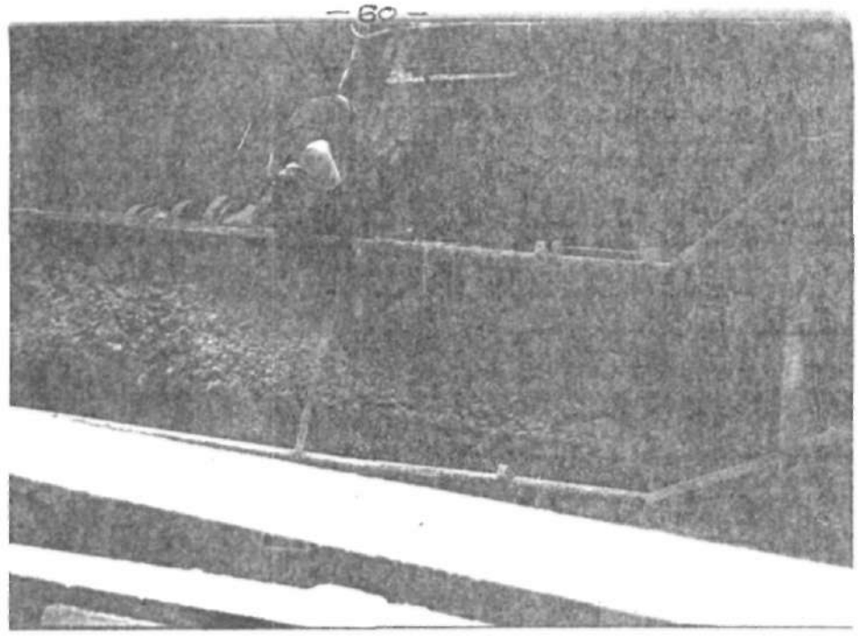


Plate (4.3) Bagasse Being Conveyed to Boiler House



Plate (4.4) Evaporators

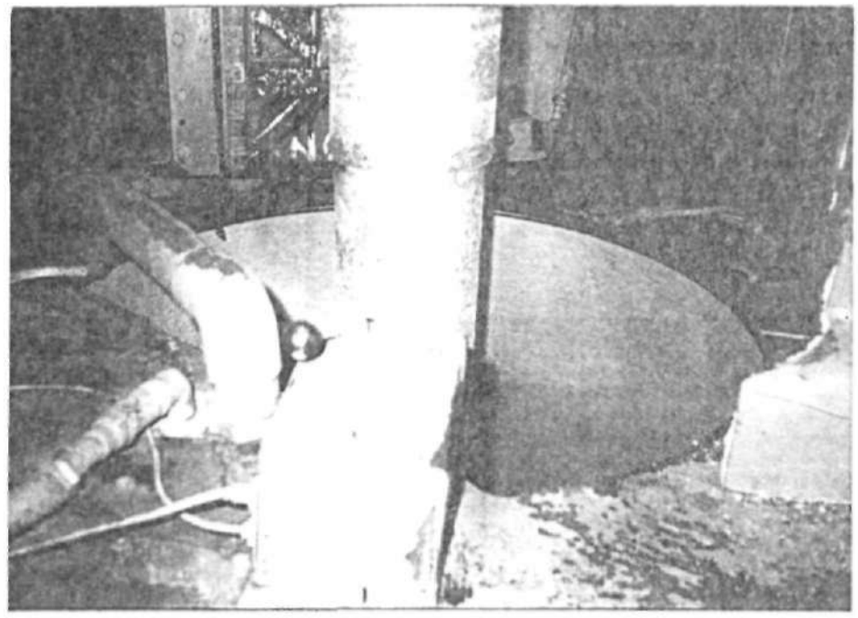


Plate (4.5) Centrifugal Machine



Plate (46) Baggaging of Sugar

With an inclined conveyor its source being a pit in the centre of the bagasse house supplies bagasse to the boiler house. The boiler house is also a two storey high steel framed building with its wall cladding arranged in a louvre like manner so as to improve the natural lighting and ventilation.

The extracted juice is slipped to the refined area from the mill house. This is where we have the evaporative heaters for the syrup to boil and evaporate so as to crystalize sugar out. See plate 5.4.

Next, the sugar is send to the centrifugal machine. See plate 5.5 after which the raw sugar is obtained. And to obtain the refined sugar, the raw sugar is re-melted and the whole process that leads to the production of raw sugar is repeated.

Finally, refined and crystallized sugar is bagged in the process hall and then conveyed to the sugar store through a conveyor. See plate 5.6.

The store is totally detached from the process house. Natural lighting within the store is rather poor so that it does not affect the stored sugar.

The molasses that is derived from the sugar cane processing is stored in 1,000,000 litres cylindrical tanks beside the process house.

The spray pond is also located beside the process house, and it basically cools hot water used in the process house.

4.1.2 Merits and Demerits

Merits:

i. The general hygiene of the layout is reasonably being catered for as there is a well functional waste collection point and good drainage.

ii. The risk of spread of fire is highly reduced as the buildings are disconnected from each other and they have a well equipped fire station.

iii. Good height clearance is provided in all buildings.

iv. A well functional production flow.

Demerits:

i. Inadequate ventilation within most of the buildings.

ii. Expansion of the factory building is not very feasible.

iii. The toilets are haphazardly located.

iv. The circulation areas are not properly defined.

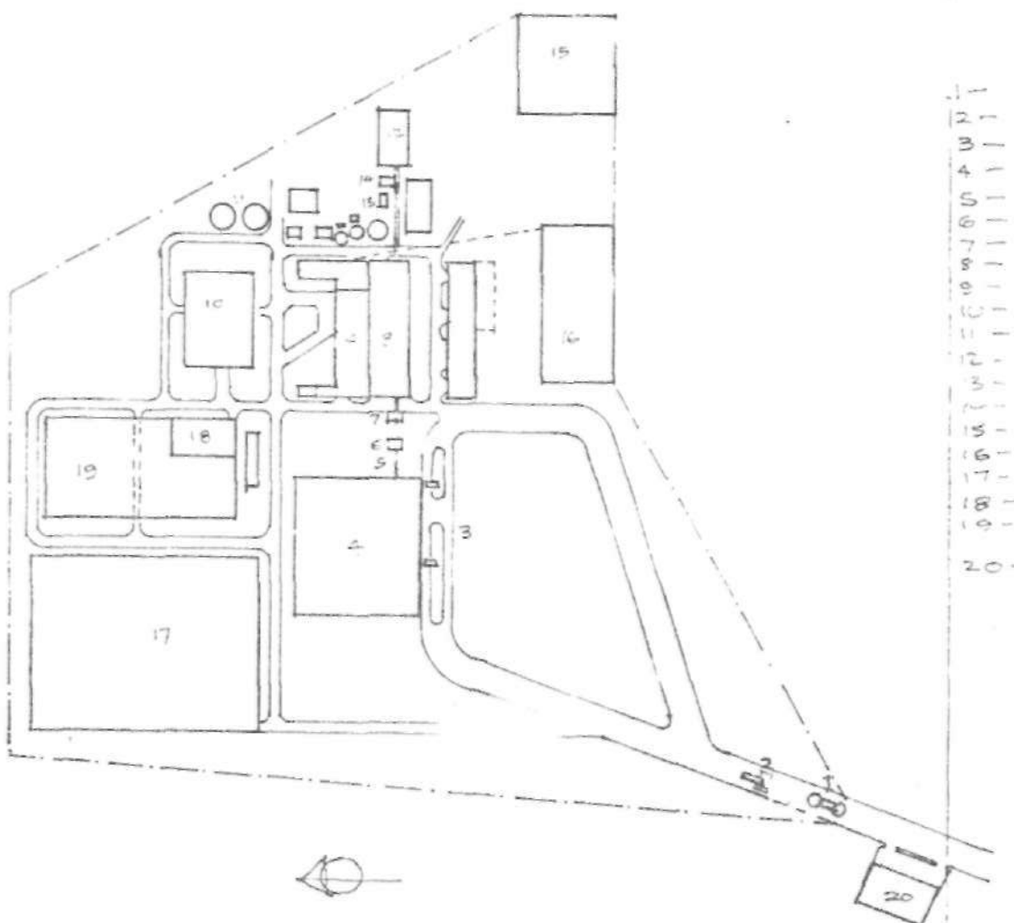
v. Complete absence of workers facilities.

vi. No landscaping of any kind.

4.2 Sunti Sugar Company Limited

The Sunti Sugar Company which is jointly owned by the Federal Government of Nigeria, Tate and Lyle of London is located on the Northern Bank of River Niger in Niger State.

SITE LAYOUT



LEGEND

1 – GATE HOUSE
2 – WEIGH BRIDGE & OFFICE
3 – HYDRO UNI-CRUSHER
4 – CANE YARD
5 – MAIN CANE CARRIER
6 – CANE LEVELLING KNIVES
7 – CANE DEEP CUTTING KNIVES
8 – MILL HOUSE
9 – PROCESS HOUSE
10 – BAGGED SUGAR STORE
11 – MOLASSES STORAGE TANKS
12 – BOILERS
13 – BOILER INSTRUMENT HOUSE
14 – BOILER OIL DAY TANK
15 – EFFLUENT LAGOON
16 – INJECTION WATER SPRAY POND
17 – FIELD WORKSHOP
18 – CHEMICAL STORE
19 – SITE CONSTRUCTION STEEL STOCK YARD
20 – MAIN ADMINISTRATIVE OFFICE

Fig. 4.2

SUNTI SUGAR COMPANY

The concept of the factory design was based on the case study of the Nigerian Sugar Company, Bacita, Kwara State and presently produces over 50,000 tonnes of sugar annually.

4.2.1 Facilities and Planning

The whole complex consists of a plantation, residential, administrative and the factory areas which like the Bacita factory are haphazardly located.

The factory layout has a single gate and a gate house which controls the movement of vehicles into and out of the layout. Immediately after the gate house is the weigh bridge which can obstruct the free flow of traffic at the gate. See figure 4.2.

Usually, the cane is slipped into the mill house by a conveyor belt via a set of knives after off-loading the cane from the cane carrier trucks/carts.

The extracted juice from the mill house then moves to the process house which shares a common wall with the mill house. This process house is a four-storey steel framed building with its external cladding arranged on louvre like manner so as to improve natural lighting and ventilation. This juice then moves from the process house to the blending station which is a steel framed building, and from here it moves to the baggaging station.

The bagasse which is the residue from the process is then transported to the bagasse house through a conveyor for onward feeding to the boilers.

The machines in the workshops have independent foundations so as to reduce vibrations and noise within the factory.

4.2.2 Merits and Demerits

Merits

i. Good and simple circulation within the factory site.

ii. Future expansion is provided for individual buildings.

iii. Well compacted site plan.

iv. Good orientation and ventilation.

Demerits:

i. Poor landscaping.

ii. Complete absence of workers facilities such as canteen, changing rooms and clinic.

iii. Toilets which are centrally located is not convenient as workers will have to move from all working areas in order to use them.

NOTES

- Nigerian Sugar Company, Fact Sheet.

CHAPTER FIVE

5.0 THE SITE

5.1 General Geology of Kwara State

The oldest geological part of the earth in the State is the basement complex, formed more than 600 million years ago in the pre-cambrian age. Rocks in this formation are categorized into meta-sediments and older sediments consisting of gneiss, granite and pebbles.

