INTEGRATED COCOA PROCESSING CENTRE
IBADAN

BY

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Master of Science in Architecture (M.Sc Arch)

Department of Architecture

Faculty of Environmental Design

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DECLARATION

I, Olagunju O.K. of the Department of Architecture, Faculty of Environmental Design, Ahmadu Bello University hereby declare that this thesis work has been a personal academic undertaking executed under the supervision of my mentor, Arc. A.A. MBINA of the Department of Architecture, Ahmadu Bello University, and that all quotations and information utilized and their sources have been duly acknowledged by way of references.

Student's Signature

Mentor's Signature

CERTIFICATION

This thesis entitled Integrated Cocoa Processing Centre Ibadan, by Olagunju Oladele Kit meets the regulations governing the award of the degree of Master of Science in Architecture (M.Sc. Arch) of Ahmadu Bello University, and is approved for its contribution to knowledge and library presentation.

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TO EVERYTHING THERE IS A SEASON AND A TIME

TO EVERY PURPOSE UNDER THE HEAVENS.

ECC. 3.1

DEDICATION

TO LAGUNJU'S FAMILY ESPECIALLY MY MOTHER WHO COULDN'T DENY SOME RESPONSIBILITY.

ACKNOWLEDGEMENT

Firstly, I am very grateful to my Heavenly Father for giving me grace, strength, wisdom and knowledge to succeed. Without him things might have taken a different course.

I am also indepted to members of my Family for their financial and moral supports they have given me in all my academic endeavours.

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I am also very grateful to all my other friends too many to mention for everything they have done for me.

ABSTRACT

The three basic essentials of life are food, shelter and clothing in their order of priority. The indispensability of food further makes it a very high priority area in the development of any nation.

It is "because of the importance of food and the very high priority accorded food industries in the national development plan that the author decided to concentrate this thesis on this area

Moreover, the importance of agricultural industrialisation cannot "be over-emphasized especially with the rapid declining situation of the economy of Nigeria, the over-reliance on importation of food items and high rate of unemployment all over the country.

However, cocoa "being one of the most important cash crops i.n Nigeria and especially in Oyo State, that is produced in abundant quantities can reliably support a processing factory using cocoa beans as the primary raw material.

THESIS TITLE:- INTEGRATED COCOA PROCESSING CENTRE

TOPIC; An architectural re-appraisal of the agric sub-sector as a means of enhancing economic development.

-

AIMS AND OBJECTIVES:

The project is aimed at undertaking a comprehensive re-appraisal of cocoa production within the context of economic development and also to architecturally enhance the process of production to complement exisiting facilitis in Ibadan at present that is (C.R.I.N) Cocoa Research Institute of Nigeria and (C.P.U) - Cocoa Development Unit.

DESIGN SCOPE:- The thesis will include the design of a processing plant that will have production and marketing ties with the existing facilities in Ibadan, Workers facilities, the administrative and auxilliary facilities

SITE:- The Owode industrial layout Ibadan is selected due to proximity raw materials and marketing of the industrial products.

Client:- Federal Government of Nigeria and Co-operative Farmers Society of Nigeria.

ARCHITECTURAL SIGNIFICANCE OF PROJECT

The design of industries in widest sense, is at least receiving great attention from architects. Not only do they set the problem of designing a suitable envelop for man and machinery to work in, but they must also achieve a satisfactory relationship between various elements involved and harmonise the often conflicting demands of several specialities. The architect must provide for the workers a high standard of creative comfort with efficient working conditions in the best possible environment. All these should be done within a cost manageable by the factory owners who always seem reluctant about workers comfort. The architect is faced with two seemingly uncompromising tasks; that of compromising the difficult to compromise. A proper investigation into the design of processing plant will, therefore, go a long way towards better planning of future industrial building in the country.

It therefore becomes imperative that the design of any industrial building be extremely flexible, because when industrial building is planned it is impossible to foresee what will be its ultimate development due to high rate of technological growth all over the world.

Flexibility, however can be of two types:- the general type or the specific type. In the general type of flexibility a facility is designed to be adaptable to any function e.g. industrial, recreation e.t.c.

In the specific type of flexibility on the other hand, provision is made only for changes with the defined category of functions; say industrial function.

The kind of flexibility of importance in this proposal, however, in the specific type. By careful planning of main design elements, by dimensional co-ordination of major building elements, changes in internal functions and easy future expansion would be facilitated.

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CHAPTER ONE

(i) HISTORY OF FACTORY DEVELOPMENT

(ii) CLASSIFICATION OF ENGINEERING WORKSHOPS

(iii) PLANNING A FACTORY

(iv) INDUSTRIAL DEVELOPMENT IN NIGERIA
(MANUFACTURING INDUSTRIES)

- Causes of industrial growth
- The tendencies in industrial investiment
- Strategy of industrial development
- Government control of industry
- Factors affecting location of industries
- Problems of industrial Growth
- Objectives of industrialisation
- Industrial policies
- Conclusion

CHAPTER ONE

(i) HISTORY OF FACTORY DEVELOPMENT

The history of factory development particularly that of the industrial development, in turn, has been one of continually changing requirements following improvements in production equipment, mechanical handling and motive power associated with shifts of philosophy from individual craftmanship to soulless production line. The latest inovation is soon outdated, and the buildings designed to accommodate it are often obsolete before they are commissioned.

(ii) CLASSIFICATION OF ENGINEERING WORKSHOPS

Engineering workshops can be classified into light, medium or heavy process.

Light process workshops.

These includes:-

(i) High precision work in laboratory - like conditions.

(ii) Small - scale craft workshops as are now being encouraged in both urban and rural areas.

Design of this type of workshops will depend on circumstances, but will tend to approximate to laboratory or office type design.

MEDIUM PROCESS WORKSHOPS

These workshops can be subdivided into:-

(i) Light - medium:- Small scale engineering, clothing factories, paint shops.

(ii) General - medium:- batch production of components for other industries, medium sized printing e.t.c.

(iii) Heavy - medium:- for industries requiring intensive use of buildings and services as in mass production.

Heavy process workshops:- Workshops such as steel-making and ship building require spaces (not necessarily enclosed) designed around the work or mechanical plant.

Traditionally, it is difficult to build adaptable structures, but modern handling techniques enable loose - fit buildings to be designed.

Planning A Factory

In the design of factories, the sizes of spaces are usually determined by the shape, size and number of machines, rigs or pieces of equipment rather than by the numbers of workplaces. There are no universal standards and as such areas must be assessed on an ad-hoc basis.

INDUSTRIAL DEVELOPMENT IN NIGERIA
(MANUFACTURING INDUSTRIES)

The government has taken a good step towards industrial development, hence the encouragement of skilled man-power through various training systems (in-service and other educational encouragements). Financially, there are various generous incentives for investors both foreign and local.

It can be said that the general trend of industrial development in Nigeria has followed a developing pattern from the history of craft industry of the villages, through the colonial local industries to the present stage of industrialisation in the country.

The history of Nigerian industrialisation can be traced to the last four decades when in 1946 the first development plan was launched when only about £300,000 (₦600,000) was provided for the department of Commerce and Industry.[1] This was for the acceleration of the tempo of industrial development in Nigeria by every possible means, scale and method for the achievement of maximum participation of Nigeria in industrial enterprises and also to secure a larger share of the world trade for Nigeria as well as a larger share of Nigeria trade for Nigerians.

Causes of Industrial Growth

The rise of both the volume of industrial investment and of industrial production since 1957 is a result of the following four reasons:

1. The increasing consciousness of the government after 1951, which can be understood from the 1952 "Aid to Pioneer Industries Ordinance" passed to encourage industrialization. It was to assist new industries to operate in the country with provision of incentives allowances and protection from initial problems. The most important of this include:
   (a) The Industrial Development - Import Duties Act 1967.
   (b) The Industrial Development - Income Tax Relief - Act 1958.
   (c) The Customs Duties (Draw-back) Regulations 1958.
   (d) The Income Tax (Amendment) Act, 1958[2].
   These were improved upon over the years through amendments to encourage the realisation of the various government policies. Moreover, land for the establishment were provided cheaply.

2. Foreign investors were appealed to and encouraged to invest in Nigeria in all types of industries except the public utilities - transportation, electricity, water and communication services. This was jointly agreed by the then three regional governments of the federation in August, 1957 and thus, the policy statement backing this up.
   That "The Government of the Federation of Nigeria of the Northern, Eastern and Western Region and of the Southern Cameroons" recognises that Nigeria

will for many years to come need overseas capital and managerial and technological skills, if her resources are to be developed to the extent which the government and the people of Nigeria desire. They realised that overseas investors will be reluctant to lend (and invest) their capital unless they can be assured that such investment and the skilled overseas personnel which may be necessary to make it successful will be welcomed. The purpose of this investment is to give such assurance and to assure foreign investors of the rejection of Nationalisation of private enterprise and guaranteed adequate compensation, should occasion call for Nationalisation".

3. The 1955 - 1962 Development Programme of both Regional and Federal Government which laid emphasis on industrialisation and provision of infrastructures that can induce industrial growth like high level man-power, electricity, transportation, communication and water supply.

4. Development of Finance Corporations to encourage new industries like Nigeria Industrial Development Bank (N.I.D.B.) and the directorate of employment for young graduate to establish small scale industries.

The Government realising the role of industrialisation in the imporovement of Nation's economy thus, encourage the setting up of industries that can use both local raw materials and man-power.

This in essence is to provide employment opportunities for Nigerians and to increase technical and managerial skills as well as to improve the market for local raw materials.

5. The present ban on importation of raw materials and emphasis laid on use of local materials so as to conserve our foreign earnings.

6. Cheap labour in the country due to the present economy glut.

<u>The Tendencies in Industrial Investment</u>

The influence of the foreign investors can be recognised from the 1962 - 1968 Development Plan when they were supposed to contribute one-sixth of the total capital formation which shows clearly the entrusting of the Nation's Economy in the hands of outsiders. This was corrected with the promulgation of the indigenisation decree of February, 1972;

- To maximise the local retention of profit.
- To increase the level of capital formation at both intermediate and higher levels.
- To create good opportunities for Nigerian indegenous business men.

<u>Strategy of Industrial Development</u>

The most import policy of Nigeria is to develop her industry as a means of promoting rapid economic growth.

Hence its industrialisation process is based on an INWARD LOCKING IMPORT SUBSTITUTION until recent years when some of these goods have been banned. The strategy recognises four basic sources of growth:

i. Growth in final consumer demand for the end products of manufacturing industries.

ii. Growth in intermediate demand, that is the increase in use of the domestic industries products (processing plants) for further productions in other domestic industries.

iii. Growth in export demand, to create an improved market for locally made products, e.g. Cocoa Cakes and Cocoa butter.

iv. Growth in the substitution of import by domestic production - import substitution.

Government Control of Industry

The influence of the government on the course of industrialisation process can be recognised from the initial minimal control during the rapid expansion and diversification of industry in 1950 through the time of the colonial government to the period between 1972 and now when the "Indigenisation Decree" among others was promulgated.

The major types of control include:

(a) Direct Control

By Acts, Regulation and Decree which stipulate specific regulation, operation and ownership of industries with penalties for non-compliance.

(b) Indirect Control

Schemes which induces individual companies and industries to operate their business in conformity with government policies and objectives.

(c) Physical Control

Law stipulating the conditions for the formation and operation of business within government influences.

(d) Financial Control

Ways of controlling money invested, spent and shared between share holders.

(e) Control of Entrepreneurs and Management

Conditions and term of employment of foreigners and indigenes.

(f) Control of Foreign Exchange

Conditions under which money can be sent into the country or invested out of the country and the amount.

(g) Control of Labour and Product

Quality and condition of service including the standard minimum quality of products for the market.

Factors Affecting Location of Industries

The factors affecting location of industries include social, economic, political and geographic factors and can be understood from the following:

- Availability of abundant raw materials.
- Availability of local labour both skilled and unskilled to be used in the industries.
- Availability of essential infrastructure ; water supply, electricity, good road and communication systems.
- Availability of land for development purposes.
- Availability of large market for the manufactured products.
- Availability of capital for financing it.
- There must be political stability to encourage the expansion and free working atmosphere.
- Availability of man-power both skilled and unskilled for the operations of the industry.

Problems of Industrial Growth

1. Infrastructural Constraints

   This is the lack of good transportation and communication system, water and electricity supplies.

2. Shortage of skilled technical man-power and relative shortshightedness of manufacturing industries to indigineous businessmen.

3. Difficulities of getting feasibility studies data to aid future/anticipated development.

4. High share of foreign capital and high degree of dependence on foreign entrepreneurs.

5. Scarcity of willing and competent foreign partners.

6. Restrictive industrial policies or administrative bottle-neck that exists within Nigerian systems.

Objectives of Industrialisation

The most important objectives of industrial development in Nigerian include:

- Creation of a greater and dynamic economy.
- Creation of an egalitarrian and just society.
- Creation of a free and democratic society.
- Provision of bright and full opportunities for all citizens..

Industrial Policies

- To ensure rapid expansion and diversification of the industrial sector of the economy.
- To increase the income realised from manufacturing activities.
- To create more employment opportunities.
- To promote even development and fair distribution of industries in all parts of the country.
- To promote the establishment of industries which cater for overseas markets in order to

earn foreign exchange.

- To expand the programme of import substitution as well as raise the level of intermediate and capital goods production.
- To initiate schemes designed to promote indigeneous man-power development in the industrial sector.
- To raise the proportion of indigenous ownership in aggregate industrial investments in Nigeria.

Conclusion

The underutilized natural resources of Nigeria can be exploited to the brim and the industrial sector expanded to the maximum if the abundant local natural resources including both human and material as well as the large domestic market due to large population efforts can be exploited and fully encouraged.

Hence with improved enlightenment, better education, the future of industrial development in Nigeria is very bright.

CHAPTER TWO

(I) INTRODUCTION

(II) COCOA - THE RAW MATERIAL

(III) COCOA BEANS PROCESSING

CHAPTER TWO

I. INTRODUCTION

(a) - Introduction

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II. COCOA - THE RAW MATERIALS

(a) - Maintenance of Cocoa Farm

(b) - Harvesting, Fermentation and Drying of Cocoa

(c) - Cocoa Beans Quality

(d) - Cocoa Production History

III. COCOA BEANS PROCESSING

(a) - Beans Cleaning

(b) - Roasting

(c) - Winnowing

(d) - Grinding or Milling

(e) - Pressing of the Cocoa Liquor

CHAPTER TWO

I. INTRODUCTION

(a) Introduction:-

Like rubber, cocoa production went into decline at the height of the oil boom. Nigeria's cocoa yield potentials were either under-developed or abandoned outright for more lucrative import trade and government contracts.

Plantations that remained in production sold their produce to Nigeria Cocoa Board at a pittance.

Cocoa's bounce back to the limelight as a major export commodity was aided by two factors. The oil glut which necessitated the return of agro-based alternatives to oil, and the scrapping of the commodity board which had erstwhile enjoyed the monoply of export trade in cocoa.

Farmers and businessmen alike suddenly realised the new potentials in cocoa trade. Business adventurers and speculators joined in the scramble and price of cocoa at the form level soared. Nigerian farmers enjoyed a boom like never before. For many exporters cocoa has not only become a status symbol, but a means of repatriating money overseas.

Today, cocoa ranks second only to oil as foreign exchange earner, thus becoming the nation's soaring grace in face of economic decline. In the 1986/87 season, alone, the total production figures rose to 88,000 metric tonnes.

Projected figures for the current season is put at approximately 140,000 metric tonnes(1).

Due to cocoa's new position as a valuable export commodity, a three man team from the International Trade Centre (IIC) an arm of UNCTAD, Geneva, educated Nigeria Cocoa farmers and exporters on the technicalities of cocoa production and trade, at the Cocoa Dissemination Seminar just ended in Lagos (Jan. 1988).

According to the experts, Gill and Duffus cocoa market report, Nigeria cocoa rates as one of the best in the world market. This good reputation became slightly tarnished at onset of the cocoa scramble when cocoa export trade became an all comers market following the scrapping of the Commodities Board.