The general geology of Kwara State is based on two principal components: sedimentary formation of cretaceous, tertiary and quaternary ages, and igneous cum-metamorphic rocks of the pre-cambrian age. The sedimentary formation covers 90% of the State where as the crystalline rocks of the basement complex cover the Northern 10% of the State. Within both formations can be sound minerals which may be used as sources of energy or as raw materials for construction and industry in different quantities and quality, petroleum, natural gas and coal including lignite and anthracite constitute the main sources of energy that could occur in economic quantity in unmetamorphesed sedimentary rocks.

The known industrial miner is and construction materials which occur in different quantity and quality in the State are limestone, clay, kaolin, gypsum, sand, gravel, silica, iron ore, bauxite, lignite and anthracite.

The region is mostly underlain by the tertiary sediments which are of soft sandstones and sandy clays with bands of clay and shale inter bedded.

5.2 Site Selection Criteria

There are a vast number of factors that would influence the location of a sugar industry in Lafiagi, Kwara State. These factors would act together to provide a choice for the citing of the industry. The industry is one which requires a large expanse of land and closeness to its major source(s) of its raw materials. This is made more interesting by the geographical dispersion of these raw material sources.

(a) Economy - There is a ready and available market for the industry's products in Kwara State on the first hand where continuous developmental projects are taking place and a taste exists for top-quality of sugar and also in the rest of the country, where these same needs exists. Ultimately, the foreign market is the target.

(b) Transport - The industry should be located along a traffic route which serves the State and other parts of the country. Proximity to River Niger as a route for export is also of importance.

(c) Manpower Resources - There is a generous output of skilled labour from our country's higher institutions like the University of Ilorin and Ahmadu Bello University, Zaria of proven capability. These may be employed as skilled workers

in the industry. Semi-skilled and unskilled workers may be employed from the residents of Lafiagi town and its environs.

(d) Availability of Raw Materials - Nearness to source in citing the industry is very important because of the bulk nature of the raw materials employed by the sugar industry. This is compounded by the geographical dispersion of these sources. The best choice of site would be one located near a cluster of these sugar-cane plantations thereby reducing the cost of transportation of the constituent raw materials which would otherwise be reflected in a greater overhead cost.

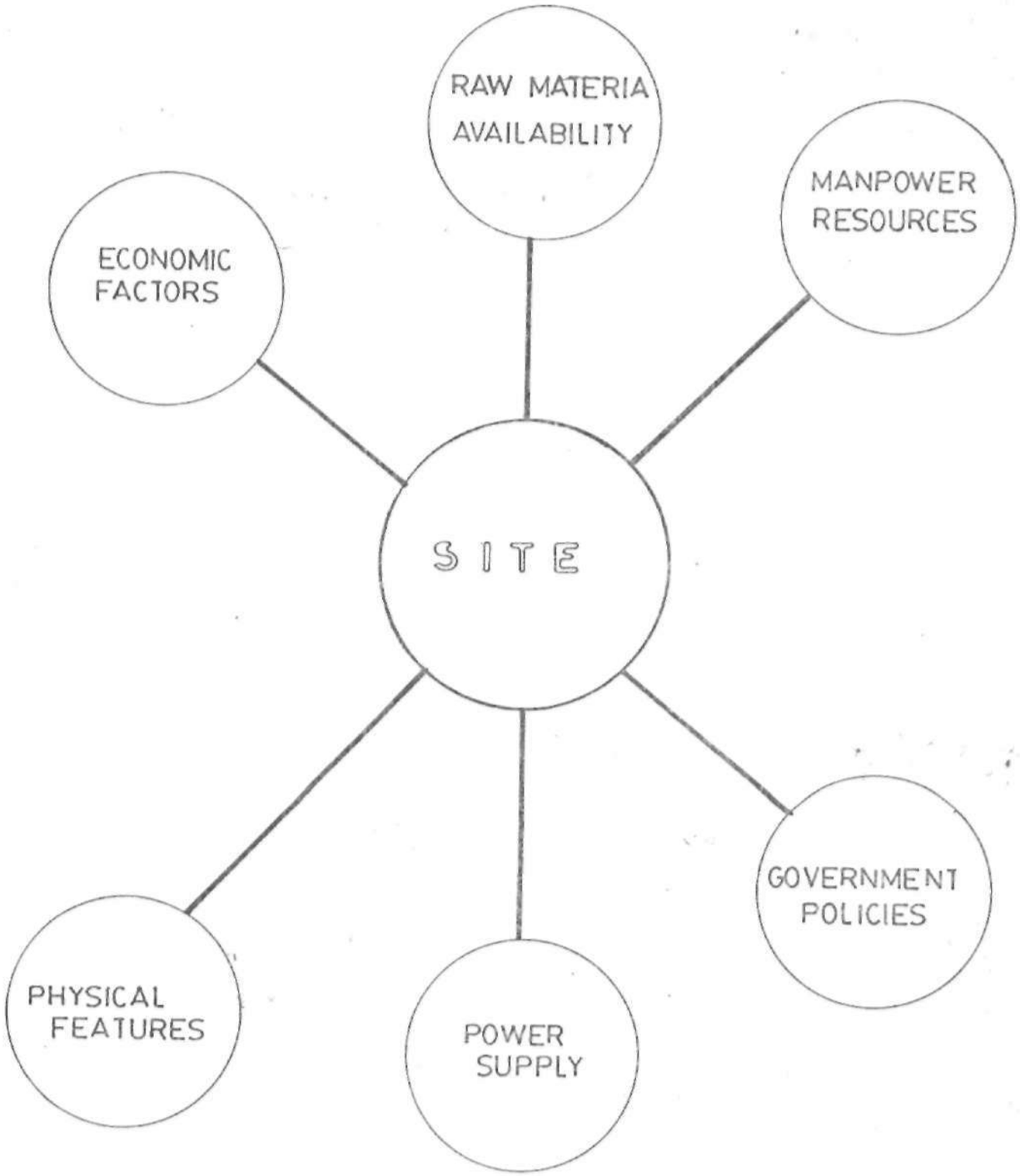
(e) Physical Features of the Site - Industrial sites are best flat or gently rolling as most industrial processes are carried out on a single level.

(f) Power Supply - There must be an adequate supply of energy for the proposed industry to meet its energy requirements. This may be in the form of electricity, petroleum or natural gas fuels. The sugar-cane processing industry demands an adequate supply of electricity to power its machines and natural gas to fuel its boilers in addition to bagasse.

(g) Government Policy - The Kwara State Government is committed to the rapid industrialization of the State owing to the backward nature of the State. It is however determined that these developments take place evenly all over the State. Investors are encouraged to site their developments outside Ilorin the State Capital as part of the Government's efforts to distribute these developments.

(h) Water Supply - The sugar-cane processing factory is one that uses up vast amounts of water in its production. For this reason, it is important that the industry is located near a steady source of water supply.

A lot of other factors must come into consideration.



SITE SELECTION DETERMINANTS

These would include the social amenities in the town to be considered. If a town satisfies all the other requirements, would the employees be able to live under the social conditions of the town? Is adequate housing for the staff readily available? Would there be need for the establishment of a staff housing scheme? Would the people of the area well came the industry? Would workers get molested by traditional hostilities? Are there existing medical facilities? Is there a land acquisition problem? What is the crime rate in the town? The industry should some where as to allow safe despation of finished products primarily by road and by sea for exportation. Good roads are of paramount importance here.

5.3 Site Choice - Lafiagi (Edu Local Government Area)

The site is located at Lafiagi, the headquarters of Edu Local Government Area of Kwara State. Lafiagi is a fairly large town strategically located off Ilorin - Jebba road in Northern Nigeria highway, about one (1) hour drive from Ilorin. And it is estimated that 60% of the raw material is to be sourced locally at Lafiagi.

Lafiagi enjoys various social amenities such as a steady supply of electricity from the National Grid, pipe-borne water from a central treatment plant, a relatively developed educational sector which includes a College of Education which incidentally has an elaborate agricultural engineering department. The town also has a NITEL earth station from

which effective telecommunications to any part of the world is possible, and a medical hospital.

5.4 Location

The project is to be cited at Lafiagi, the Headquarters of Edu Local Government Area of Kwara State.

In the early part of the 17th century, the present Lafiagi land area formed a significant part of a few segmented settlements inhabited by Nupes South of the River Niger. Lafiagi has an area of 1,600 square kilometres and a population of about 45,583 (according to 1963 census) basically of Nupe speaking whom are farmers producing rice and sugar-cane and significant number of fishermen can also be found owing to the presence of "Egwa" river (a tributary to River Niger).

The district is bounded in the north by a line running parallel to the bank of the River Niger, in the south by the Ifelodun Local Government, in the west by Kogi Local Government and in the east by Moro Local Government Area. See figures 6.2 and 6.3.

5.5 Description of Site

The proposed factory would be cited in the Northern part of Lafiagi towards Puta township which is bounded on the east by River "Egwa" which is a tributary of River Niger. This is part of the area set aside for industrial development of the town. The site is about 5 kilometres from the town and it is to be located along the major road Puta - Lafiagi - Ilorin.

5.6 Climatic Analysis

According to available climatic data, Lafiagi in Kwara State is on the transition zone between savannah belt of the country and the coastal belts, hence it exhibits the characteristics of both belts.

Below are the analysis of the climatic data!

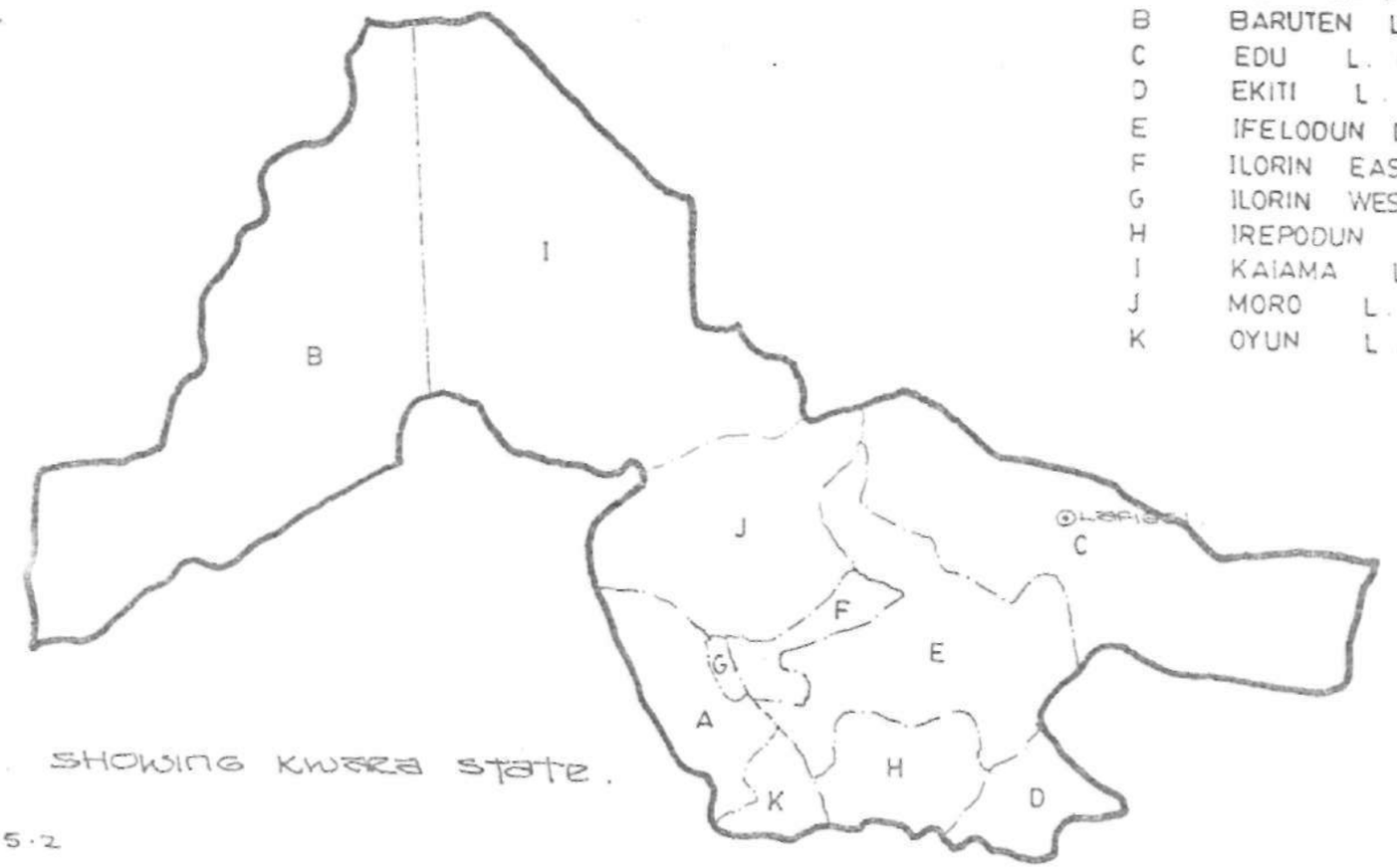
(a) Temperature - Monthly temperature are quite uniform, February and March are the hottest months (95oF) during the dry weather where there is virtually no cloud cover, while July and August are quite cool due to the cloud cover which act as blanket cover over the sky, but the coldest period is December and January (65oF) due to the harmattern effect.

Table 5.1 below shows the average monthly temperature at Lafiagi.



Fig. 5.1

MAP OF NIGERIA SHOWING LAFIAGI IN EDU L.G.A. OF KWARA STATE.



Map showing Kwara state.

figure 5.2

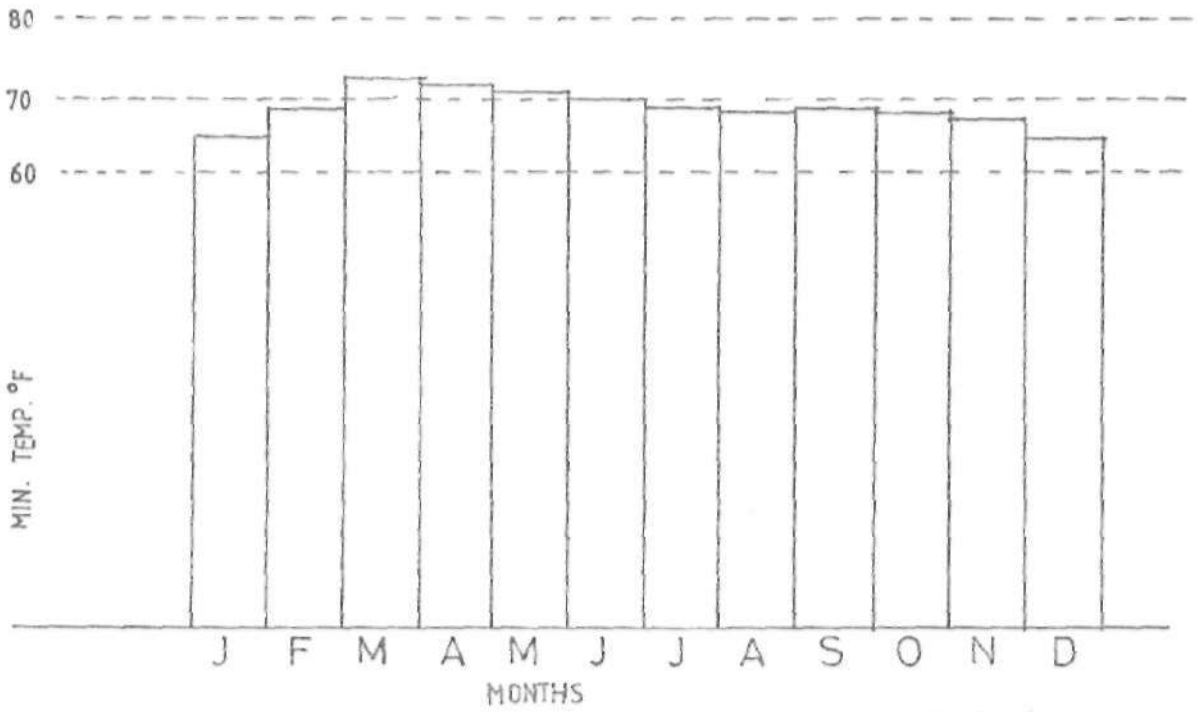


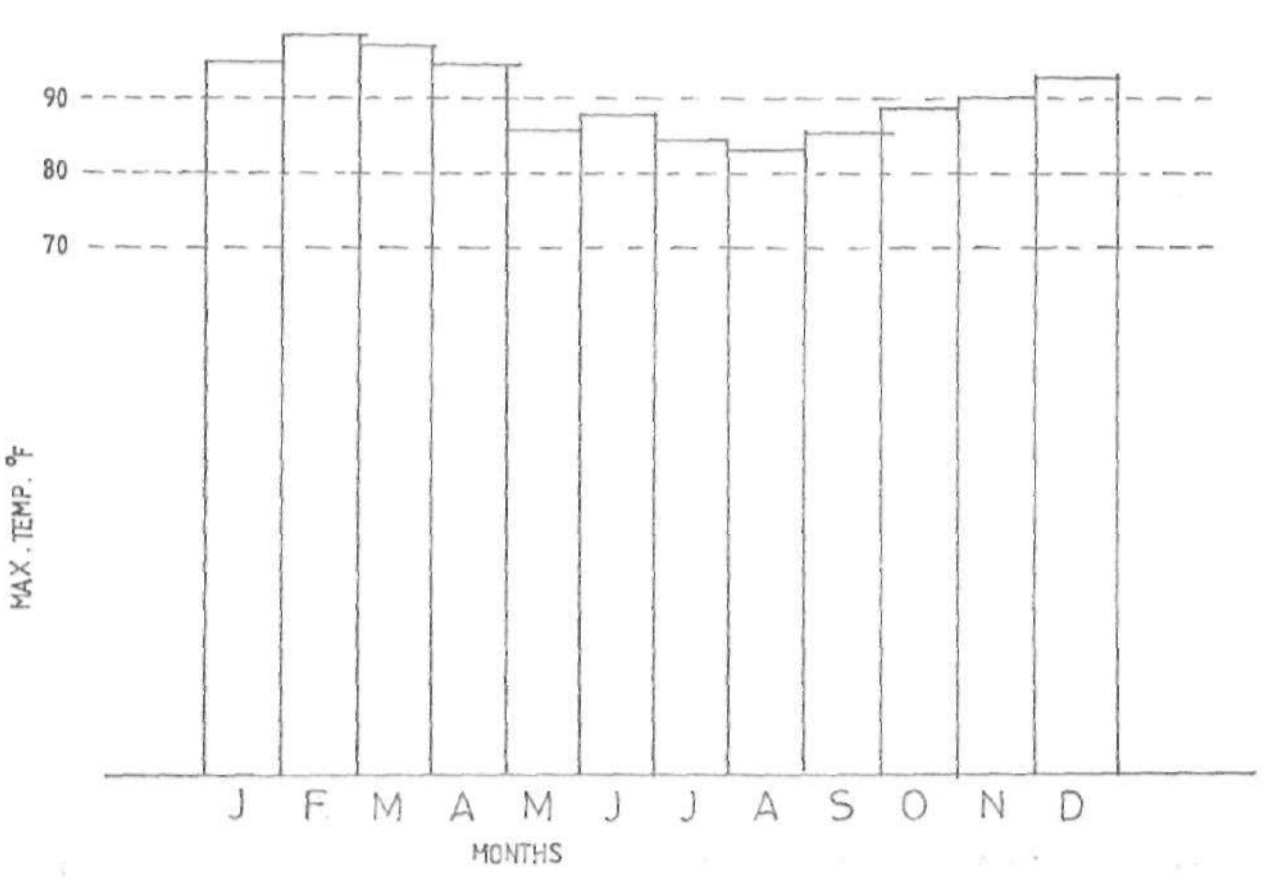
MAP OF EDU LIGA
SHOWING IBFIGI.

MONTHS	MAXIMUM TEMPT. (@F)	MINIMUM TEMPT. (@F)
JANUARY	93.2	65.3
FEBRUARY	96.5	69.1
MARCH	96.1	72.7
APRIL	93.3	71.4
MAY	86.0	70.4
JUNE	87.9	69.8
JULY	84.7	69.4
AUGUST	83.8	69.5
SEPTEMBER	85.6	69.4
OCTOBER	88.6	69.5
NOVEMBER	89.7	67.9
DECEMBER	93.0	64.0

TABLE 5.1

AVERAGE MONTHLY TEMPERATURE AT LAGIAGI


80
70
60
MIN. TEMP. °F
J F M A M J J A S O N D
MONTHS


90
80
70
MAX. TEMP. °F
J F M A M J J A S O N D
MONTHS

(b) Rainfall - The mean monthly distribution of rainfall varies from 2cm-20cm which annual rainfall may reach up to 1m. Nearly all rainfall occurs in wet season, that is, between April and October, while there is little or no rainfall during the dry season which is between November and March.