The Nigeria cocoa rated by the experts as sligh1y lower than Ghana cocoa is used in blending most other cocoa beans for the production of chocolate and other cocoa products for improved flavour. But the Cocoa Association of Nigeria (CAN) sees this allegation as blackmail and international consipiracy to force down the price of the Nigerian Cocoa since the genetic and productional quality of Nigerian cocoa is not in doubt.

(b) Discovery

Since the discovery of mild cocoa plant by the Americans, the production and use has spread across the world. In regions where cocoa did not thrive, the crop was consumed in one or several of its processed form. Chocolate is

particularly favoured in temperate countries because of its low melting point. Chocolate which solidifies after melting loses its eating value.

The world's total cocoa production for 1986/87 period was put at about 1,957,000 tonnes. Of this, Africa produced 55.6 percent, America 29.5, Asia and Oceania 12.4 percent and West Indies 2.5 percent.(2)

For the same period Western Europe consumed 37.1 percent of cocoa grindings followed by Americas at 33.3 percent Eastern Europe 13.5, Asia 8 percent and Africa 8.2 percent.(3)

Only very few crops are as versatile as cocoa. From the discarded pods to the shells of the cocoa beans, every item is useful. While pods and shells may be considered as waste in some countries, others have found various uses for such waste.

The cocoa beans is the most valuable part of the crop. The harvested cocoa crop is processed for the beans which are fermented before inn-drying to reduce its moisture content. It takes the beans about three months from farm level to world market at the earliest.

The fermented and well-dehydrated beans is pressed into cocoa liquor (paste). This pure cocoa mass contains about 55 percent cocoa butter, and 45 percent cocoa cake ground into powder.

When pressed 250 metric tonnes of cocoa beans gives about 95 tonnes of Butter, 105 tonnes of cocoa powder(4).

The rest is waste, made up of shells and moisture loss in production.

Cocoa beans sell at a much lower rate than butter. While the cake is the cheapest product.

But Nigerian exporters find it is easier to export cocoa butter as this fetches high revenue and reduces complications arising from food and drugs regulation of the various importing states and spoilage in transit.

(c) Uses

The use of the cocoa beans are diverse and numerous. The butter is used in confectionery, pharmaceutical and cosmetic industry. Chocolate is obtained from the cocoa mass, while the powder is utilised in dairy and confectionary industry.

With such versatile range of use, the cocoa trade is not only lucrative but essential. But as with export commodities, the danger of over-production is always very near its economic successes.

(d) Problems

On the home front, problems facing the farmers have been that of disease, high cost of pesticides labour and other overheads. Price fluctuations also make long-term planning or other economic capitulating meaningless. As of now, the farmers are at the mercy of world market prices which hikes or depresses in the asking price.

Since 1946, the cocoa trade has been characterised by sharp fluctuations, with prices hitting rock bottom at the peak of production. To maintain fair market level, over expansion should be curtailed while increased home consumption by the producer nation is expedient.

II COCOA - THE RAW MATERIAL

Cocoa is the botanical name and refers to the tree, the pods, and the infermented beans from the pods, cocoa refers to the manufactured product that is, the powder sold as beverages and for food manufactured but of recent has been used to describe the fermented beans in bulk.

Cocoa beans of commerce are the seeds of tree species theobram Cocoa 1 (indigenous to South America) which consists of twenty species of small bushes and trees.

Types:- T cocoa is the only one of commercial value and is divided into main groups namely "Criollo" C Cocoa seed without colour and "forasters" C cocoa seed with purple cotyledon but there is a third group known as "Trinitario" which is a breed between the former two.

Forasters is the most important commercial type, Trinitario constitute about 5% of the world's production with criollo less than 1%.

The cocoa tree grows to an average height of 7-10 meters and requires some shade from larger forest trees. From the time the seedling reaches a height of 1-2 meters, it throws out 3-5 fan branches.

(a) MAINTENANCE OF COCOA FARMING

The maintenance of a cocoa farm is an all-year programme embracing various operations at different periods of the year. The operations vary with factors such as climates fertility of the soil, age and vigour of cocoa trees and method of establishment of the cocoa farm. If the maintenance is correctly and adequately carried out; diseases and weeds will be less of a problem and their control can be achieved far more efficiently and effectively through weeding, mutching, shade management pruning, regeneration, replacement of dead trees.

(b) HARVESTING, FERMENTATION AND DRYING OF COCOA

HARVESTING: Pods are removed from the trees by cutting clearly through the stalk, care must be taken to avoid damage to cushions, since such damage can reduce bearing and permit entry of fungi. Knives are used to remove pods within arm's length and hooks for those in upper reaches of trees.

Ripe pods assume a distinctive coloury, green pods turning yellow, red pods and orange shade.

To keep farms clean of waste materials a pontential source of disease, fermentable pods are conveyed to the fermentary and hiks are remove there.

FERMENTATION AND DRYING OF COCOA:

Fermentation and drying of cocoa is done in the fermentary. The beans with pulp removed and transferred to heaps, boxes or baskets for fermentation to take place which lasts for about 5-6 days with the

temperature increasing from 32-50°C(5). It is important to give occasional mixing to earate the beans. After fermentation, the beans are placed in shallow trays or mats to try. In West Agrica where the sun is hot enough, the beans are sun-dried while in places like South America, dryers such as chula, samoon, and mechanial dryers are used.

The development of good chocolate-flavour depends mostly on good fermentation, drying and storage of the beans together with controlled processes of manufacture.

FLOW DIAGRAM OF COCOA FERMENTATION

WET BEANS

IN HEAPS, SWEAT BOXES OR BASKETS

Breakdown of pulp and drainage of sweatings

Access of air at surface of mass

Bacterial oxidation of alcohol to acetic acid

death of beans

loss of germinatory power

Destruction of coloured anthocynains

Development of chocolate aroma and flavour potentials

(c) COCOA BEANS QUALITY

The importance of a consistently high standard of quality in cocoa beans cannot be over emphasised. The bulk of the World's cocoa is used in the manufacture of chocolate the quality of which depends solely on the quality of the cocoa beans processed. Chocolate is food. It is paramount therefore for growers, manufacturers and everybody else involved in the cocoa industry to be conscious of the cocoa beans quality and to strive to maintain high quality standards.

The grade standards as laid down by the World's standard bodies such as the cocoa Association of London (CAL), the Association Francaise du Commerce des Cacao (AFCC), the United States Cocoa Merchants Association (CMA) and the codex Alimentarius commision are shown in the table below.

TABLE I:- COCOA BEANS GRADE STANDARDS(6)

	% Slatey	% Mouldy	% Other defects
GRADE I	3 Max counted	3 Max counted	3 Max counted
GRADE II	8 " "	4 " "	6 " "
NO GRADE	78	74	76

Slatey:- Beans are characterised by grey slate colour and cheesy texture.

Mouldy:- Appearance of visible moulds.

Other defects:- Coerminated, flat smoky.

The Cocoa Beans are also classified as Main Crop or Light Crop (Lic) depending on the beans size and informity % shell content and % fat content.

Finally, it is pertinent to say that normal manufacturing process will not improve the defective state of a consignment of cocoa beans particularly in respect of defects relating to flavour, so Grade I main crop (M.C) beans should be used.

(d) COCOA PRODUCTION HISTORY

Cocoa as a commodity crop is produced in 32 countries of the world in varying degrees of intensity. Prominent amongst World producess of reput are in major countries that account for about 72% of total World production as follows(7).

Ivory Coast	=	29.6%
Brazil	=	19.3%
Ghana	=	11.2%
Malaysia	=	6.5%
Nigeria	=	6.2%
Cameroun	=	6.1%

It is an undisputable fact that cocoa is a political crop and as such plitical decisions are always made in cocoa producing countries to reflect the thinking of the leaders of those countries.

III. COCOA BEANS PROCESSING

Cocoa beans processing involves the following stages of operation in sequential order.

(a) BEANS CLEANING

The beans are cleaned to remove foreign matter such as stones or pebbles, twigs, strings, metallic objects etc. Uncleaned or poorly cleaned beans will lead to - damage to machine parts

- poor quality of finished products.

(b) ROASTING:

The cleaned beans are roasted to:

- develop the inherent chocolate flavour derived in the finished product.
- reduce moisture level
- make the shell loose and easy to remove.

The roasting stage is critical to the quality of the finished product. It is during roasting of the cocoa beans that the chocolate flavour most desired by the manufacturer and the consumer of the finished product is developed. This operation therefore calls for skillful and careful handling. Here the beans size and uniformity are of vital importance as nonuniform size beans will not roast evenly. Here also attention is paid to quality. Highly slaley and highly mouldy beans will be expected to produce off flavours.

The level of moisture in the roasted beans is expected to be less than 2%.

Higher level of moisture will be attended by process problems such as poor flow of the liquor along the process lines. Good roasting will give rise to good grading and easy release of fat from the cocoa solid.

Typical composition of roasted cocoa beans(8).

Nibs 87.1% containing about 55% fat

Shell 12%

Germ 0.90%

(c) WINNOWING

Winnowing is the process of breaking the roasted beans followed by the seperation of the shell from the flesh (cotyledon or cocoa rib). Complete seperation of the shell from the ribs is not possible but the level of shell in ribs or ribs in shell is usually kept below 0.5%. Excessive level of shell in ribs poses difficulty in grinding while excessive level of ribs in shell results in lowering of yeild of product.

(d) GRINDING OR MILLING

In the process of grinding, the roasted cocoa ribs are transformed into a paste or fluid cocoa called cocoa masse or cocoa liquor. During the grinding process the cocoa fat is released in the heat that accompanies the mechanical process. Thus in the liquor or masse the cocoa solid swims in the sea of its own butter or fat. No water is added.

The degree of finess of the liquor or masse depends on.

- The type of mill used. There are various types of mills designed for different stages or grinding. We have mills for primary, secondary or tertiary grinding.
- The number of stages of grinding.
- The desired level of finess of the finished cake or powder as specified by the customer or end user.

The two grade of finess commonly requested for by the end user of the cocoa cake or powder are:

- less than 2.0% residue on 200 mesh sieve
- less than 10.0% residue on 200 mesh sieve

(c) PRESSING OF THE COCOA LIQUOR

Pressing is the process of compressing the cocoa masse or liquor to the extent that the free and available butter sips out of solid cocoa.

Prior to pressing, the cocoa liquor is held or stored in tank at specified temperature and for specified period to mature. During this period the moisture level of the cocoa liquor is brought down to a level desirable (below 1.5%) for easy pressing. Also during the heating process the level of bacteria in the material is brought down to a tolerable level. The heating is controlled to prevent overheating and subsequent damage to the cocoa butter.

The amount of butter pressed out of the cocoa liquor depends on:

- the level of fat required in the residual cocoa solid (cake) as specified by the user.

We have low fat (10-12% fat) cake as well as high fat (20-22%) cake.

- The efficiency of the presses.

The cocoa butter pressed out of the presses is passed through hydraulic press fillers to remove the cocoa solids in it. The filtered butter is then tempered and packed in corrugated craft paper cartons in units of 25kg weight. The butter flows out of the tempering machine chilted and fluid but soon solidifies inside the cartoon. The butter is stored in an air conditioned room of 22°C prior to shipment. It takes about 2 weeks for the solidified butter to mature.

The melting point of cocoa butter is 34°C and will therefore remain solid under normal ambiant room temperatures. The residual cake is discharged from the press in form of discs each weighing about 8-9g. These are fed into kibblers which break down in manageable pieces (kibbled caked). The kibbled cake is packed in poly propylene bags lined with nylon in unit weights of 40kg for export.

The cocoa cake is referred to as Natural/ordinary cake if no chemical has been added to the cocoa during processing while the cocoa cake is called Alkalised cake if an alkali (e.g. sodium or potasium carbonate) has been added. The process of adding solution to the cocoa ribs or cocoa liquor is called Alkalization or simply the Dutch process.

The Alkalised cocoa cake is usually pulverised into cocoa powder for use in beverage manufacture.

A yield of 80% is expected in cocoa processing. That is for every 100 tons of cocoa beans processed 80 tons of butter and cake are expected. And of the 80 tons cocoa cake portion is expected to give + 45 tons while the butter portion will be + 35 tons.

The overall yield may in fact be less than 80% if the starting raw cocoa beans contain a lot of fat beans or high percentage of shell.

The cocoa butter and cake are immediate products which are further processed to produce other products.

NOTES

1. SUSANNAH O. - "COCOA".
DAILY TIMES, FEB 9 1988
P7

2. Ibid, P7

3. Ibid, P7

4. ADVISORY PAMPHLET No 1 - "COCOA"
COCOA RESEACH INSTITUTE OF NIG.
MAY 1986 P4.

5. ADVISORY PAMPHLET No 6 - HARVESTING, FERMENTATION AND DRYING OF COCOA
COCOA RESEARCH INSTITUTE OF NIG.
MAY 1986 P1

6. Ibid P10

7. YESUFU T.A. - COCOA
A PAPER PRESENTED AT A COCOA CONFERENCE AT AKURE (ONDO STATE) Organized by the Nigeria Export Promotion Council (NOV. 1987) P1

8. Ibid P2.

9. Ibid P3.

CHAPTER THREE

CASE STUDIES

(1) COCOA INDUSTRIES LIMITED, IKEJA, NIG.

(2) COCOA PRODUCTS FACTORY, TAKORADI, GHANA

CASE STUDIES

The purpose of carrying out case studies when designing a factory are:

(a) To examine the principles involved in the design of such factory.

(b) To see how the predecessors translated these principles into reality.

(c) And to analyse the problems as per the design of the factory so that the proposed factory will be devoid of these problems.

Research work for the purpose of case study has been carried out on 2 major cocoa industries in West Africa, namely:

(1) Cocoa Industries Limited, Ikeja, Nigeria.

(2) Cocoa Products Factory, Takoradi, Ghana.

Geographically, these two industries are situated in the Southern part of West-Africa hence they share in common sc many factors affecting industrial goods and service production e.g. climatic condition etc.

THE COMPARATIVE ANALYSIS OF CASE STUDIES

(a) Site

1. C.P.F. Takoradi Ghana

56 Arces (22.7 Hectares) South of city centre in area designated for both residential and industrial development site is prominent. Site on undulating ground and adjacent to valley which is public open space.

As impact of project on adjacent residential community would be considerable landscaping assumed exceptional significance client mounted exhibition to explain project to local community groups.

(ii) C.I.L. IKEJA NIG.

A member of C'dua group of companies is located in Ikeja industrial estate in Lagos State of Nigeria. It was incorporated in 1965 with commercial operations commencing in 1967 and expanded in 1975. The present factory covers an area of 14 acres in industrial area.

(b) GENERAL INFORMATION

1. C.P.F. TAKORADI

DESIGN TEAM:- SOM + PRT GHANA

ARCHITECTS:- SOM + PRT GHANA

STRUCTURE:- Felix J. SAMUEL & PARTNERS

SERICES:- STEENSEN Varm harm & Partners

QUANTITY SURVEYORS:- Gleeds

LANDSCAPE:- Kenneth Booth

SOUND CONTROL:- The Wolfson Unit.

Project Team

W.D & H.O. Wills project group materials handling consultants modern materials management and design team.

Building Team

Constructed by thyssen stahlunion of Dusseloorf in 1963, GHANA.

(d) Zoning

(i) C.P.F. TAKORADI

The factory is not properly zoned. The administrative block is in front of the production Hall. The workers facilities are to the side a little far back. The auxilliary facilities and loading bays are behind the production hall. The security blocks are by the two gates. See fig.

(ii) C.I.L. IKEJA

The noisy and dirty zone of the factory (for example production hall, maintenance workshop) are sited at the hall while the quiet and lean zone (for example admin block, framing school) are infront but the fuel tank and one of generators are also infront which give the factory an unsightly impression. The workers facilities like canteen and clinic are close to the administrative block while the maintaince workshop is close to the production hall. There is a well defined loading bay front of the production hall. The laundry and fire station which are less often in use are a bit on the far side of the factory. The visitors car park outside the factory, while only the executives have a defined car park in the factory, the other workers just park anywhere as long as you are not obstructing the road. There is a gate house with clock-in facility by the gate. See fig.

(c) WORKERS FACILITIES

(i) C.P.F. TAKORADI

Workers facilities available are senior and junior canteens, clinic Training School, changing rooms and toilets common rooms and library.

(ii) C.I.L. IKEJA

Some are above excluding common rooms and library.

(f) Interior Design

(i) C.P.F. TAKORADI

In the two factories, there are good colour impact where the colours of the machines, services pipelines, wall and floors are complementary to each other for good working conditions.

(g) Services

(i) C.I.L. IKEJA

There is laundry where all the overalls are washed weekly. Waste dispose by the use of dust bins. Apart from fire in sulating materials used in construction of the buildings there is fire station on site in case of any fire outbreak, good sanitary conditions for high standards of hygiene.

(ii) C.I.F TAKORADI

Same as above including fire extinguishers in the production hall while there are fire fitting fighting pumps and hydrants with a radius circulation of 25meters outside the hall.

(h) PRODUCTION FLOW

C.I.L. IKEJA

The processing is orthodox in the sense that the high graded beams are subjected to the traditional sequence of processing involving bean cleaning

roasting winnowing, rib grinding pressing, clarification, tempering and pàcking of cocoa butter. The production flow is a straight line.

(ii) C.P.F. TAKORADI

Same as above. But the production flow is "u" shaped

(I) Flexibity

They all have flexible production halls, that is without major changes, building can be used for new production technology or for different activities of the factory.

(J) Future Expansion

(i) C.P.F, TAKORADI

Has vast land behind the factory fence for future expansion, not appropriate and well planned.

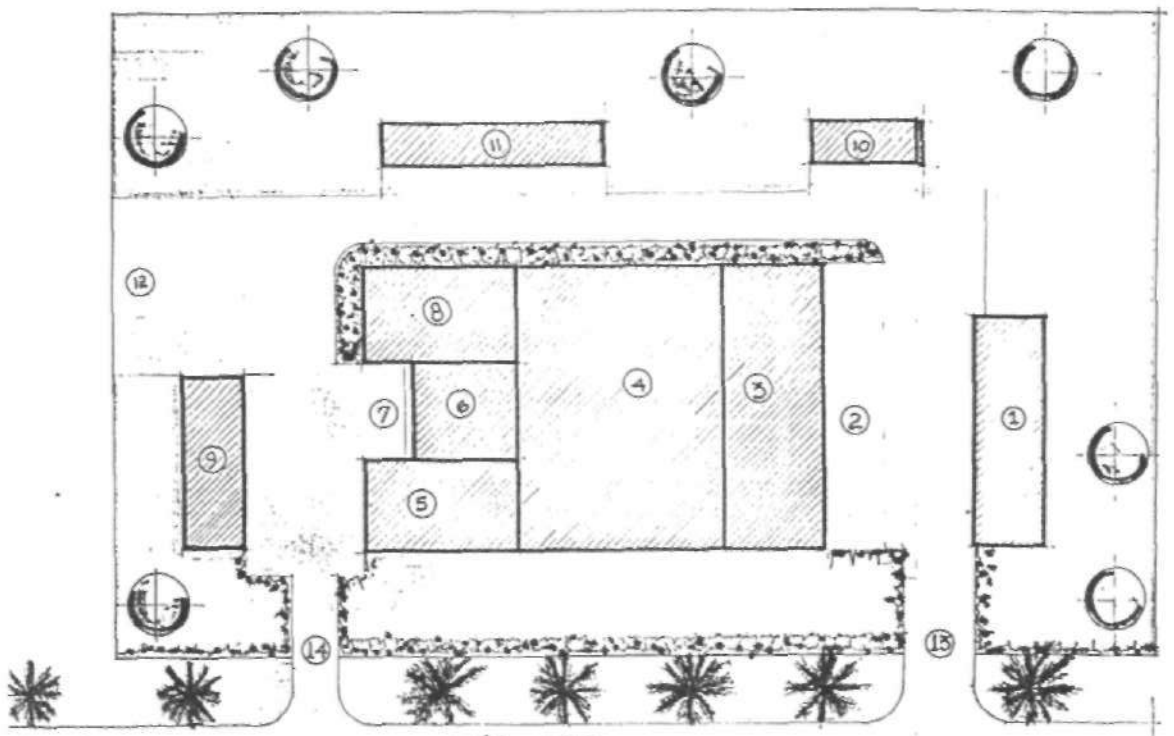
(ii) C.I.L, IKEJA

Has very little land for future expansion.

Findings

- Use of high building to house some machines due to special function is needed to be performed by the machines -
- Farness of changing rooms.
- Inadequate office accommodations.
- Use of manpower for intermediate flow during processing reduces production.
- Adequate land needed due to technological growth.
- Best production flow is u-shaped.
- Good zoning needed.

cocoa products factory takoradi 'GHANA'



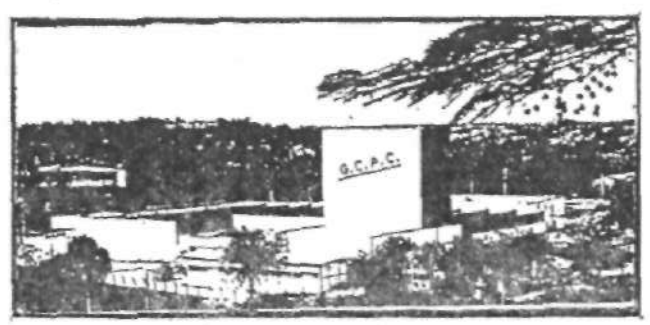
key

1 ADMIN BLOCK.
2 CAR PARK.
3 PROCESS FUNCTION
4 PRODUCTION HALL
5 RAW MATERIAL STORE
6 OFFICES
7 LOADING BAY.
8 PACKING AND STACKING OF FINISHED PRODUCTS
9 AUXILIARY BLOCK.
10 BOILER HOUSE
11 CATEEN, CLINIC, EDUCATIONAL CENTRE
12 ENTRANCE FOR LORRIES
13 ENTRANCE FOR CARS.

SITE

56 ACRES (22·7 HECTARES) SOUTH OF CITY CENTRE IN AREA DESIGNATED FOR BOTH RESIDENTIAL AND INDUSTRIAL DEVELOPMENT. SITE IS PROMINENT SITE ON UNDULATING GROUND AND ADJACENT TO VALLEY WHICH IS PUBLIC OPEN SPACE. AS IMPACT OF PROJECT ON ADJACENT RESIDENTIAL COMMUNITY WOULD BE CONSIDERABLE LANDSCAPING ASSUMES EXCEPTIONAL SIGNIFICANCE CLIENT MOUNTED EXHIBITION TO EXPLAIN PROJECT TO LOCAL COM

layout



SITE PERSPECTIVE

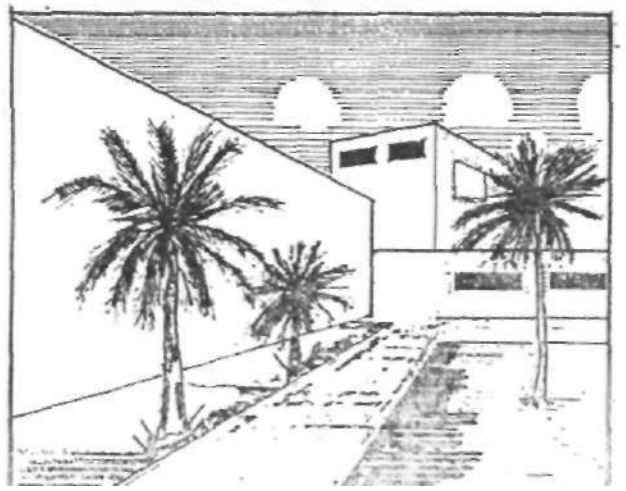
DESIGN TEAM.
ARCHITECTS: GAM + PRT GHANA
STRUCTURES: FELIX J. SAMUEL & PARTNERS.
SERVICES : STEENSEN VARIA HAM & PARTNERS
QUANTITY SURVEYORS: GLEEDS.
LANDSCAPE: KENNETH BOOTH.
SOUND CONTROL: THE WILFSON UNIT.

PROJECT TEAM.
W.D & H.O WILLS PROJEC GROUP MATERIALS HANDLING CONSULTANTS. MODERN MATERIALS MANAGEMENT, AND DESIGN GAM.

BUILDING TEAM.
CONSTRUCTED BY THYSSEN STAHLUNION OF DUSSELDORF IN 1968.

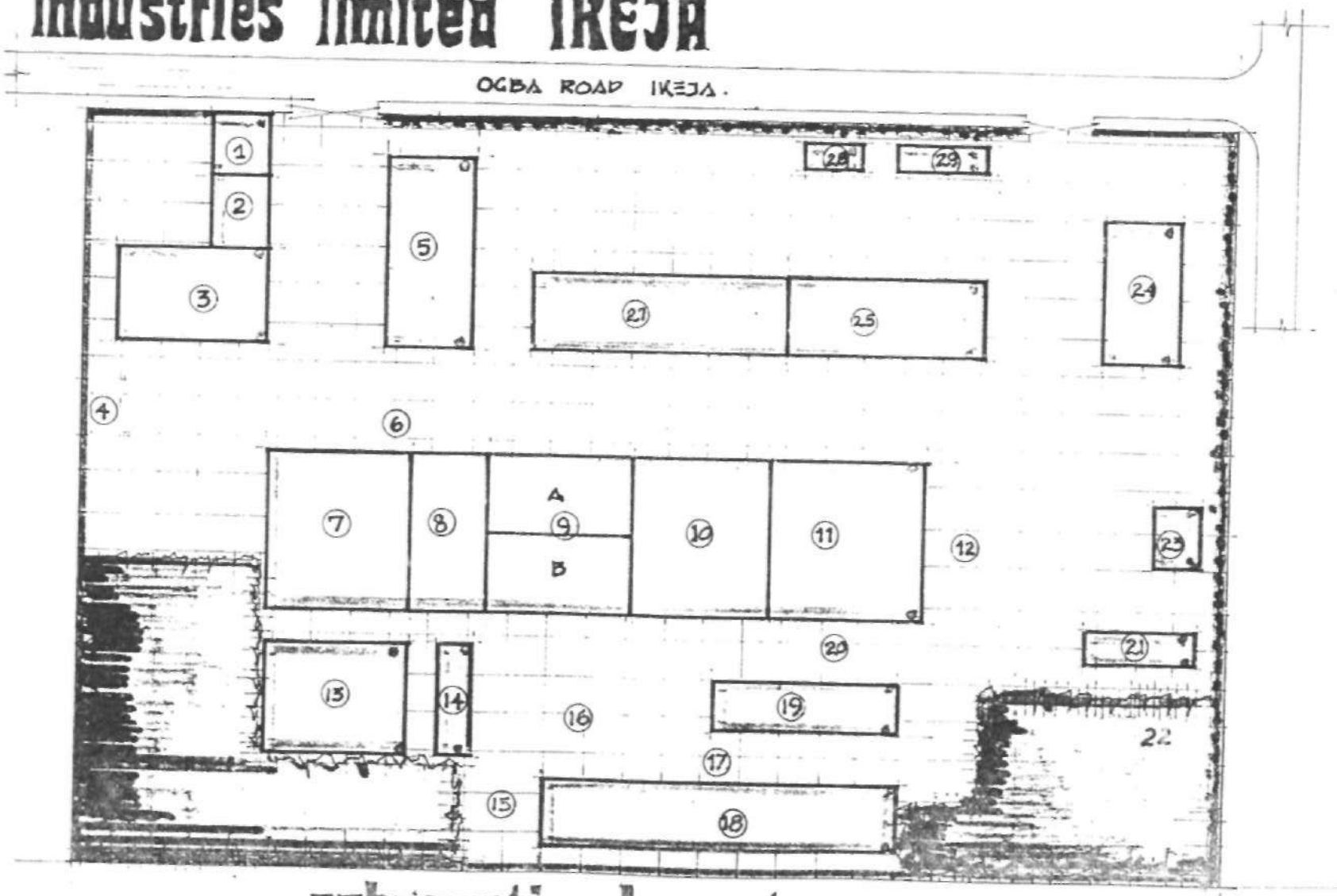
CLIENT.
OPERATED BY THE GHANA COCOA MARKETING BOARD.

INTERIOR PERSPECTIVE



case study 2

cocoa industries limited IKEJA



schematic layout

key

1 GATE HOUSE.
2 CLOCK-IN.
3 ADMIN / ACCOUTS.
4 CAR PARK - STAFF.
5 PERSONNEL & TRAINING MANAGER/CLINIC
6 LOADING BAY.
7 VITALO PRODUCTION HALL.
8 FINISHED PRODUCT STORE.
9 COCOA POWDER AND BUTTER 'P' HALL.
10 PRODUCTION HALL.
11 COCOA BEANS STORE AND PROCESSING
12 OFF LOADING BAY.
13 FACTORY EXTENSION.
14 MARKETING / PRODUCTION STAFF.
15 WORKERS CAR PARK.
16 CARPENTERS WORKSHOP.
17 CAR PARK.
18 AUXILLIARY WORKSHOP/OFFICES.
19 WATER TREATMENT PLANT.
10 WASTE PRODUCT
21 MAINTANENCE CAR PARK.
22 MAINTANENCE YARD.
23 FIRE STATION.
24 QUALITY CONTROL DEPARTMENT.
25 CANTEEN.
26 CANTEEN.
27 KITCHEN.
28 FUEL TANK.
29 GENERATOR HOUSE.

SITE.

A MEMBER OF ODUA GROUP OF COMPANIES IS LOCATED IN IKEJA INDUSTRIAL ESTATE IN LAGOS STATE. IT WAS INCORPORATED IN 1965 WITH COMMERCIAL OPERATIONS COMMENCING IN 1967 THE PRESENT FACTORY WAS BUILT IN 1975. CIL MAKES DRY COCOA MIX NAMELY 'VITALO' AMONG OTHER THING.

BUILDING TEAM.

JOHN LAING CONSTRUCTION (MANAGEMENT CONRACTORS) WILLS PROJECT GROUP AND DESIGN TEAM.

SITE:

14 ACRES. IN INDUSTRIAL AREA.

CHAPTER FOUR

(I) FACTORY PRODUCTION PROCESS

(II) PRODUCTION FLOW DIAGRAM AND TECHNOLOGICAL LAYOUT

(III) ANALYSIS OF NECESSARY MACHINES

(a) The dry stoner

(b) Continous convectional beans roaster

(c) Winnower

(d) Beater blade mill

(e) Agitator ball mill

(f) Vacuum mixer -

(g) Presses

(h) Cake crusher

(i) Powder plant

(j) Pressurized cooler with Pre-cooler cocoa butter

(I) FACTORY PRODUCTION PROCESS

For many people, design as an expression conjures up a concern with aesthetics, that is to say, an appreciation of the beautiful. On the other hand, technology, is regarded as being concerned with the technical means of achieving a given goal. The former seems very much a theoritical and abstract approach while the latter is a pratical down-to-earth business.

There are many definitions of design, but a useful one is, a purposeful plan before creative activity. However, without some understanding of the technology of material in which one is working, it is impossible to design effectively especially for an industry. There is little doubt that the design of an industry and the technological process of its products are very close partners in any creative activity of a three-dimesional nature. This close relationship, although they are not always equal partners, should become established in the designer's mind.

It is in the light of the fore said that detailed study of the production process and technology of the proposed factory was undertaken.

A factory either has a layout based on production or on a process. If a factory produces a large quantity of a few products, then the design is functioned on

production layout while if a factory produces a great number of products, each relatively small, run by similar processes, then the design is functioned on a process layout. The proposed factory design is based on product layout since only 4 products of large quantity are to be produced.

There are 2 basic classes of raw material used in industrial processes namely:

(a) The unprocessed raw material.

(b) The semi-processed raw material: This is the raw material that has already undergone some industrial process from the crude form.

In this industry, the unprocessed raw material is the cocoa beans. A foresight into production process is available in (Chapter 2 page).

There are 4 finished products to be produced by this factory are:

(a) Cocoa powder

(b) Cocoa cake

(c) Cocoa butter

(d) Shell

These raw material (cocoa beans) are brought to the factory by trailers and vans which offload the goods in the delivery bay from where they are transported by forklifts to the store. The store keeper keeps records of all deliveries and issuings.