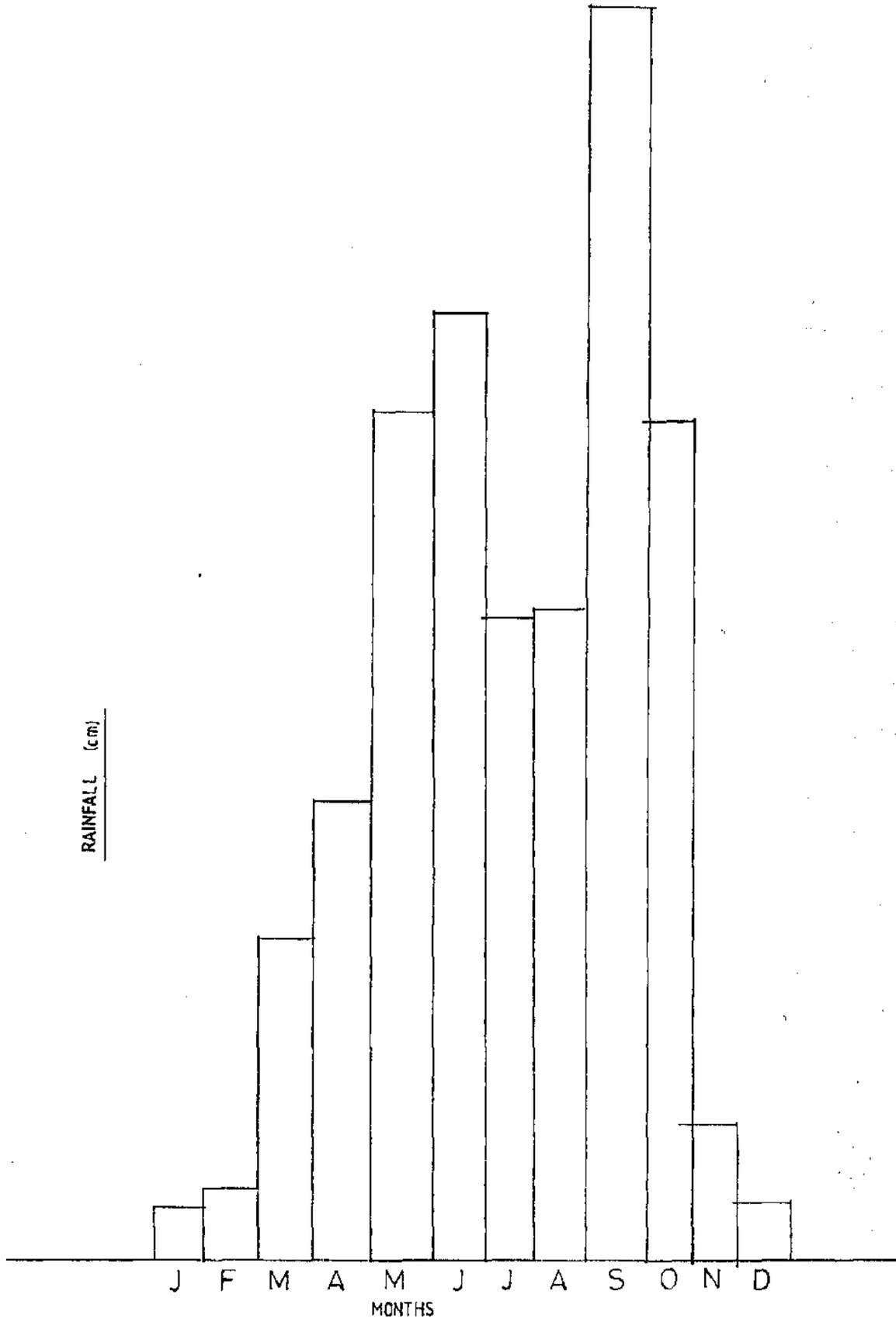
The average rainy days is about 110 days. The greater part of rainfall occurs between sunset and sun rise, mostly accompanied by thunderstorm.

Table 5.2 below shows the mean monthly rainfall at Lafiagi.

MONTHS	RAINFALL (CM)
JANUARY	1.00
FEBRUARY	1.40
MARCH	6.20
APRIL	8.66
MAY	15.49
JUNE	17.78
JULY	12.17
AUGUST	12.25
SEPTEMBER	23.70
OCTOBER	15.66
NOVEMBER	2.57
DECEMBER	1.05

TABLE 5.2

MEAN MONTHLY RAINFALL AT LAFIAGI


RAINFALL (cm)
J
F
M
A
M
J
J
A
S
O
N
D
MONTHS

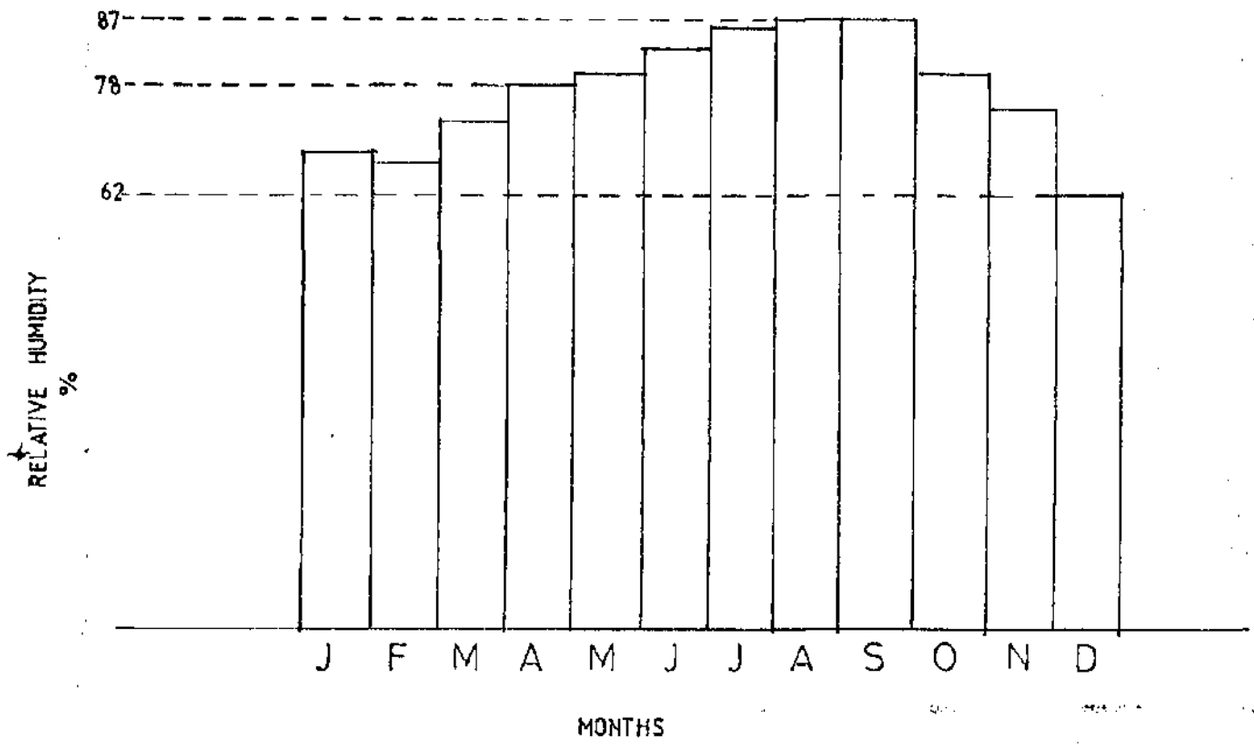
(c) Relative Humidity - The relative humidity is influenced by the equatorial maritime with the highest relative humidity during rainy season between April and October (75-85%) and the lowest being during the dry season between November and March of about 60%.

Table 5.3 below shows the relative humidity at Lafiagi.

MONTHS	RELATIVE HUMIDITY (%)
JANUARY	68
FEBRUARY	66
MARCH	72
APRIL	78
MAY	80
JUNE	83
JULY	86
AUGUST	87
SEPTEMBER	87
OCTOBER	80
NOVEMBER	7[illegible]
DECEMBER	62

TABLE 5.3

RELATIVE HUMIDITY AT LAFIAGI


87
78
62
RELATIVE HUMIDITY
%
J F M A M J J A S O N D
MONTHS

CHAPTER SIX

6.0 PRODUCTION PROCESS

6.1 Weighing of Cane

The cane on arrival from the plantation to the site is generally weighed on large platform scales usually located around the route of the transport - motor truck, trailer,mule cart or the like. Where direct weighing is impracticable, the cane weight is estimated by an inferential method.

6.2 Unloading Devices

All modern factories employ mechanical unloaders. When cane arrives in carts or trucks, the usual practice is to leave it in the carts and trucks respectively. Until it is delivered to the carrier, which is done either by lifting the cane out of the carts and trucks in bundles by hoists, or by tipping the truck load of cane on a tilting platform.

After unloading, by whatever type of device, the cane travels to the mills on heavy conveyors or cane carriers of various designs.

6.3 Cane Cleaning Equipment

As a part of the cane carrier, or auxiliary to it, is the process of cleaning the cane, made necessary where mechanical harvesting prevails. See figure 6.0.

6.4 Milling Process

6.4.1 Milling Machinery - The classical combination of three rollers arranged in triangular form (see figure 6.1) is the standard milling unit for the industr

Each unit is commonly drive by separate motor power, either steam engine, electric motor, or in more recent installations, steam turbine. In addition are crushers or shredders or both, cane knives, and intermediate carriers.

A heavy-duty "tandem"of mills, with driving machinery, bed-plates, driving mechanisms, gearing and other accessories constitutes one of the largest and heaviest machinery combinations in use in any industry.

6.4.2 Preparation of Cane for Milling - The milling process may be separated into two steps:

i. The preparation of the cane by breaking down the hard structure and rupturing the cells; and

ii. The actual grinding of the cane. The preparation of the cane is accomplished in several different ways:

   a. By revolving cane knives that cut the cane into clips but extract no juice.

   b. By shredders that tear the cane into shreds but extract no juice.

   c. By crushers that break and crush the structure of the cane, extracting a large proportion of the juice.

   d. By combinations of any or all of the above means.

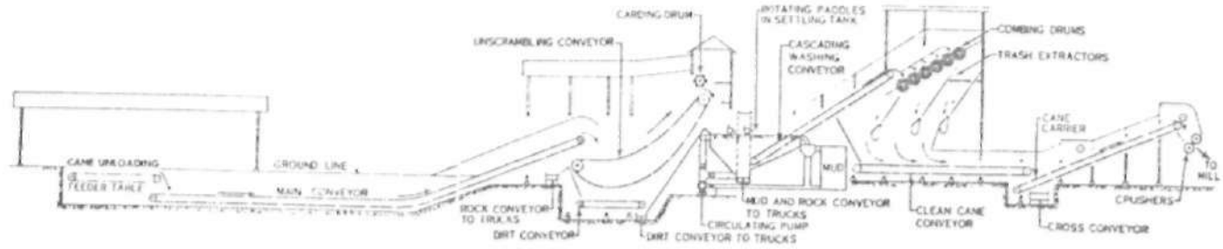


Fig. 6.0 Cane Cleaning Installation. (Link Belt Co.)

Figure (6.0) Cane Cleaning Installation

FIGURE 6.1

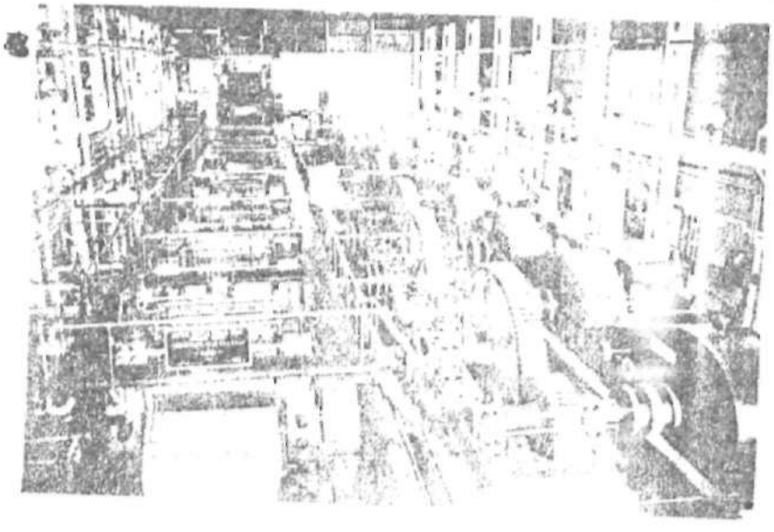


Figure (6.1) Milling M[illegible]e

6.4.3 Revolving Cane Knives - Revolving knives first came into general use in Hawaii about 1920, but are now standard equipment in most large milling plants throughout the world.