From this the cocoa beans goes into processing through the following sections as discuss in Chapter 2.

(1) Bean roaster/Winnower section.

(2) Beater blade/Refinery section

(3) Press section

(4) Cake section

(5) Powder section

(6) Cocoa butter section

(7) Packing section.

See production flow diagram fig. over leaf.

(II) PRODUCTION FLOW DIAGRAM AND TECHNOLOGICAL LAYOUT(1)

(III) ANALYSIS OF NECESSARY MACHINES

(a) The dry stoner (cleaning machine)(2)

- Function - To remove stones and other particles from the cocoa beans and discharge them through the stone outlet.
- Type Range

  three dry stoner sizes are available

  1) MTSB - 50 = $0.5m^2$ Area of sep plate

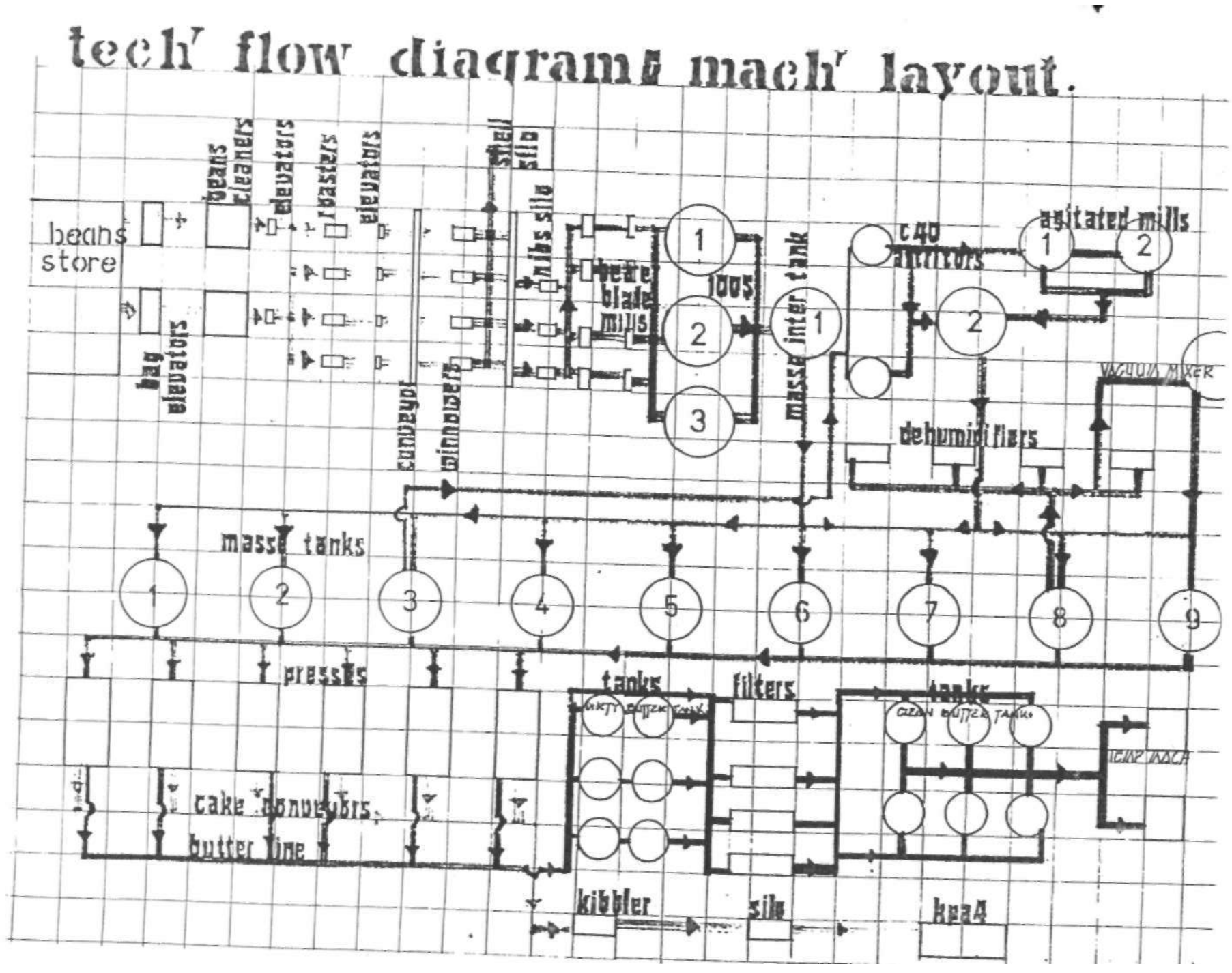
  2) MTSB - 100 = $1.9m^2$ " " " "

  3) MTSB - 150 = $1.5m^2$ " " " "

  All the 3 sizes can be supplied in reinforced design for abrasive products.
- Erection

  level lenght and width of substructure in horizontal position with the aid of a sprit level and both to the fixing holes in the bottom.

tech' flow diagram & mach' layout.



(b) Continous Convectional Beans Roaster(3)

The machines uses cheap gas to roast the cocoa beans thus preparing it for easy breaking for further processing.

(c) Winnower(4)

- Function:- The machine serves to crush raw, roasted or Kiln - dried cocoa beans and to subsequently separate the shells from the nibs, thus obtaining a product with an absolute minimum number of shells.
- Type

BR 62 - made by Bauermeister Company

Connected load	KW	16
Air thoughput	M^3/m	3780
length	mm	4150
width	mm	3300
height	mm	2.636
weight	kg	4300

(d) Beater Blades(5)

- Function - for the continous grinding and subsequent vacuum processing of pre-dried and roasted cocoa nibs as well as other raw materials with a high oil content. No after - roasting during the grinding due to sufficient cooling within the mill. Smooth product handling achieves optimum floor properties.

- Type

Vacuum Veater Blade Mill SMT 800V

Throughput	Kgs/h	up to 1000	
Sieves	mm	0.15 - 0.5	
Connected load		mill vacuum unit	
		48.61	4.25
length	mm	2320	1550
Width	mm	1460	900
Height	mm	2180	2410
Weight	Kgs	1850	200

- Floors

There will serve all floors resisting to more than 800Kg/m^2. Bases are required only if the height of 355mm for the product discharge is not sufficient, or if an easier maintenance of the v-belt shall be secured.

The dymanic load of the floor is low and must not be taken into consideration. It is very important that the machine is perfectly levelled across the conveying direction of the dooring apparatus.

e) Agitator Ball mill(6)

- Function - The liquor fed into the mill is ground by the balls moved by the agitator and pumped out from below by liquor pump. The ball are retained by the sieve in the chamber below.

- Type

Weiner 100s typer rated to do 1.5tonnes/hr

lenght - 2180mm

width - 1180mm

height - 2250mm

- Subsoil and foundation

Special foundation not required. If the mill has no calotte feet the subsoil must be horizontal and plain, in order to guarantee a perfect resting of the base plate of the lower part of the mill on the floor. If the floor bearing capacity is not significant, the doubt of the supports must be increased by placing steel plates underneath it.

- Special requirement for Operation and Maintainance

On all sides, the mill should be at distance of at least 1000mm from the neighbouring machines or building. Height of the room should not be less than 3.200mm.

(f) Vacuum Mixer - Type PMV 3(2)

- function:- The machine intensively mix a pre-set water quantity with the product to be treated so as not to easy dissolutions. Afterwards, the added humidity is again rapidly eliminated by condensing the vapours and discharging them by means of vacuum pump.
- Type PMV 3

The model PMV3 is one-shaft mixer with a filling capacity of 3000 litres.

- Dimensions

lenght - 2.60m

breadth - 1.50m

height 0.90m

(g) PRESS(8)

- function - The press serves to squeeze out the butter content of the cocoa masse. It presses down to 10% residual fat in the masse. The butter from there is pumped into settling tanks for further processing while the cake goes to the crusher via the conveyor belt.

(h) Cake Crusher(9)

- function - The crusher serves to reduce the cocoa cake into nut sizes. The amount of fires in the kibbled cake is made as low as possible. The crusher has too distribution lines one leading the Kibbled cake to the scale for weighing and parking for marketing while the other goes to the powder section.

(i) Powder Plant(10)

The powder plant grinds the crushed cake into powder for packaging, and distribution. It is an inflammable machinery thereby necessitating provision of both automatic cooling plant for the engine as well as fire fighting machines to combat fire outbreak.

(j) Pressurized cooler with Pre-cooler (Cocoa butter)(11)

The cocoa butter is aspirated by the pump out of the storage tank. At the 3-way cock (G) the butter can be conducted directly to the cooling unit (IX) or through the pre-cooler (UK) and then to the cooling unit, which uses ammonia gas (NH_3) for cooling.

NOTES

1. Bauermeister - "the experts for cocoa industry"
Probat London May-1987. Pp 2-3.

2. (11) Ibid pp7 - 106

CHAPTER FIVE

(I) PRODUCTION CAPACITY

(II) LABOUR FORCE

(III) PRODUCTION HALL

(IV) WORKERS ZONE

(V) ADMINISTRATIVE ZONE

(VI) AUXILLIARY ZONE

(I) CAPACITY OF FACTORY

Capacity of the factory is determined by the capacity of storage and the secifications by the International Cocoa Organisation (ICCO).

ICCO specified 31,000metric tonnes of cocoa maximum that can be processed by any Industry in West-Africa due to the climatic conditions man power availability and market for finished products. The expected cocoa (raw material) that will be processed in this industry is 30,000 metric tonnes per year which can conveniently be supplied by the cocoa Research Institute of Nigeria and the Co-operative Farmers Society store of Ibadan. The storage capacity of the store is expected to be 90,000 metric tonnes which can serve the processing plant for 3 years in case of inadequate raw material supply.

(II) LABOUR FORCE OF THE PROPOSED FACTORY

Is the total number of people expected to work in the factory, that is both the skilled and unskilled.

Four production shifts (RED, BLUE, GREEN AND YELLOW) are expected to operate the factory continuously on a 4-shift system covering 24hours of each day, seven days of the week and fifty weeks in a year in the last to weeks of the year the factory will be shot down for intensive over haul. There are basically 4 categories of labour force.

		NO REQUIRED
(a)	The Production staff	440
(b)	The Administrative and Sales staff	100
(c)	The Auxilliary and Maintenance staff	60
(d)	The Workers facilities staff	50
	Total number of staff	650
	Number of femal staff	90
	" " Male "	460

(III) SHEDULE OF ACCOMMODATION

The allocation of the right amount of space to every activity and function in a programme greatly determines the quality and efficiency of a design. The Architect at this point of programming process needs to translate the clients ideas into square meter area of net usable space as well as into square meter of space required for services and circulation. For a factory, these values relates to the production process inside the factory.

The proposed factory will comprise 4 main zones namely:

(a) PRODUCTION ZONE

(b) WORKERS FACILITY ZONE

(c) ALMINISTRATIVE ZONE

(d) AUXILLIARY ZONE

(a) PRODUCTION ZONE

The size of the production halls depends largely on the sizes and number of the various machines, which depends largely on the capacity of the proposed factory.

Total Operational hours = 8400HRS = 50 WEEKS

To know the number of machines required per unit, the efficiency of the machines is required. To calulate the space requirement for production halls, these variables are used. Considering all machines working at maximum efficiency and if all variables are positive.

$$\text{No of machines required} = X = (T)\ \frac{\text{Production capacity}}{E \times 8400}$$

Where T = 30,000 Tonnes per year

E = Efficiency of machinery

8400 = Total operational hours per year

TYPE OF MACHINERY	Efficiency (E)	NO REQ.	AREA OCCUPIED PER 1 (m^2)	TOTAL AREA REQ' + CIRCULATION AREA (m^2)
VERTICAL BEAN ELEVATOR	10 tonnes/hr	1	1	1.5
BEAN CLEANING MACH' BUHLER TYPE	3.5 tonnes/hr	3	17.84	60
Bean roasting mach' Probat type	1 tonne/hr	5	12	70
Bean winnower	2.2 tonnes/hr	5	14.5	45
Bauermeister beater blade mills model smm 800	0.8 tonnes/hr	8	2.5	25

TYPE OF MACHINERY	Efficiency (E)	NO REQ.	AREA OCCUPIED PER 1 (m^2)	TOTAL AREA REQ' + CIRCULATION ARE. (m^2)
Ball mills C-40 type	0.5 tonne/hr	6	2	15
Dehumidifiers B-type	2 tonnes/hr	6	4	30
Vacuum Kneader B-type	2 tonnes/hr	1	3.9	3.9
Presses B-type	2presses/hr	6	5	36
Cake Kibbling Mach'		2	2.5	6
Schule press fitters	1 tonne/hr	1	3	4
Butter fitter mach.	0.8 tonne/hr	2	5	12
Tempering mach'	2 tonnes/hr	1	3.5	5
Powder plant for Cocoa powder 1-pin-disc Mill-B' type KPA4	1 tonne/hr	1	30	35

WORKERS FACILITIES

ACCOMMODATION	No of Rooms	Area Req/1 Room m^2	Total Area m^2	REMARKS
Senior Staff Canteen	1	50	50	Enough space for dinning of 40 people at a sitting serving space and circulation space
Junior Staff Canteen	1	90	90	Enough space for the dinning of 100 people at a sitting serving and circulation space
Caterers Office	1	12	12	Working space, 1 1 file cabinet and circulation
Kitchen	1	70	70	
Pantry	1	Ample	Ample	For non-perishable goods
Wet Store	1	Ample	Ample	For perishable goods
Common Room	3	45	135	Each for 15 people at a time
Toilets and Showers	2	15	30	For Catering Workers
Changing Rooms			200	With lockers for all the production wo workers who need to change
Bicycle Shed	1	Ample	Ample	
Training School	2	30	60	15 Students each
Clinic	1			
Examining Room	1	20	20	Doctors working space examination bed, wash hand basin, book shel shelf and circulatio space

ACCOMMODATION	No of Rooms	Area Req/1 Room m^2	Total Area m^2	R E M A R K S
Waiting room	1	25	25	For 8 persons at a time, working space for a nurse and circulation space.
Dispensary	1	20	20	Working space for a dispenser.
Card room	1	15	15	Working space for 1 attant, shelves for cards and clati space.
Store	1	Ample	Ample	For drugs and Clinical Equipments.
Toilets	2	3	6	For the medical personnel and patients
Ampulance park	1	Ample		

V. ADMINISTRATIVE ZONE:- The need for administrative department of any factory is to ensure smooth management of the factory. The space needed depends largely on the type of business organisation, number of pieces of furniture and the degree to what work-places are partitioned.

ACCOMMODATION	NO OF ROOMS	AREA REQ PER ROOM (m^2)	TOTAL AREA (m^2)	R E M A R K S
Reception lobby	1	80	80	Working space for 2 receptionists, a show room for display of products, a waiting room for visitors, toilets for visitors and circulation space.
Public Relations Officer	1	25	25	Working space, 2 visitors sofa, 2 file cabinets and a book shelf.
General Office	1	130	130	Working spaces for 6 clerks, 3 typists and 2 messangers, 4 file cabinets and circulation space.
General Manager	1	36	36	A large working space, 6 visitors sofa around a coffee table, 2 file cabinets, book shelves and circulation.
Gneral Manager's Secretary	1	25	25	4 file cabinets, working space, visitors waiting area, coffee mailing area, messenger's seat and circulation space.
Personnel Manager	1	25	25	Working space, 2 file cabinets, book shelf and circulation spac
Personnel Office	1	30	30	Working space for 3 personnel staff, 4 file cabinets and circulation space.
Personnel Office Secretary	1	20	20	Working space, 4 file cabinets, Coffee making area, visitors waiting area and circulation area.
Sales Manager	1	25	25	Working space, 12 visitors sofa, 2 file cabinet and circulation space.