All knives revolve in the same direction that the cane travels. Various patented designs of knife blades developed throughout sharpening and reduce breakage of blades.

Knife sets are generally supplementary to crushers or shredders. They give more or even feed, increased capacity to the will train, and more effective use of maceration water, resulting in increased sucrose extraction.

6.4.4 Crushers - Crushers in general consist of two (occasionally three) deeply grooved rollers which crush or break the cane and facilitates the extraction of juice by mills.

6.4.5 Shredders - As the name implies, a shredder tears the cane clips into shreds without extracting any juice. They are normally installed after crushers to complete preparation and disintegration of cane so as to facilitate extraction of juice by mills.

6.5 Extracting the Juice

6.5.1 Milling Process - With the aid of equipment already described, the cane parts with only 70-80 per cent of its weight in juice passing through the crusher and the first mill.

It is universal practice to add water or thin juices to the bagasse after each mill, thus diluting the contained juice and increasing the extractions as this juice is expressed. This use of water is termed saturation, imbibition, or maceration.

6.5.2 Maceration and Imbibition - Maceration is defined as "the process in which the bagasse is steeped in an excess of water or juice, generally at a high temperature." The water so used is termed maceration water.

For imbibition, it is the process in which water or juice is put on the bagasse to mix with and dilute the juice present in the latter. The water so used is termed imbibition water.

6.6 Clarification

Clarification is the process whereby the extracted juice leaving the mill is cleansed of its impurities. Hundreds of materials have been used for clarification, but the main once are line, sulphurous acid and phosphoric acid.

Calcium Oxide (CaO) - lime is the oldest chemical used. When lime is applied to cane juice, the juice coagulates albumiriod mater, some pectin and colouring mater is destroyed or rendered in soluble, but its purification effect on juice is minimal and mainly physical as juice is almost same before and after application.

Sulphitation is the process of using sulphurous acid (H2SOA) for clarification. This process eliminates colouring mater, reduces ferric salts formed by contact with tanks and

pipes to colourless compounds. It also makes juice settle faster, improves colour and crystallization, saves time in clarification and boiling.

Phosphoric acid occurs on two main forms in canes as soluble phosphates of the juice and combined with protein or cell material. Phosphoric acid added to juice precipitates part of the colloids and colouring mater, improves clarification of refractory juices.

6.7 Subsidation

After juice undergoes clarification, it is allowed to settle, in order to separate clear juice from precipitate formed in body to be settled is fed into the subsider uniformly and continuously. The subsider is large enough to reduce velocity of flow and circulation of juice to a low value, that does not prevent settling.

Clear juice obtained is removed from the upper part of the subsider in a uniform and cautious manner and so also are the muds formed removed from the lower portion.

6.8 Juice Heating

Juice has to be heated at least once in the course of its treatment. High pressure steam is very valuable, exhaust steam or preferably bled vapour from evaporators used for heating.

Juice heater are designed to provide heat exchange between vapour and juice, and it is assembled in tubes with juice circulating in them and vapour outside them.

6.9 Filtration

This is the process by which the clear juice got after clarification and subsidation is filtered to separate it from suspended matter like insoluble salts and fine bagasse which it contains filtration is best done when juice is not less than 80oC and a pH value of between 8.0 - 8.5.

6.10 Evapouration

The juice got after clarification and filtration consist of water and sugar, the process of separating this water from sugar is known as evapouration.

Evapouration is done in an evapourator, this consist of a tubular calandria serving heat exchanger.

As water is extracted from the juice, the sugar becomes concentrated and starts approaching saturation point, when crystallization occurs. The concentration is pushed to its maximum until space left between the crystals is that for the Mother liquor, thus forming massecuite.

6.11 Crystallization

This is the process of mixing massecuite for a certain time after dropping from pans and before passing to the centrifugals, aim is to complete formation of crystals and forcing further exhaustion of the mother liquor, this is carried out in crystallizers.

6.12 Centrifugal Separation

Centrifugal separation is done on exhausted mother liquor so as to separate crystals and obtain sugar commercial form.

This process is carried out on centrifugal driers, also called centrifuges, centrifugals, but usually called fugals.

Centrifuging is best done in centrinuous centrifugals. This machine runs at a constant speed and it is fed constantly by a stram of material and furnishes a constant output of sugar.

6.13 Baggaging, Drying and Storage of Sugar

Sugar is dried usually in driers to reduce its moisture content from about 2.0% to between 0.2-0.5%, hence more life span.

Sugar driers consist air heater with a fan, which is divided into drying and cooling portions.

The sugar hopper after driers should have a set of scales. These scales could either be bagging scales, if used during baggaging, or a continuous integrating scale on the conveyor belt. These scales are used for weighing sugar before shipping.

Commercial sugar leaving centrifugals have a moisture content of about 0.5-2.0% which is actually not good for sugar especially if it exceeds 1%.

The conditions for storage of sugar differ, but there are more accepted ones like the one given by one Spengler and Bottger, which says that "quality of sugar is independent of temperature, if the temperature is between 10 and 30oC."

Sugar in its granulated form can be stored in sacks or in bulk. See figure (6.2) and (6.3) for produc n flow diagram.

If sugar is to be stored in sacks, it should be:

i. bagged dry and at temperature not exceeding 38oC to avoid hardening;

ii. sacks should have their button layer lined with bitumen paper or grating as damp protection;

iii. stacked in cubical shape to reduce surface area relative to volume;

iv. stacks should be covered with bitumen line paper at the top and sides.