ACCOMMODATION	NO OF ROOMS	AREA REQ PER ROOM (m^2)	TOTAL AREA (m^2)	R E M A R K S
Sales Manager's Secretary	1	20	20	Working space, 4 file cabinets visitors waiting area and circulation space.
Assistant Sales Manager	1	20	20	Working space, 1 file cabinet visitors waiting area and circulation space.
Purchasing Manager	1	25	25	Working space, 1 file cabinet, visitors sofa and circulation space.
Sales Office	1	65	65	Working spaces for 5 sales clerks and 1 messenger, 4 file cabinets and circulation space
Cash Office	1	50	50	Working space for 2 cashier a large safe, 2 file cabinets an good circulation space.
Accountant	1	25	25	Working space for 1 person, a large safe visitors chairs, book shelf, 2 file cabinets and circulation space.
Accounts Office	1	30	30	Working space for 1 secretary 2 accounts clerks, 2 file cabinets, visitors waiting and circulation space.
Research Market Analyst	1	20	20	Working space, a computer, 1 file cabinet and circulation space.
Training Co-ordinator	1	20	20	Working space, book shelves and circulation space.
Cleaners Room	1	10	10	
Transport Office	1	15	15	Working space for 1 transport clerk and 6 drivers and circul tion space.
Library	1	110	110	Working space for 1 Librarian, space for 500 books, and Journals, reading space for about 20 people plus the circulation space.

ACCOMMODATION	NO OF ROOMS	AREA REQ PER ROOM (m^2)	TOTAL AREA (m^2)	REMARKS
Telephone exchange	1	18	18	Telephone exchange machines, cables and Telex, working spaces for 2 operators waiting room and circulation space.
Technical Drawing Office	1	30	30	Working space for 2 draights men cabinets to store drawing equipment, worktop photo copying machine, book shelves.
Conference Room	1	40	40	Large conference table for 15 people at once, toilet and circulation space.
Coffee Room	1	8	8	Wash hand basin, a fridge, Cabinet to store tea cups and saucers, worktop and circulation space.
Stationery Store	1	Ample		
Store Keeper	1	6	6	
Gate house	2	12	24	4 Security attendants enough room for temporary detaining of suspects and circulation space.

For primary circulation which is essential to provide access and means of work place area, a 20% of net usuable area is taken and added to net required area.

(VI) AUXILLIARY ZONE:

ACCOMMODATION	NO OF ROOMS	AREA REQ PER ROOM (m^2)	TOTAL AREA (m^2)	R E MAA R K S
Production Managers Offices	2	18	36	Working spaces for 2 product managers and circulation spa
Engineering Manager's Office	1	24	24	Working space for 2 engineer and circulation spaces.
Welfare Officer	1	12	12	Working space and circulatio space.
Carpentary Workshop	1	50	50	Enough space for the machine work top. Adequate storage room. Working spaces for 3 carpenters.
Electrical Workshop	1	50	50	Enough space for the machin worktop storage room workin spaces for 2 electricians a circulation space.
Mechanical Workshop	1	70	70	Same as above including working space for 4 mechani technicians
Scrap Store		Ample		
Quality Control Lab	2	35	35	Working spaces for 2 labora technicians, apparatus worktop, storage space and circulation space.
Maintenance Garage	1	130	130	for broken down forklifts trucks and buses
Generator House	2	50	50	To accomodate 2, 250kv generators and a switch roo for 2900 litres of fuel.
Water tank	1			For 2,000 litres of water.
Boiler Room	1	100	100	To Accommodate boiler of 500KV and circulation space
Laudry	1	Ample		
Fire Station	1	50	50	
Sewage treatment plant and incinerator				

CHAPTER SIX

FACTORS AFFECTING PLANNING OF INDUSTRIES

6.00 Comfort requirements

6.10 The site

6.1.1 Site location

6.1.2 Site selection

(a) Natural factors

(b) Cultural factors

(c) Aesthetic factors

6.1.3 Site factors

The macroclimate

The moocon

The harmattan

Temperature and relative humidity

Air movement

Precipitation

Duration of sunshine

Evaporation

Geology

Topography

Land forms

Hydrology

Soil

Vegetation

6.2 Vegetation and Cross ventilation

Vegetation

Cross ventilation

6.3 Conclusion

CHAPTER SIX

FACTORS AFFECTING PLANNING

6.1 COMFORT REQUIREMENTS

Buildings serve as the barrier between major climatic cycles and the activities of people. To do this, they must be designed to respond to both external environmental conditions and the comfort requirements of the user. These comfort requirements are usually defined in terms of thermal characteristics air temperature, relative humidity, air motion, and radiation. Humans, like other organisms living in the biosphere, use the short-term solar energy fixed by photosynthesis to do work, build body tissue, and maintain a constant temperature of 98.6°F. Because the body uses only about 20 percent of its generated heat internally, the remaining 80 percent must be released to the surroundings. At the same time, there is a thermal exchange taking place with those sorroundings. This demands that thermal gains equal losses in order to maintain a stable body temperature Table (6.1).

Table 6.1 Body Heat Exchange

Gains	Losses	Percent Loss at Typical Room Temp. (68°)
Metabolism	Convection	30
Shivery	Radiation	45
Radiation	Evaporation	25
Convection	Conduction	negligible

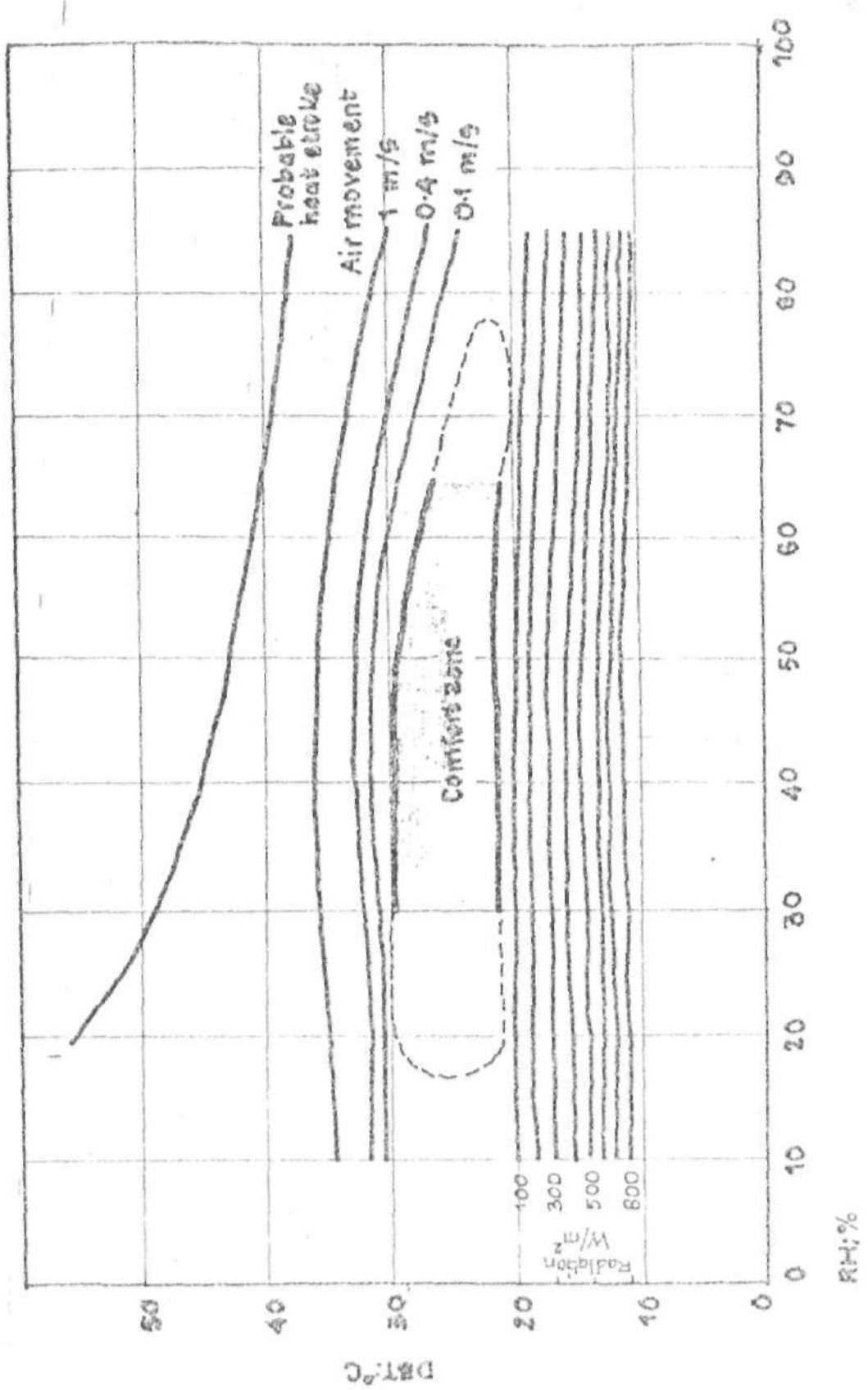


FIG. 1 BIOCLAMATIC CHART FOR MEN AT SEDENTARY WORK-WEARING I CLO. CLOTHING--IN WARM CLIMATES (Original by V. Olgyay in British units— some values revised according to Australian

Skin surface temperature is about 92°F. Therefore temperature colder than that will cause the body to use energy to maintain its heat, while with a temperature warmer than 92°F, the body will be absorbing heat.

The importance of the different methods of heat gain or heat loss vary. However, evaporation becomes temperature. Conversely, heat loss at lower temperatures can be slowed, by higher surface temperatures or increased humidity. Air-conditioning of course, will solve either problem, but with the necessity of mechanical energy imput.

However no single set of condtion constitutes comfort, but rather range of conditions. Comfort, for any one individual or group of individuals, may vary considerably according to the culture, age, clothing, sex and health of those involved. The energy-conscious designer must then respond to the needs of the specific location.

There are four primary responses the designer may use as a means of co-ordinating building thermal environments (and the resultant energy use) with the comfort needs of the user. There are the manipulation of site climate, building membrane, building use, and mechanical and natural thermal modification.

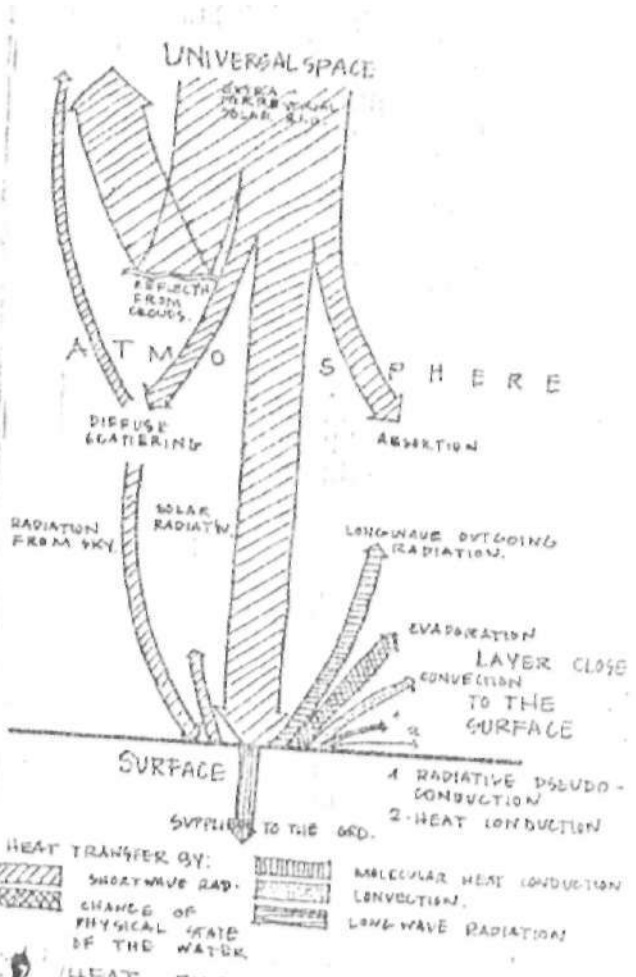


FIG. 2 (HEAT EXCHANGE AT NOON FOR SUMMER DAYS (ARROWS' WIDTH REPRESENTS AMOUNT OF HEAT TRANSFERED)

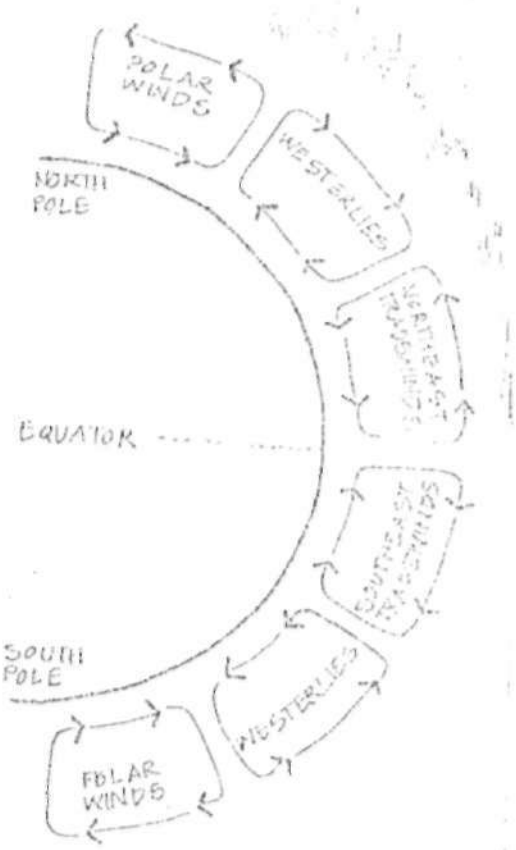


FIG 3
GLOBAL WIND PATTERNS.

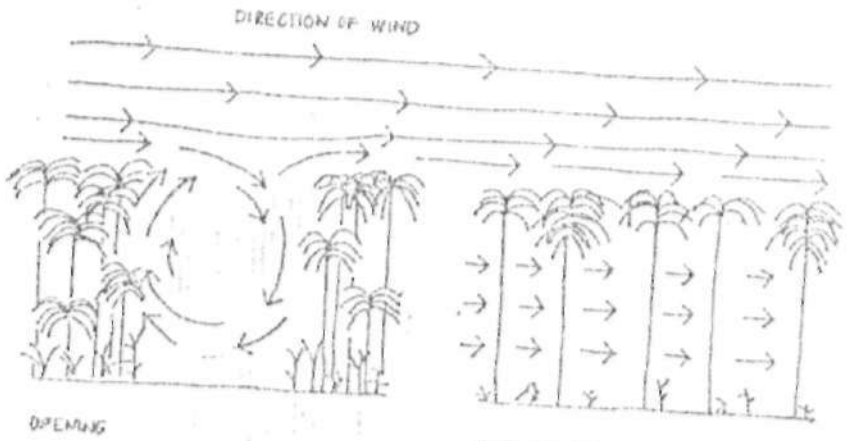


FIG 4 VEGETATION AND WINDFORCE.

6.2 The Site:

6.2.1. Site Location:- The site is located in Ibadan capital of Oyo-State. The city of Ibadan lies between lattidues 7°21' and 7°28' North and 30°51 and 30°55' east. The average altitude is 129 metres but Ajadi hill is about 288 meters above sea level.

6.2.2. Site Selection:- The selection of a site for any architectural development require, a detailed analysis of potential sites. The analysis of a site in turn, includes all natural, cultural and desthetic factors that affects it as summarised below.

(a) Natural factor

1) Geology - bedrock and surficial.
2) Physiography - geomorphology, relief topography.
3. Hydrology - surface and ground water.
4. Soils - classification of types and uses.
5. Vegetation - Plant ecology.
6. Wildlife - habitats.
7. Climate - solar orientation, wild precipitation and humidity.

(b) Cultural factors

1) Existing land use - ownership or adjacent property and offsite misances.
2. Traffic and transit - vehicular and pedestrain circulation on or adjacent of site.

3) density and zoning:- legal and regulatory controls.

4) Socio Economic factors

5) Utilities - sanitary and storm water systems water, gas, steam, electricity and telephone.

6) Existing buildings.

7. Historic factors - historic buildings, land marks and archaeology.

(c) Aesthetic factors

1) Natural features

2) Spatial pattern - views, spaces and sequences

However only four factors are of immediate importance, as far as the choice of alternative site selection for the Integrated Cocoa processing Centre is concerned. These are the site conditions, the climatic condition, accessibility and services.

However, the third factor makes Owode Industrial Estate Ibadan a better location than Ajoda Estate in which accessibility to local raw material (Cocoa beans) and market potentials for finished products. Moreover, the site must be near a source of water and power supply, since both are very essential for the smooth operation of any industry. Infact from being necessary for the smooth operation of the industry, the later is a functional prerequisite for any industry that is going to run for 24 hrs of a day.

Hence after considering all the above factors together, Owode industrial Estate has been selected as the best site for the proposed industry.

This is because of its close proximity to the sources of raw material which is the Cocoa store and CRIN (Cocoa Research Insitute of Nigeria). Moreover, water and power supply will not be a problem since the main water co-operation main pipe is on the site and good power supply.

Furthermore by locating the industry at Owode industrial layout, interaction with the existing facilities i.e CRIN and Cocoa Development Unit(C.D.U) Ibadan which are concentrated in the area, will be enhanced.

The chosen site, which coincidentally is the site earmarked for the industry by the state government, is located along the Abeokuta road, just opposite the Co-operative farmers Society Store. It occupies about 60,000m^2 of more or less flat farmland.

6.2.2. Site factors

The microclimate: The five major macroclimatic regions of the tropics are the result of general atmospheric circulation of air masses over the earth modified by topographical conditions and other changes civilization has brought to its surface. Hence a brief review of the major macroclimatic para meters that apply to Ibadan in general should reveal the general pattern that could be applied to the particular site under study. The specific microclimatic factors that might alter this general picture will be reviewed later on. Ibadan belongs to the forest region of the five major macroclimatic regions of the tropic.

The principal air masses affecting this region are: The monsoon and the harmattan.

The monsoon:- This is a moist, cool, air mass with a long history of sea tracking over the south Atlantic occean. It is South Western in direction and has a small decrease in temperature with height.

The harmattan:- This is a dry, dusty and cold air mass with a large decrease of temperature with height. It has a long history of desert tracking before reaching Ibadan as a North Eastern wind.

The monsoon and harmattan air masses flow towards each other from opposite direction. The belt where these northerly and southerly winds converge is known as the "Inter ropical Covergence Zone" (ITCZ) or more generally "Inter-Tropical Discontinuity (ITD) which oscillates slowly and irregularly during the year. The annual movement over Nigeria is Northwards between February and August and Southwards from September to January South of the ("ITCZ") air streams charged with moisture together with the mechanism that converts it to rain. A rainy season starts when the "ITCZ" is consistantly north of the area of precipitation.

Temperature and relative humidity:-

The hottest period is between, February and April with an average minimum temperature of 23.8°C while the coldest period is between July and August with an average minimum temperature of 22.2°C and average maximum temperature of of 28.5°C.

During the harmattan period that is from November to February the temperature at night could be as low as 15.5°C, but during the hot season, the midday temperature could be as high as 37.7°C.

The air is damp most of the year, this is because of the very high relative humidity in the area. The relative humidity is very high in the morning between 77% and 88% and decreases to a minimum in the afternoon between 37% and 79%.

Low humidity occurs between January and March while period of high humidity occurs between July and September.

Air Movement:- In Ibadan, the prevailing wind directions (about 90% of the time) are South and West.

Although the harmattan in the dry season affects the climate, this wind direction does not prevail. Thus, the area has two opposite wind systems of North-East (harmattan) in the dry season and the South-West (monsoon) in the Wet season. These winds are usually persistently strong but abates towards the end of the dry season.

PRECIPITATION: When moisture bearing winds occur persistently from the same direction, the effect on hills on rainfall patterns can be very pronounced; with the windward side receiving more rain than the leeward side. This is because the hill forces the air mass to rise and as it rises it cools and can no larger support the moisture carried. Conversely, a descending air mass inceases in temperature and can absorb more moisture, rather than precipitate any(2).

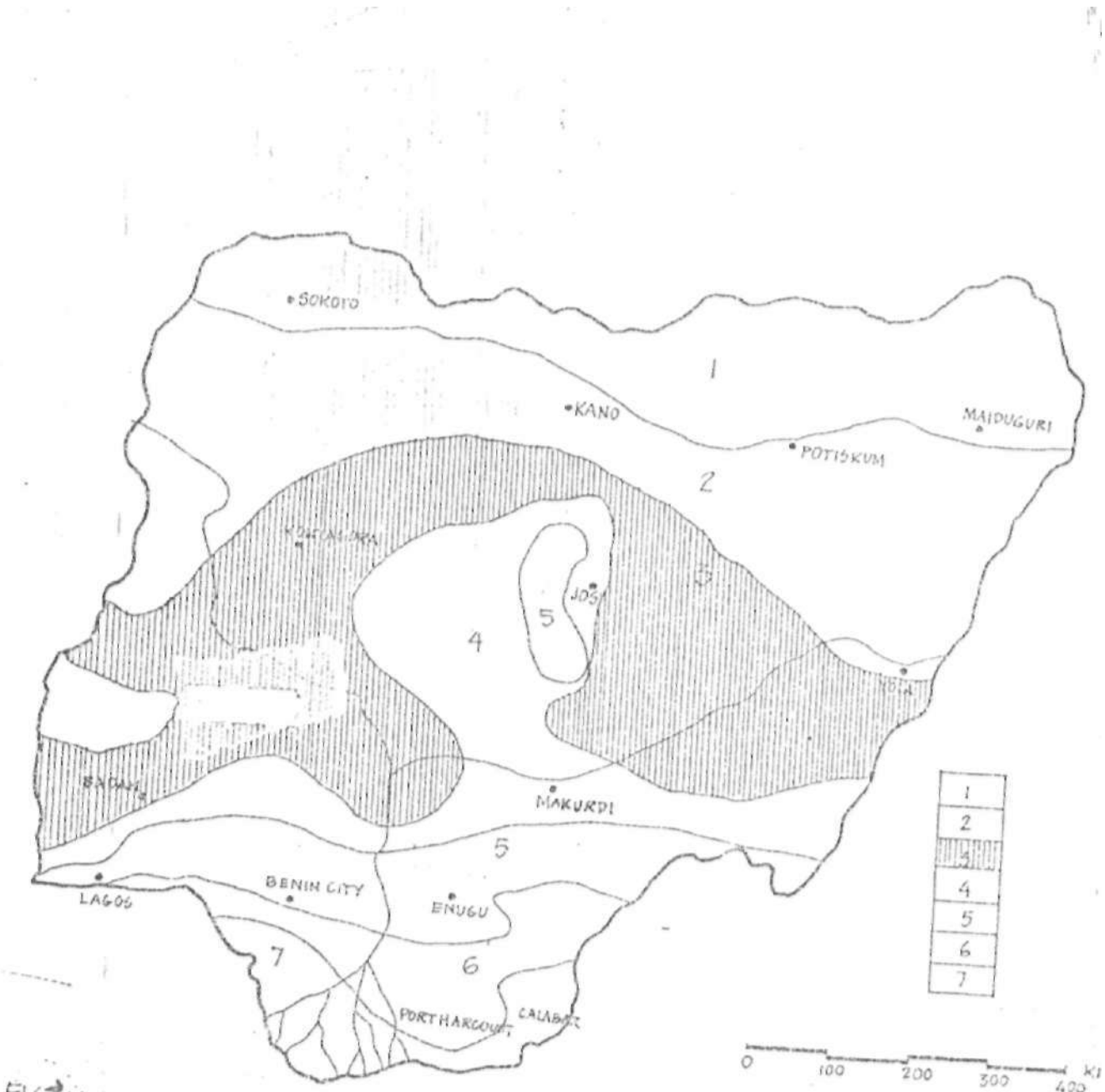


FIG. MEAN ANNUAL RAINFALL DISTRIBUTION.

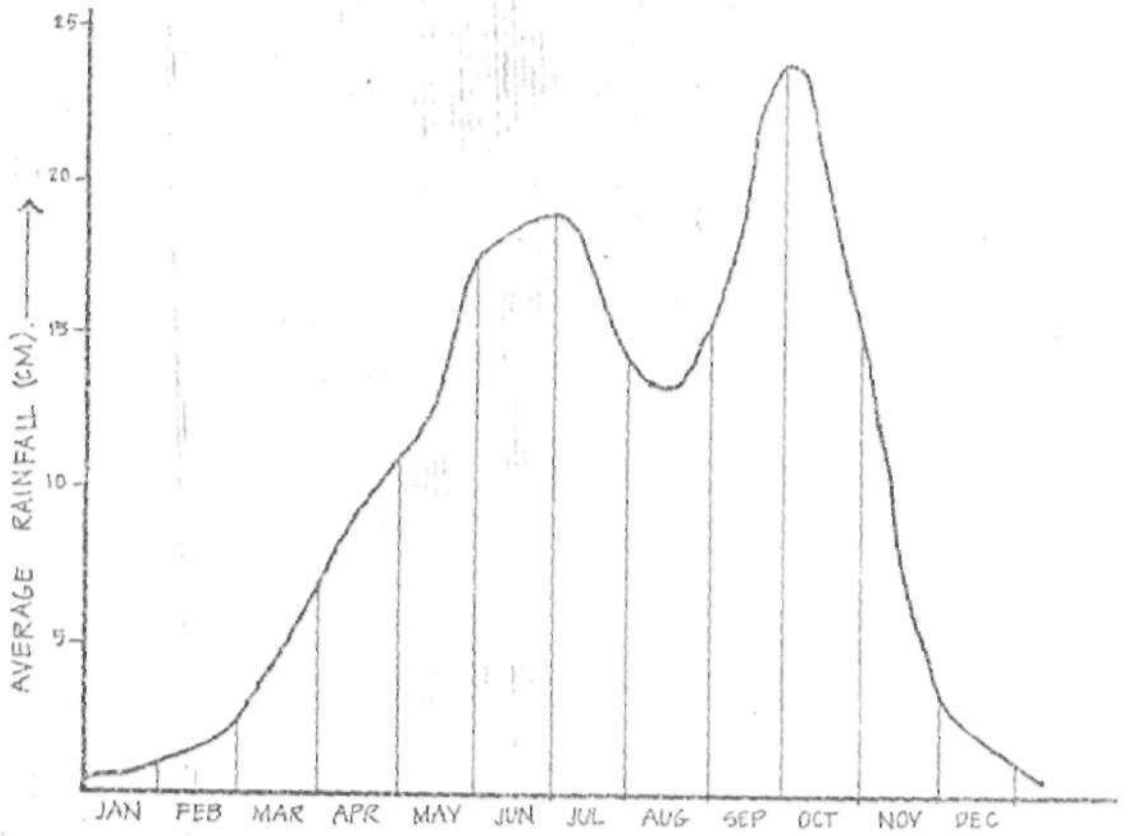
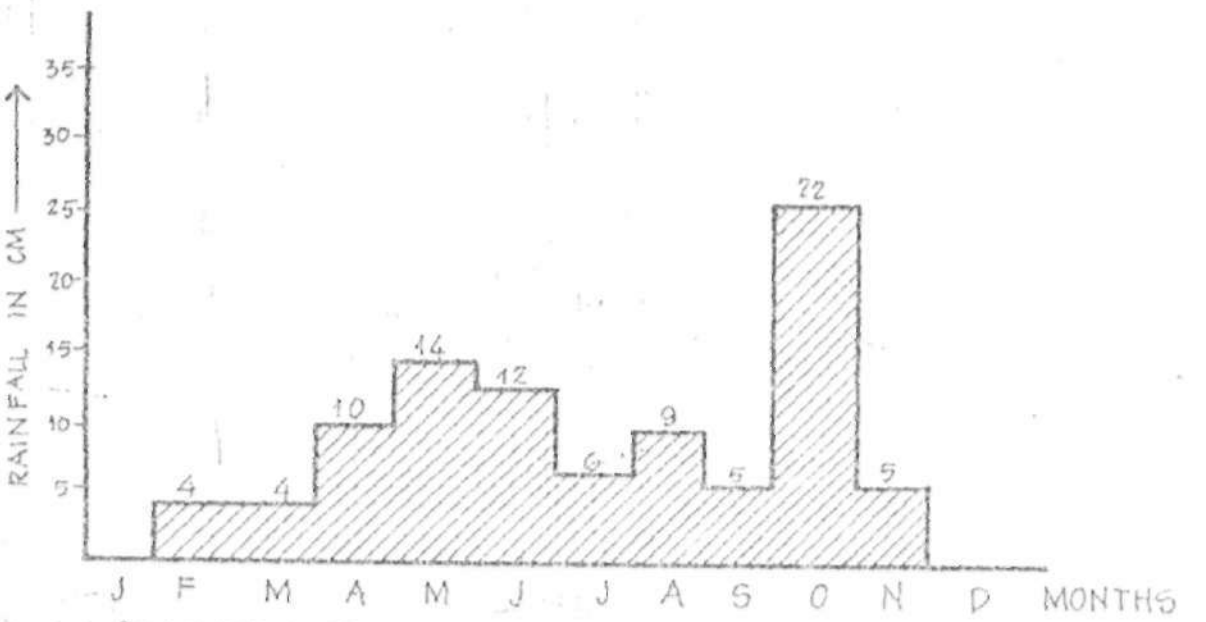


FIG. 6 AVERAGE MONTHLY RAINFALL IN IBADAN



7 MONTHLY RAINFALL WITH NUMBER OF RAIN DAYS IN IBADAN.

Considering Ibadan which is located within hills therefore the site under consideration has a western exposure and is therefore exposed to the monsoon trade wind. It consequently receives more than the average rainfall characteristic of the region.

There are two main seasons; the dry season which is from November to February and wet season from March to October. The dry season has a minimum rainfall of 47.7mm, while the wet season records rainfall as high as 361.1mm between July and September. It is so called two peak type, with the picks in June and September. The rainy season starts around April and lasts until November.

Duration of Sunshine: The effect of cloud cover over the region on the amount, distribution and assimilation of incoming radiation and on the microclimate is pronounced. In the absence of cloud the number of sunshine hours would average 12.00 hrs.

Evaporation: The extreme mean minimum evaporation is 191mm and occurs in March. The average yearly evaporation is 1,629mm.

Geology: In greatly simplified terms the geology of the area under study might be described as comprising the pre-cambrian basement complex which are the oldest known rocks in Nigeria. It has a geological history as old as any known plant or animal life. Its formation dating back to some 4.5 billion years ago. This belongs to what geologists

call the archeozoic proterozoic era(4). The geological rock formation is principally composed of metamorphic and igneous rocks such as granite gneiss and migmatites. There is a tiny discontinuous mantle of weathered rock of the order of 15 metres. The mantle of weathered material is too thin and too clayey to serve as an efficient acquifer, the general water table is shallow and subject to much fluctuations in height during the rains.

Topography: The area under study is relatively flat.

Landforms: There are no spectacular landforms on or near the area under study.

Hydrology: As has been mentioned above the mantle of weathered material is generally too thin and too clayey to serve as an efficient aquifer. Hence, the general water t table is shallow and subject to much seasonal fluctuations. However the site under consideration has a higher water table as is evident by the state ministry of works.

The general drainage pattern on the site follows the major topographical slope direction. Hence the major run-off would occur down the slope towards Abeokuta road.

Soil: The site is located on a good farmland which composed of light, well drained red to brown laterite soil. The average depth of weathered material is of the order of 15 metres.

Vegetation: Ibadan belongs to the forest region. Generally the vegetation of this zone consists mostly of thick-barked, 10-12 metres in girth and upto 6 metres in height growing

in Tussocks. However the vegetation of the site understudy remain greener for a major part of the year and some of its vegetation are that of the tropical maritime species (e.g. bamboo).

6.3 Vegetation and Cross Ventilation

Modification of the site climate to the greatest extent possible is the first response required if comfort condition are to be achieved.

There are many techniques for controlling or modifying climatic factors major among which are the efficient use of vegetation and adequate cross ventilation.