Making raw sugar

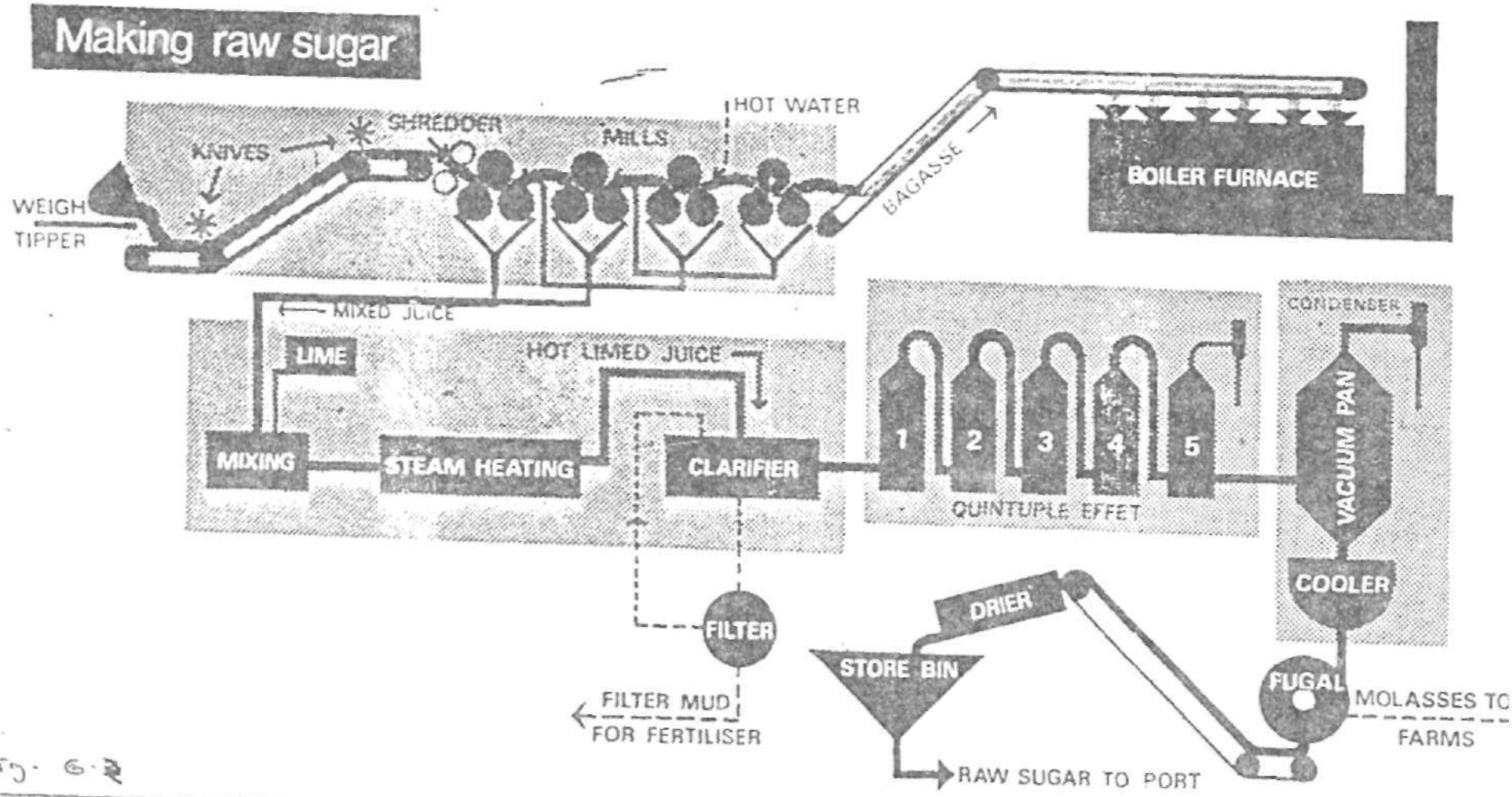


Fig. 6.2

Refining the raw sugar

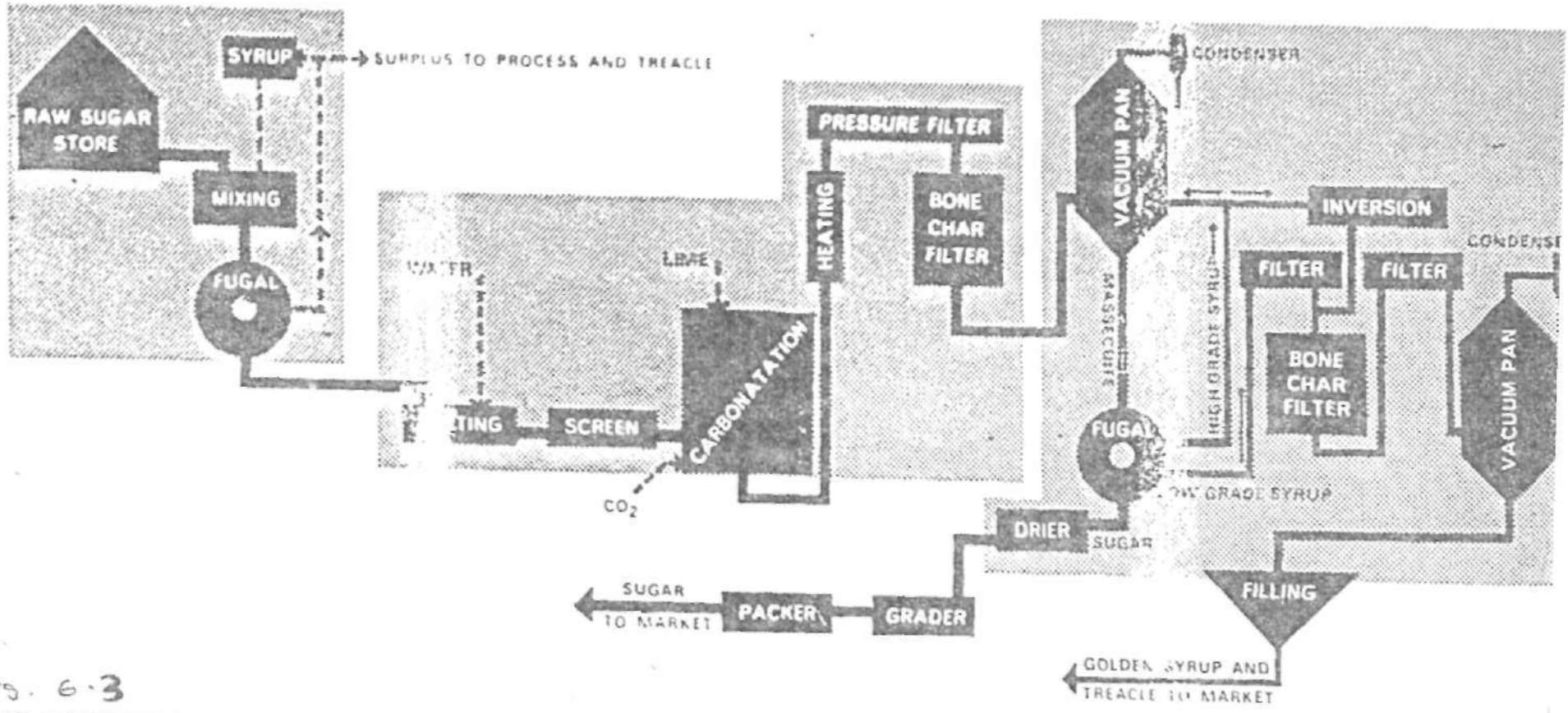


Fig. 6·3

NOTES

1. Hand Book of Sugar-Cane Engineering by HUGOT, E. (1972)

2. Cane Sugar Hand Book by George, P. M.

CHAPTER SEVEN

7.0 THE DESIGN

7.1 Design Factors

In any factory design, emphasis is placed on the following factors:

a. Citing and Layout of Factory - Its location with respect to a city is an important factory which determines whether it is economical to locate it or not. As its closeness to a city can make it utilize some city's facilities.

b. Essential Services

i. Water - As the industry requires large quantity of water, it is to be located near the river or a good source of water.

ii. Sewage and Drainage - Sewage disposal plant is to be provided and site contours are to be considered much for drainage purpose.

iii. Electricity - Electricity supply be easily available.

c. Transport and Storage - Position of loading bay is to be given due consideration and is best located close to the beginning and end of the production hall. Vehicles should have sufficient space for turning the parking.

In general, a trailer length is 12-15 metres, width 2.5 metres and platform height 1.32 metres for turning, it required 15 metres radius.

The storage hall is to be enclosed and its size will be proportional to the production capacity.

d. Planning of Production Hall - Planning of production hall shall be governed by:

i. the type of machine, size and space required;

ii. production line should not be disturbed by the cross traffic. There should be clear passage for worker movement. Auxiliary facilities such as workshops, boiler room and generator room should be near the hall.

e. Flooring - Generally, concrete flooring is to be used with hard core below, although it has little resistance to acid, hence terrazzo finishing is to be adopted. Flooring should have sufficient slop towards drainage.

f. Social Facilities for Workers - These include:

i. cloak rooms and changing rooms;

ii. public conveniences (toilets);

iii. first aid and medical treatment room;

iv. canteen, recreation and rest room.

These facilities should be preferably attached and not far away from production hall entrance.

g. Administrative Building (The Office Block) - An office is a place of work. The function of most offices is to be "the administrative headquarters of the business, which provides management with a service of communications and a record of past transactions and operations."

This should be preferably separated from main production hall to avoid noise and disturbances, but should not be too far.

h. Special Requirements - As a basis for any design at all, data must be determined for the external conditions likely to be experienced on the site and for the internal environmental standards required in various zones of the building.

Design standard for air flow requirements are based on two criteria, namely, fresh air ventilation and the air change required to maintain suitable conditions. (The amount of fresh air required for breathing purposes is actually quite small; about 0.2 litre/person). Natural ventilation of rooms/offices - the number of air changes/hour will depend on the space/occupancy relationship.

The following values for fresh air supply rate are satisfactory:

APPLICATION	LITRES/SEC/PERS	LITRES/SEC/M2
Board Room	8-12	-
Factories	-	0-8
General Offices	5-8	1-2
Private Office	8-12	-
Restaurants or Lounges	12-18	-

Table 7.1

Fresh Air Supply Rate to Areas

TYPE OF BUILDINGS	MINIMUM RATES OF FRESH AIR SUPPLY
Canteen	28m3/hr/per
Factories/Workshops	22.6m3/hr/per
Lavatories and WCs	56m3/hr
Kitchen	28m3/hr/per
Restaurants	3 Air Changes/hr
Cloak Rooms	3 Air Changes/hr
Corridors	2 Air Changes/hr.

Table 7.2

RECOMMENDED MINIMUM RATES OF FRESH AIR SUPPLY TO BUILDINGS FOR HUMAN HABITATION

SOURCE: Air-condition Engineering by Jones, W. B.

i. Lighting - Lighting is a very significant factor in architectural designs, especially interior designs. It can be used externally to display the character and features of the building to reveal views of the interior and draw interests, including an inviting entrance. Functionally, external lighting is a necessary requirement for safety, security and control. Illumination is used to draw attention to signs, directions and hazards variety can be introduced in several ways:

i. the intensity of light can be varied

ii. materials with different light reflecting or transmitting properties may be employed;

iii. lighting positions and the distribution of light from fittings can be changed;

iv. colours can be introduced in the light source, shading the surroundings.

Area	Lux	Lumens/m2	Limited Glare Index
Entrance Lobby	200	20	-
Reception Area	400	40	-
Offices	100	10	-
Lounges	200	20	-
Toilets	100	10	-
General Office	200	20	20
Kitchen	400	40	25
Stores	200	20	25

Table 7.3

STANDARD OF ILLUMINATION

SOURCE: Based on Standards of the Illuminating Engineering Society.

7.2 Design Brief

The proposed Lafiagi Sugar-cane Processing Factory which is a complex shall be made up of:

i. The administrative area;

ii. Workers facilities;

iii. Production (milling and process) hall;

iv. Field Workshop;

v. Maintenance workshop.

7.3 Schedule of Accommodation

7.3.1 Administrative Block

	No.of Users	Floor Area (m2)
General Manager	1	30
Secretary to Manager	1	24
Assistant General Manager	1	28
Secretary to Assistant GM	1	24
Sales Manager	1	24
Secretary to Sales Manager	1	20
Purchasing Manager	1	24
Typists and Clerks	5	30
Company Secretary	1	24
Secretary to Company Secretary	1	20
Chief Security Officer	1	16
Telephone Exchange	3	20
Chief Accountant	1	24
Secretary to Chief Accountant	1	20
Clerks and Typists for Accountants	8	30
Secretary to Personnel Manager	1	24
Welfare Manager	1	20

7.3.2 Workers Facilities

Clinic	3 Beds	120
Cafeteria	100	300
Changing Rooms	50	100
Staff Common Room	20	50

7.3.3	Production Area		
	Cane Yard	8	540
	Mill House/Process House	30	2,800
	Granulated Sugar Bagging	3	90
	Bagasse House	2	216
	Boiler House	4	216
	Spray Pond and Pump House	1	288
7.3.4	Storage		
	Raw Sugar Store/Refined Sugar Store	-	600
	Packaging raw Material Store	-	150
	Molasses Tanks	-	8 diameter
	Chemical Store	-	216
	Cold Water Tank	Overhead	100
	Hot Water Tank	Overhead	100
7.3.5	Field Workshop		
	Workshop Manager	1	16
	Secretary to Workshop Manager	1	12
	Assistant Workshop Manager	1	16
	Field Manager	1	16
	Tools and Spare Parts	1	30
	Service Bay	12	324
7.3.6	Maintenance Workshop		
	Factory Manager	1	20
	Secretary to Factory Manager	1	12

Chief Mechanical Engineer	1	16
Factory Engineers	3	20
Drawing Office	-	20
Equipment Store	-	20
Maintenance Area	8	432

7.3.7 Design Population

Location	No. of Users
Administration	31
Production	48
Field Workshop	17
Maintenance	14
Total	110

7.4 Site Zoning

The zoning of the site for the purpose of this factory is based on three main criteria, viz: fire risk rate, noise level and function.

The site is zoned such that areas accessible to the factory's customers (public areas) are those areas that will service the immediate needs of these customers, most especially the administration area. The production area is considered as private zone, since customers are not expected there.

An intermediate zone which is considered to be semi-private is created, this area is to be used by both factory

workers and customers if necessary, but basically for factory's staff.

This zoning criteria reduces rate of risk as it gives a clear distinction and makes easier to control customers movement. Zoning for fire also gives rise to the separation of vehicular access to the site, one for customers and staff and the other for cane carts from sugar-cane plantation and trucks for loading the finished products.

Noise is a strong factor of safety as such it forms a major criteria for site zoning. The most noise in sugar factories comes from the production area, while workers facility and administration areas also produces varying levels of noise. As such, the site is zoned into noisy, semi-noisy and quiet areas. The production area, which is the noisiest is located in the noisy zone. Workers facilities are placed next to the production area, and the administration area which is relatively more quiet is then placed next to it.

Function which is also a very important part of the design is well taken care of, as such, the site is zoned in line with production flow of sugar factories and in cognizance with privacy and noise zoning. The site is zoned such that sugar-cane which is the raw material comes through one entrance through the production process to storage, the storage area is serviced by the same road. The administration and workers facilities shares the same d. Hence, the

synthesis of fire safety, noise and function produced a simple, functional and balanced site plan.

7.5 Design Concept

The design concept which is "simplicity" was evolved and adopted so as to give rise to simple but functional site plan.

In evolving the design concept, orientation, functionality and simplicity were taken into considerations in cognizance with the site zoning criteria, to achieve a simple and functional site.

Access to the site is via two gates, one gate for customers and staff, and the other one is for sugar-cane supply trucks and finished products trucks. All buildings on the site are oriented such that the long axis lies along the east-west.

In evolving the various floor plans and elevations of the various buildings, their functions were first considered as such two sets of buildings evolved, viz: the industrial and non-industrial buildings. Then the incorporation of fire safety measures and control were thought of to achieve the objectives of this thesis.

The concept for the industrial buildings were based largely on function, as such a simple "rectangle" was adopted as their floor plans.

The administration block was also conceived along the lines of simplicity, but with a view to make it "dominate" the

factory skyline. As such, it has to be most attractive to sight. The offices in the administration block are both single banked, and double banked and the block also has a courtyard, both help to improve ventilation and reduces fire spread.

7.6 Design Overview

7.6.1 Site Plan - The site plan is simple, efficient and functional. All buildings on the site are well oriented for solar radiation and winds. Short sides of all buildings face the east and west, to reduce the effect of solar radiation on interior spaces. The longer sides of the buildings as such face the south and north, as such they are about 45o to the prevailing winds. Thus, good cross ventilation is achieved without causing a draught of air in the interior spaces.

Access to the site is by two sets of gates for good, effective and simple circulation. The gate to the north is used by cane carts and trucks while the southern one used by customers and staff.

Customers and members of staff who do not have vehicles are dropped of by taxis or "achaba" at the taxi and bus drop off located outside the souther gate.

7.6.2 Buildings - All the industrial buildings designed, have portal frames. The portal frames span 30m and 35m respectively and are spaced at 6m centre to centre. The east and west walls are partly 'solid' walls of sand-crete blocks and where openings are, shading devices are used while those

of the south and north are made up of fixed louvre. These louvres are demountable, as such they allow for the ease of installing or removing machinery. Fixed louvres are used to allow for cross ventilation, thus cooling the interiors, and also providing natural light while reducing solar radiation considerably. Roof vents are also provided to help in exchange of heated air with fresh one and in the venting off fires in case of any fire outbreak.

The administration block is a sand-crete framed multi-storey building with sand-crete block in-fills. Offices in the administration block are both single and double banked and a central courtyard is provided to achieve good cross ventilation and to reduces immediate spread of fire. The structures housing the workers facilities and gate houses are made of simple load-bearing concrete blocks.

7.6.3 Expansion - The design of sugar factories is peculiar in that unlike most other industries, its immediate expansion is provided for in the initial building. As such, sugar factory buildings provide two phases in them, one for its immediate needs and the other as expansion. This is so, because to increase production by about half of the installed capacity, only a few machinery like centrifugals and clarifiers that needs to be installed.

Thus,it is economical to provide enough space for machinery for phases one and two, that is, initial production and immediate expansion. If expansion of about hundred

percent or more is subsequently required, this is done as a reflection, that is, new structures are to be erected. In view of these, enough land is provided around the production area.

7.7 Conclusion

Noise and vibrating action of machinery in these factory buildings are combatted by mounting machinery on resilient mountings. The incidence of structure borne nose due to vibration from machines through buildings is reduced by making the portal frames to carry the roof structure and the wall only. Cladding is independent of the floor on which machines are mounted.

Usually, heat is generated by machinery and solar radiation. This can be combatted by good cross ventilation via fixed louvres, while effect of solar radiation is minimized by orienting building, such that its short sides face the east-west, as the east-west facades do not have openings, so as to reduce the effects of solar radiation in the building. Roof vents are also provided to effect ventilation by stack effect, and also to help in venting fires whenever required.

Floors in the production hall are finished in terrazzo so as to reduce the effect of chemical on bear concrete floor. In the mill and process house, which have upper floors, these floors are finished with textured steel sheets.

First-aid points are provided in each building, and a central clinic provided to cater for the employees of the factory. Each building is also provided with escape doors.

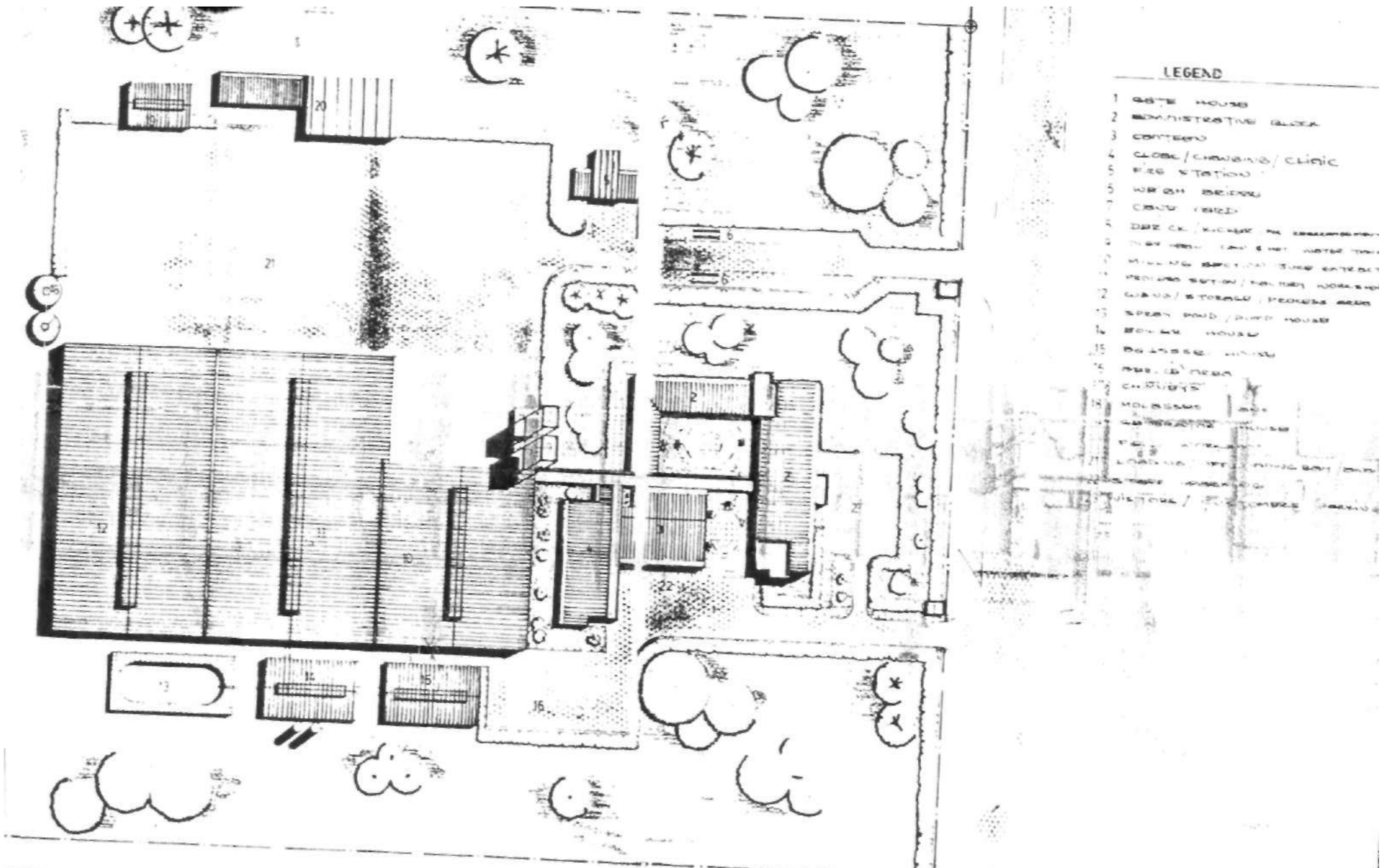
In case of fire outbreak, the factory had been provided with a mini fire station and fire hydrants located at strategic places. These factors coupled with good management go along towards evolving a safe and comfortable sugar factory.