Vegetation: In addition to the pleasant visual effect and camouflage, vegetation can be used to intercept solar radiation either direct or reflected, before it strikes building surface. Deciduous trees are excellent shading devices, because the respond to local climate: they lose their leaves when it is hot. Plant diffuse and reflect radiation due to their multifaceted and generally rough, dark surfaces. Placement of low shrubs or can be critical in controlling reflection from water or paving surfaces. Vegetation also reduces the temperature near the ground in warm climate. This is accomplished by the canopy shading of trees and the continuous process of transpiration. Hence, the temperature of a forest will be cooler than that of a concrete pavement on a hot day. In colder weather, the forest will be warmer than open land, because of the reduced

wind velocities and the trapping of warm air by the over head vegetation. Insulating dead-air spaces can be created next to buildings to utilize such effects and reduce building heat loss. Vegetation can be used to reduce temperature build up in paved areas, particularly where it will radiate its heat to adjacent building. Moreover, vegetation can be utilized to provide protection against glare, dust, erosion and strong wind. At a distance of three kilometres from a dust source, dense vegetation has already filtered more than 75 percent of the dust content at of the air. Also, wind barriers can impede undesirable excessive air movement and well-planned planting can direct the wind so that the building is well ventilated.

Thus the position of bushes and trees on a site their relationship to the building and to one another and the types of plants affect the micro-climate of the site.

However, vegitation can have disadvantages. The desirable air movement can be drastically reduced or directed away over the building if the planting is not well planned or is too dence. Mechanical damage to foundations and drainage pipes can be caused by roots (the eucalyptus family are particularly notorious), blockage of roof gutters and damage to the external cladding are further harmful effects of vegetation. If vegetation is too loose to building there is the risk of damage by pests and harmful animals that live underground (insects, snakes, rats etc.).

Cross ventilation:- The continuous ventilation of a room has various purposes. In tropical regions it serves primarily to improve the interior climate.

Moving air has the ability to improve thermal comfort in hot and humid regions, because it increases evaporation and thus, lowers the skin temperature. Non-saturated air is continuously brought into contact with the body, so that its moisture perspiration can be absorbed and the body becomes cooler.

Interior air-movement can be achieved by taking advantage of wind or of contrast between insolated and shaded facades. These two forces can, according to the orientation of the building and disposition of its windows, reinforce or oppose each other. The efficiency depends either on the temperature difference between two sides of a building or on the pressure difference. Windows on opposing sides of a building are needed for cross ventilation. As the climatic conditions of the hot, humid zones give rise to only slight temperature differences, thermal cross ventilation cannot be very great. Pressure differences according to wind speeds can, on the other hand, be very large, so that this method of achieving cross ventilation is considered in detail in the following paragraphs.

The aim of planning is to obtain and control air-flow through the interior. These are various ways of affecting the air flow but the difficulty is, it does not readily change direction and does not take the shortest route between inlet and outlet.

The resultant air-flow in a room is determined by the combined effect of inlet position and pressure on the building facade. Bad positioning of the windows can mean quite inadequate entry of air, whereas appropriate building measures can direct the air exactly where it is most needed.

Ideally, the air-stream should benefit the occupant at sitting to standing height in a room and at sleeping height in a bedroom.

These rules are valid for the sections as well as the plan of a building. Change in air-flow is bwought about by pressures variation around the inlet, along the facade.

Thus each building-measure alters the interior air-stream. If, for example, a window in the facade is placed to provide an air-stream at body height, it can be lost by window-screening, fixed close to the facade, or by a wertical projecting wall. Air pressures on the facade force the air upwards or sideways into the interior. If the screening or the projecting wall is set away from the facade, for example, with an air-slit, the required conditions are restored.

If a movement of air is required under the ceiling of a room as well as at body height, it is not enough to place two windows on the windward side at the corresponding heights. The lower opening must be fitted with appropriate louves for altering the direction of air. Without these the air would be upward.

The cooling effect is not determined by the number of air-changes per hour, but by the air-speed. The interior velocity can be increased if the outlet is larger than the inlet. This is a common phenomenum in aerodynamics. Briefly, this means that to achieve the most effective cooling, the air-inlets should be designed and positioned depending on the course to be taken by the air inside, and suitably positioned inlet windows should be as large as possible. The air speed can be varied by a number of adjustable openings in the inlet windows, resulting in controllable natural air-conditioning.

Partition walls, obstructions, non-rectangular planning of rooms e.t.c. do not only change the direction of the air-stream, but also drastically reduce it. Partition walls should therefore be completely perforated or have air-openings even if the doors in them are kept permanently open. Obviously, the maximum air-speed is achieved if the air-lets and outlets are exactly opposite one another and if there are no intervening obstructions. Thus narrow buildings naturally have a better cross ventilations than compact cube-shaped ones. As every ventilation system must continue to work during the frequent storms or periodical high winds, it must be possible to moderate them during the colder rainy seasons when such turbulent conditions are common.

Good cross ventilation requires that the wind approaches the building from the most favourable direction. Fig. show how this can be done using landscaping elements.

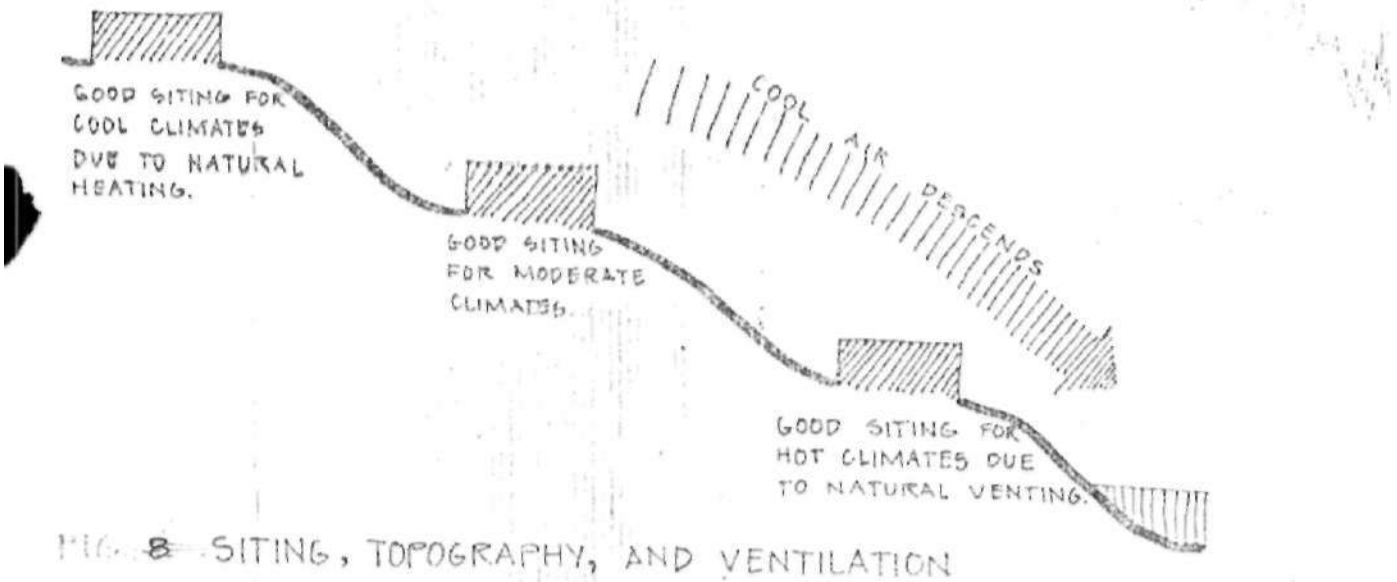


FIG. 8 SITING, TOPOGRAPHY, AND VENTILATION

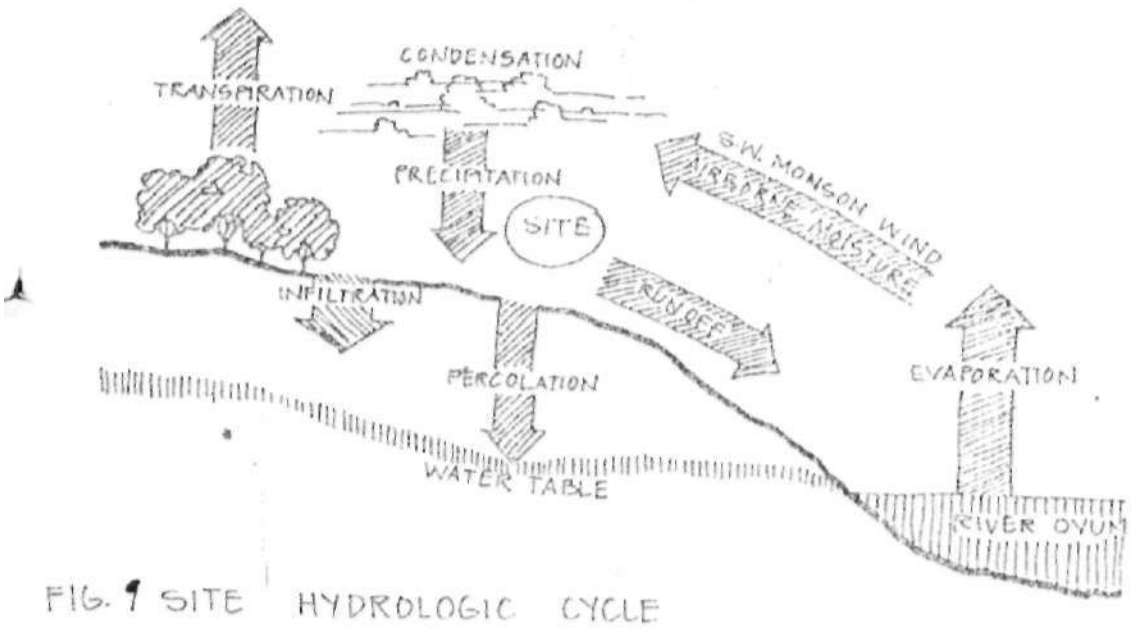
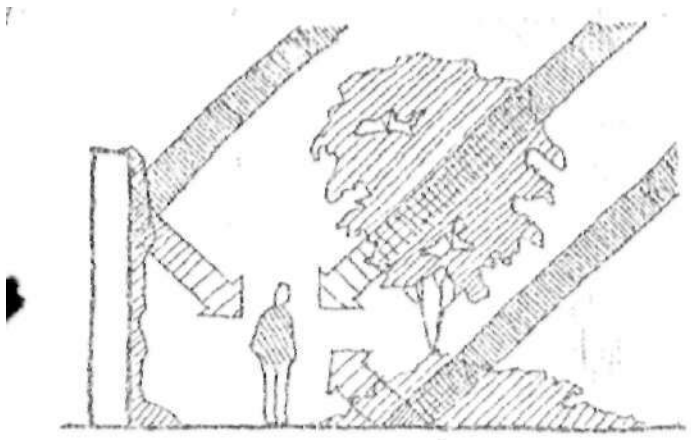
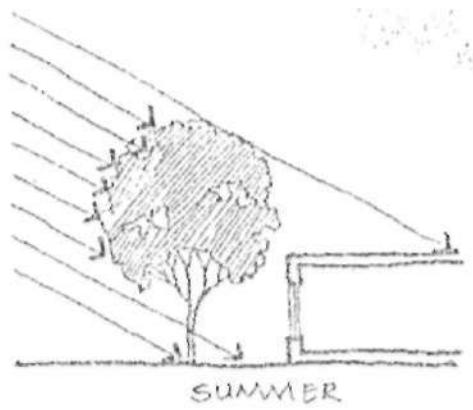


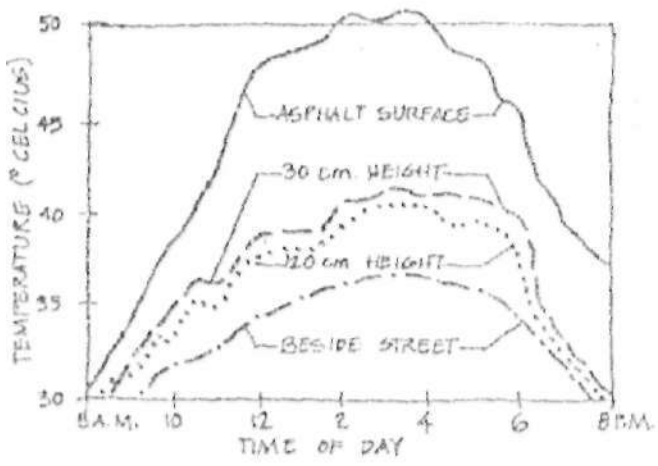
FIG. 9 SITE HYDROLOGIC CYCLE



FIG. 10 SURFACE AND GROUND WATER







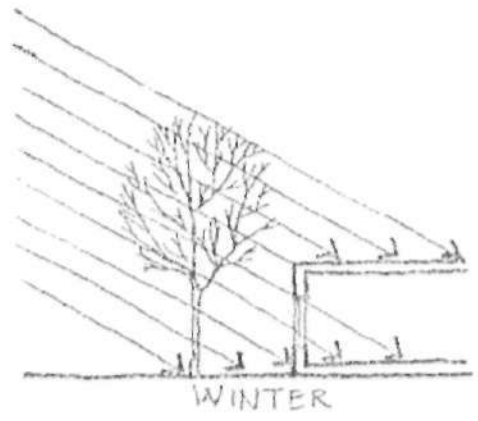


FIG. 12 INCIDENT SOLAR RADIATION AND VEGETATION

V. CLIMATE NEAR THE GROUND
(AFTER RUDOLPH GEIGER, THE CLIMATE NEAR THE GROUND, 1950)

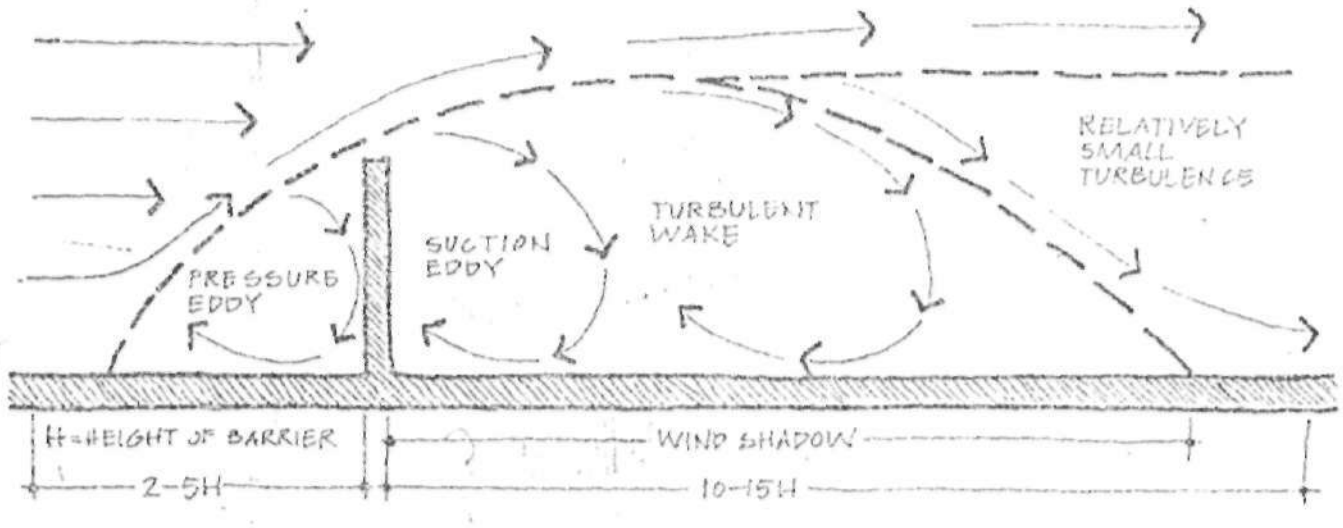
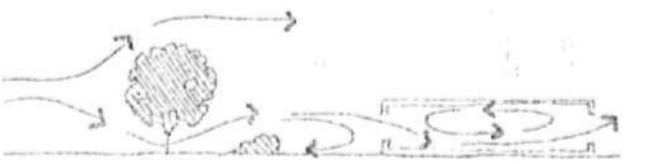