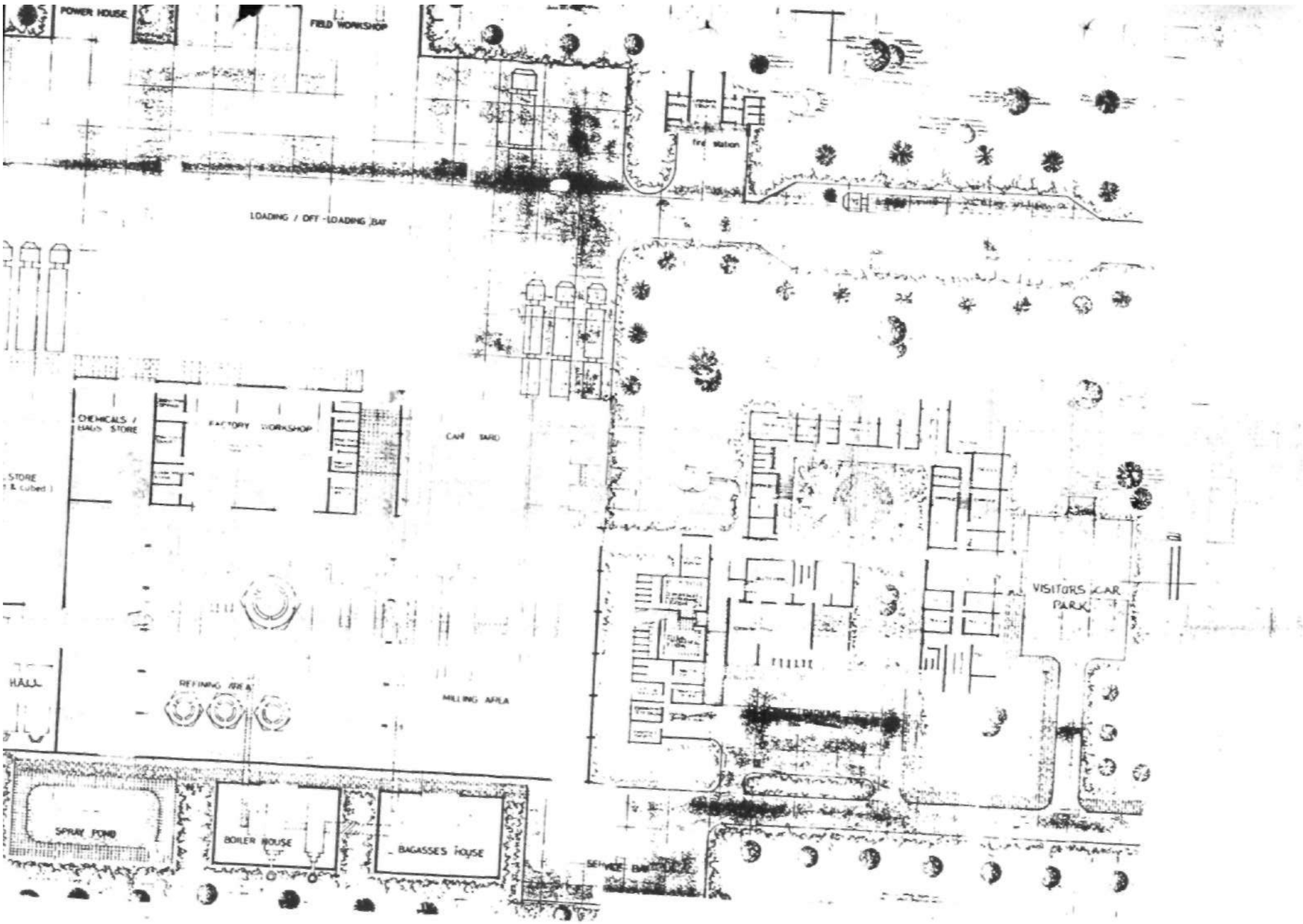
APPENDIX A

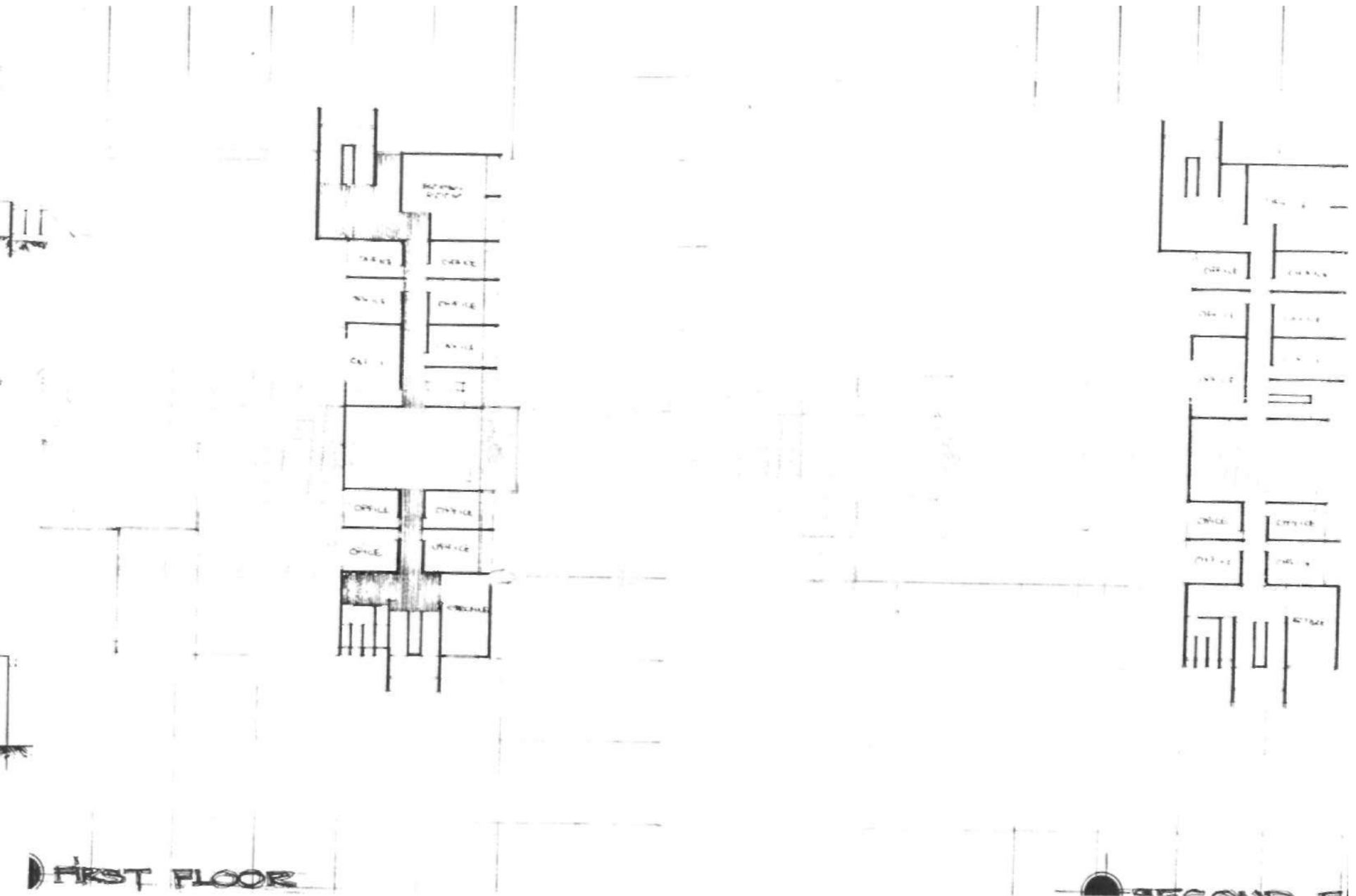
DEFINITION OF SOME TERMS IN SUGAR FACTORY CONTROL

- ABSOLUTE JUICE: - "All the dissolved solids in the cane plus the total water of the cane; cane minus fibre."
- UNDILUTED JUICE: (normal juice): "The juice expressed by the mills or retained in the bagasse corrected for imbibition water."
- PRIMARY JUICE: "The juice expressed before dilution begins." In most mills, this is the combined crusher and first-mill juice.
- SECONDARY JUICE: "The diluted juice which, together with the primary juice, forms the mixed juice."
- MIXED JUICE: "The juice sent from the crushing plant to the boiling house."
- RESIDUAL JUICE: "The juice left in the bagasse: minus filter."
- FIBRE: "The dry water-insoluble matter in the cane."
- IMBIBITION: "The process in which water or juice is put on the bagasse to mix with and dilute the juice present in the later."
- MACERATION: "The process in which the bagasse steeped in on excess of water or juice, generally at high temperature." By the above definitions, maceration is a special kind of imbibition.
- DILUTION WATER: "That poetion of imbibition or maceration water in the mixed juice."

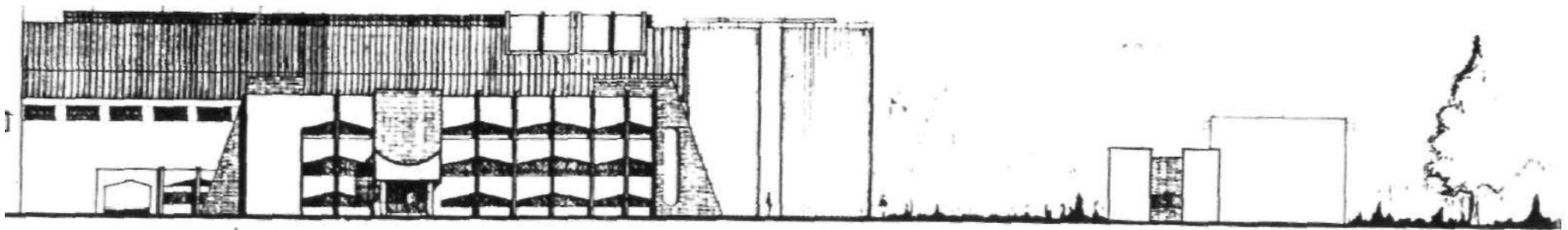
- SYRUP: "The concentrated juice from the evapourators, before crystallization has removed any sugar."
- MASSECUTTE: "The concentration syrup or molasses or in which the sugar has been crystallized or the material has been concentrated to a point where it will crystallize."
- FADAMA: "Swampy or water-logged areas."
- OIL BOOM: "The period between 1960-1982 in Nigeria."
- ACHABA: "Motor-cycle for transporting commuters."


LEGEND
SITE PLAN
SUGAR cane


POWER HOUSE
FIELD WORKSHOP
fire station
LOADING / OFF - LOADING BAY
CHEMICALS / GASES STORE
FACTORY WORKSHOP
CAR YARD
VISITORS CAR PARK
REFINING AREA
MILLING AREA
SPRAY POND
BOILER HOUSE
BAGASSE'S HOUSE

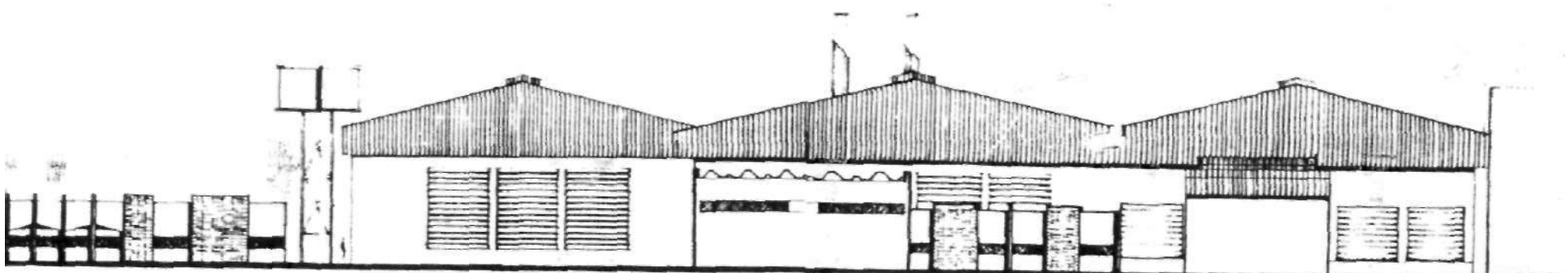

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FIRST FLOOR



EASTERN ELEVATION

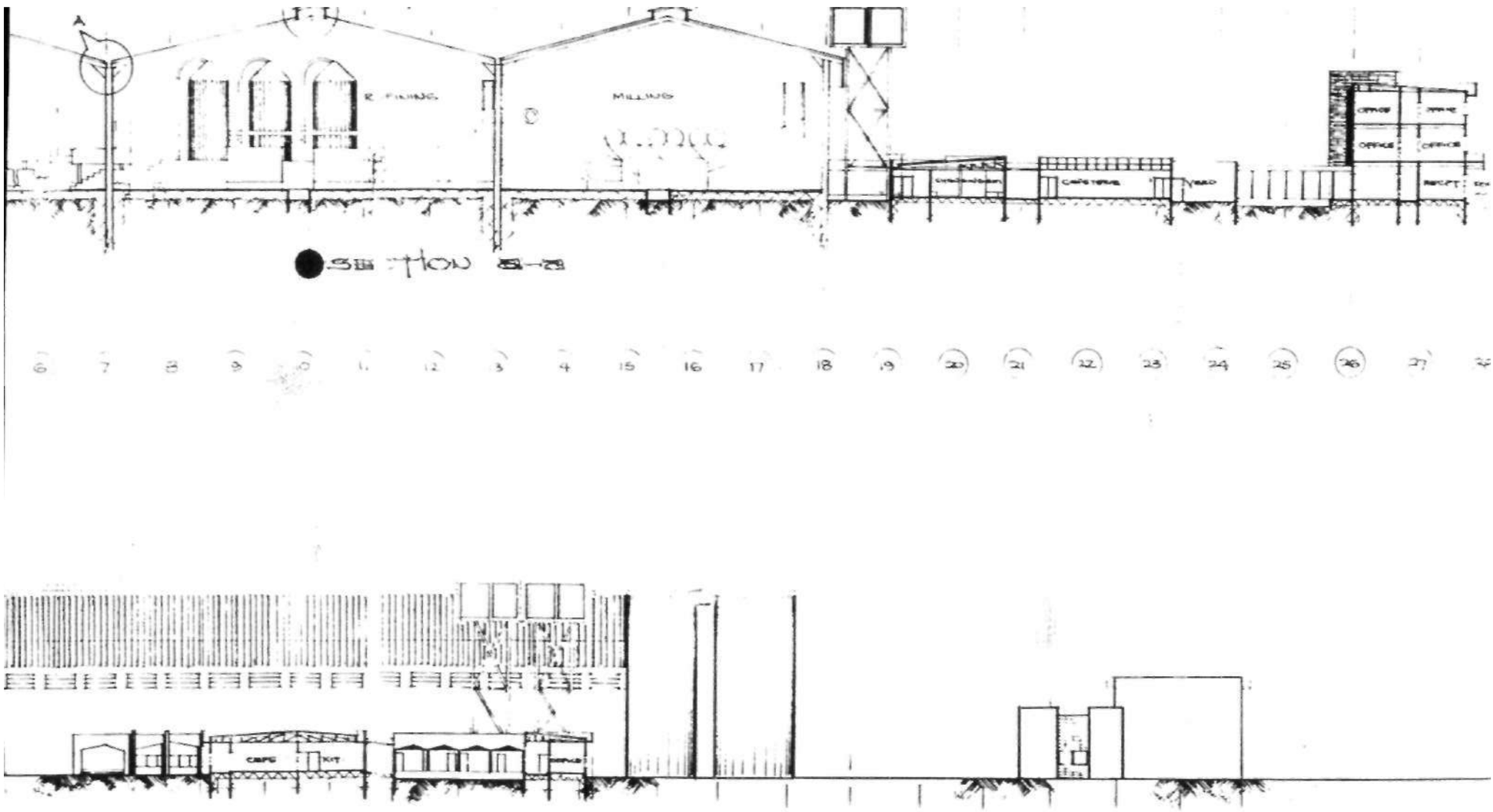
C D E F G H I J K L M N O P Q R S T U V



NORTHERN ELEVATION

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SUPERVISOR: ERC M.D. AHMED


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