FIG. 13
WINDBREAK EFFECTS



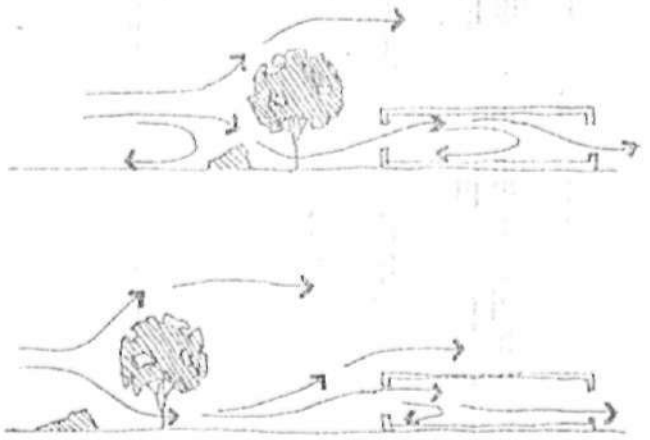


FIG 14
COLD-AIR DAM

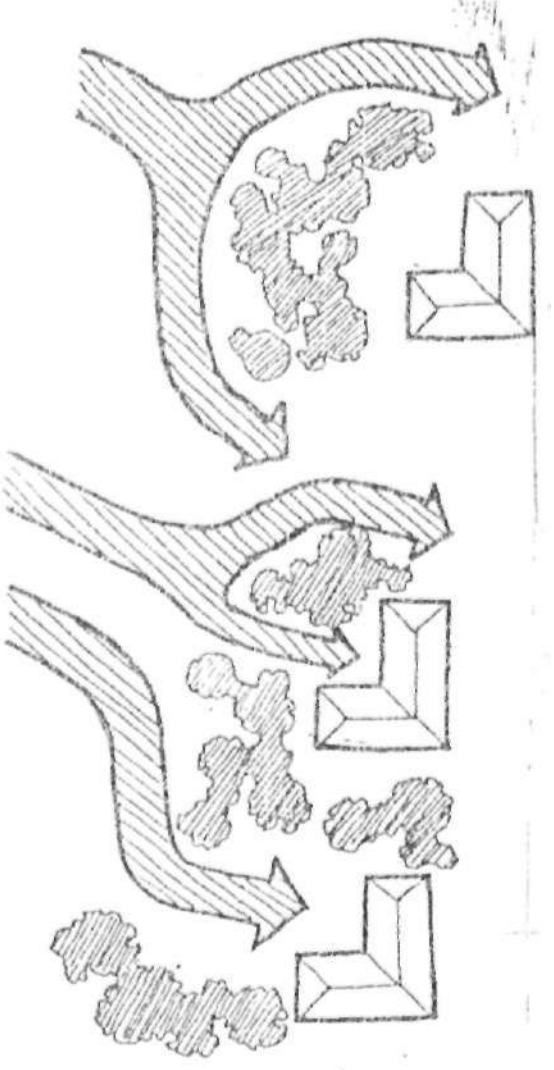
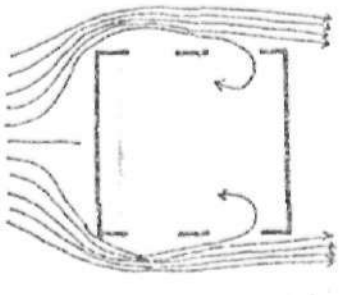


FIG 15 VEGETATION, WINDFLOW AND BUILDINGS, (AFTER R.F. WHITE)



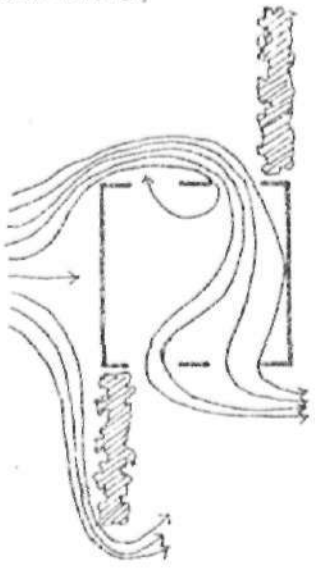
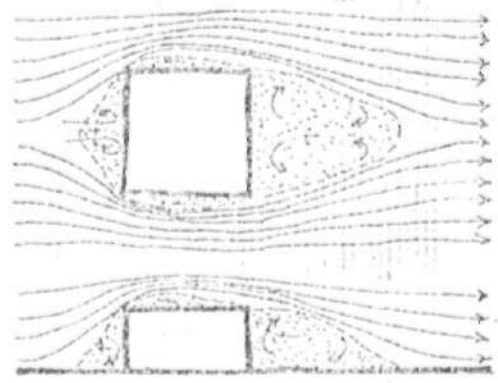
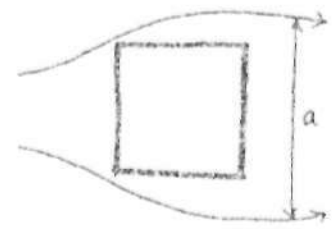


FIG 16 VEGETATION, WINDFLOW AND BUILDINGS





a<b

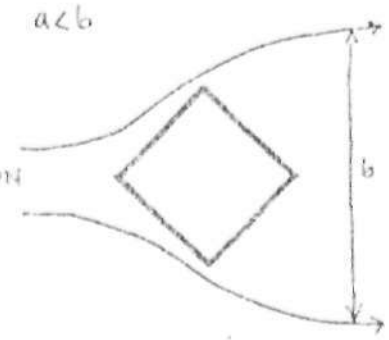
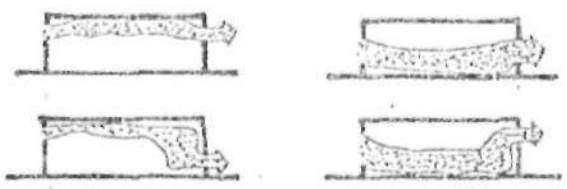


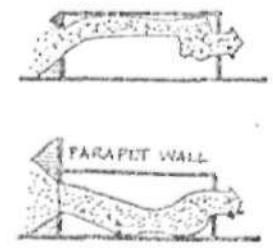
FIG17 : AIRFLOW AROUND A BUILDING AND EFFECT OF DIRECTION ON THE WIDTH OF WIND SHADOW.

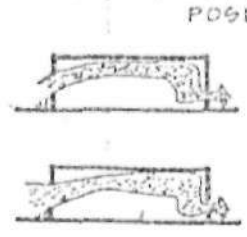


LACK OF CROSS-VENTILATION.

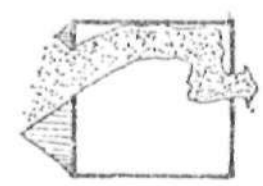


EFFECT OF OPENING POSITIONS.

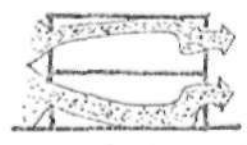




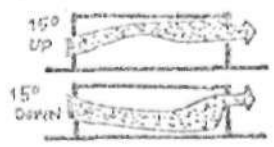
TOP: EFFECT OF SASHES AND BELOW: EFFECT OF CANOPIES ON AIRFLOW IN BUILDINGS.



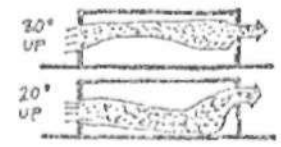
PRESSURE BUILD-UP AT INLET.



AIRFLOW IN A TWO STOREY BUILDING.

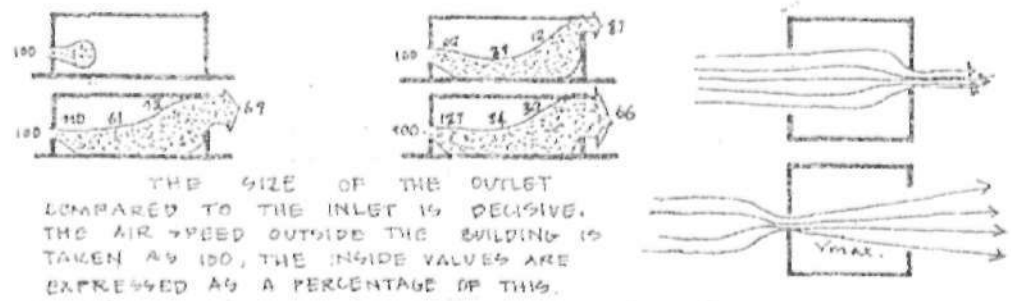


EFFECT OF LOUVRES ON AIRFLOW





EFFECT OF INLET POSITIONS ON AIRFLOW IN BUILDINGS.



THE SIZE OF THE OUTLET COMPARED TO THE INLET IS DECISIVE. THE AIR SPEED OUTSIDE THE BUILDING IS TAKEN AS 100, THE INSIDE VALUES ARE EXPRESSED AS A PERCENTAGE OF THIS.

FIG 18 CROSS VENTILATION IN BUILDINGS.

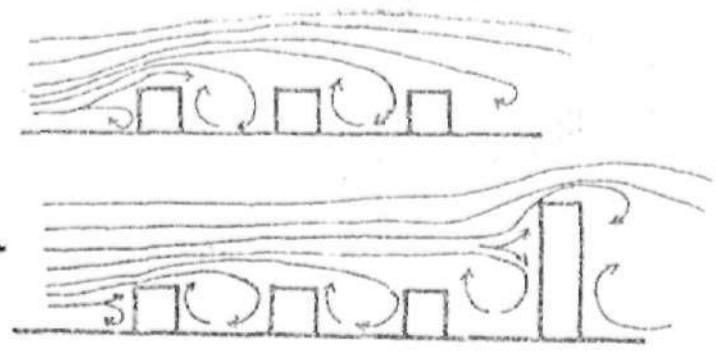


FIG 19 AIR STREAM SEPARATION AT THE FACE OF BUILDINGS

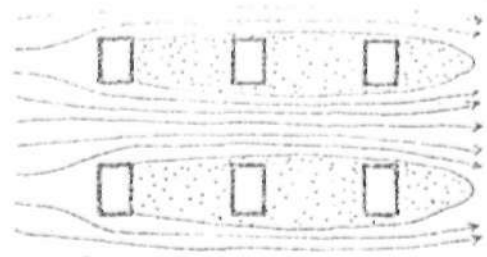


FIG 20
AIR FLOW : GRID-IRON LAY-OUT.

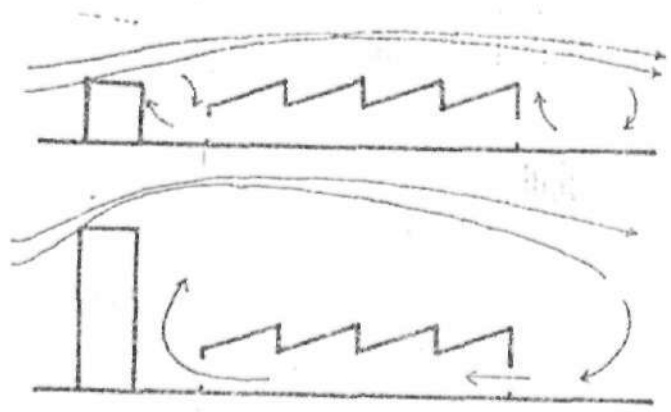


FIG 21 REVERSE FLOW BEHIND A TALL BLOCK.

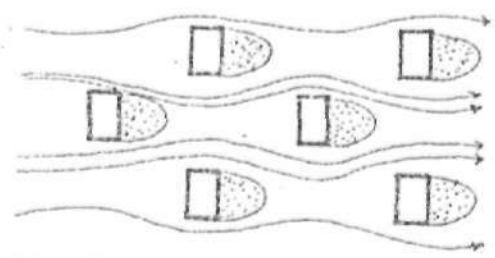


FIG 22
AIR FLOW : CHECKER BOARD LAY-OUT.

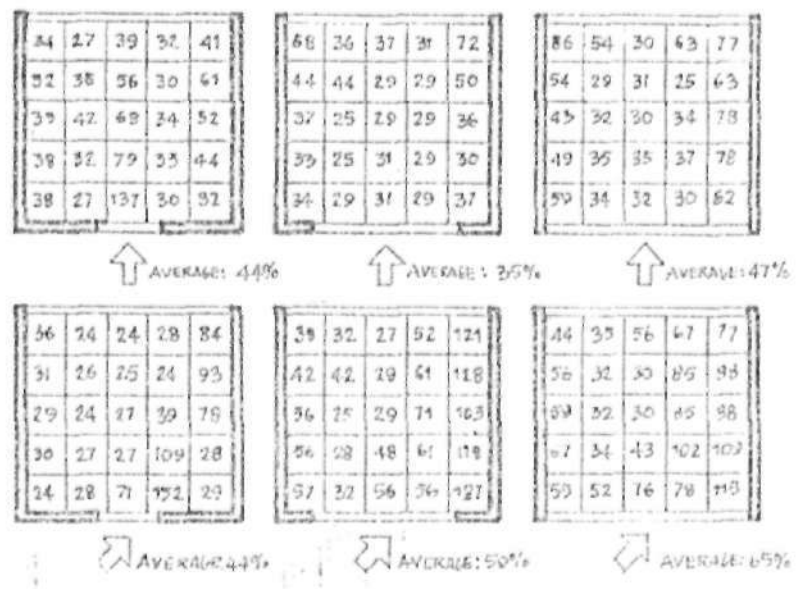


FIG 23

EFFECT OF WIND DIRECTION AND INLET OPENING SIZE ON AIR VELOCITY DISTRIBUTION.

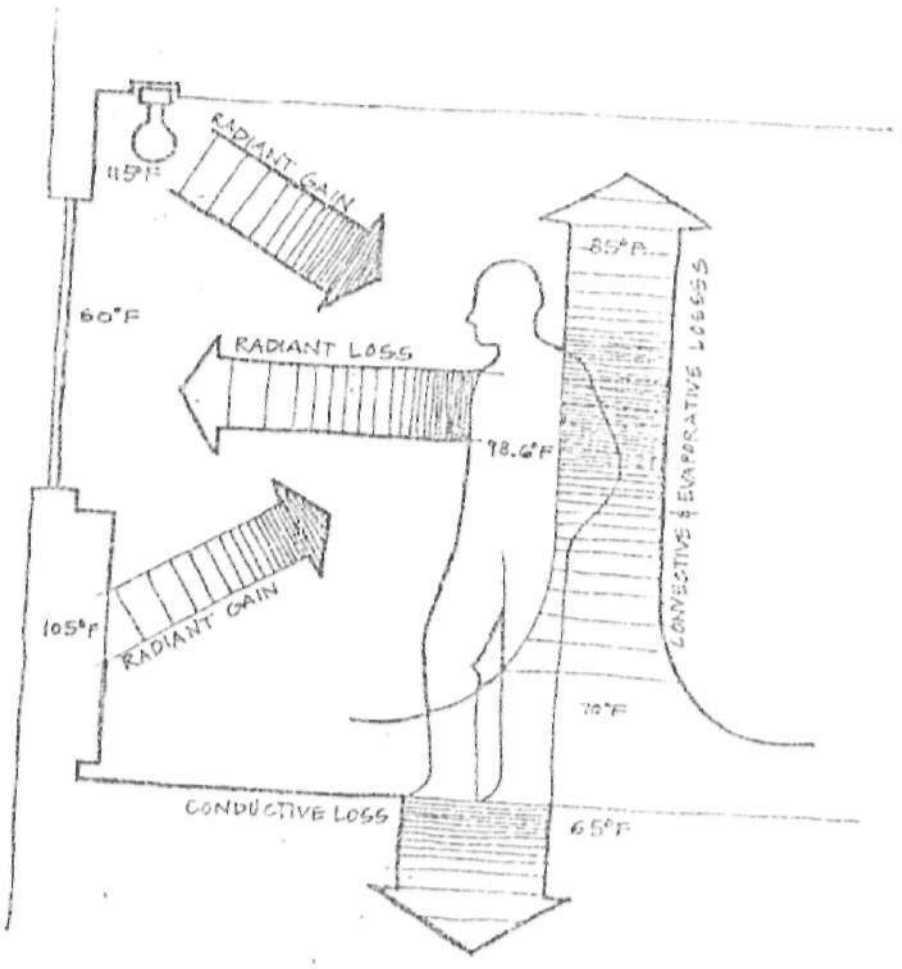
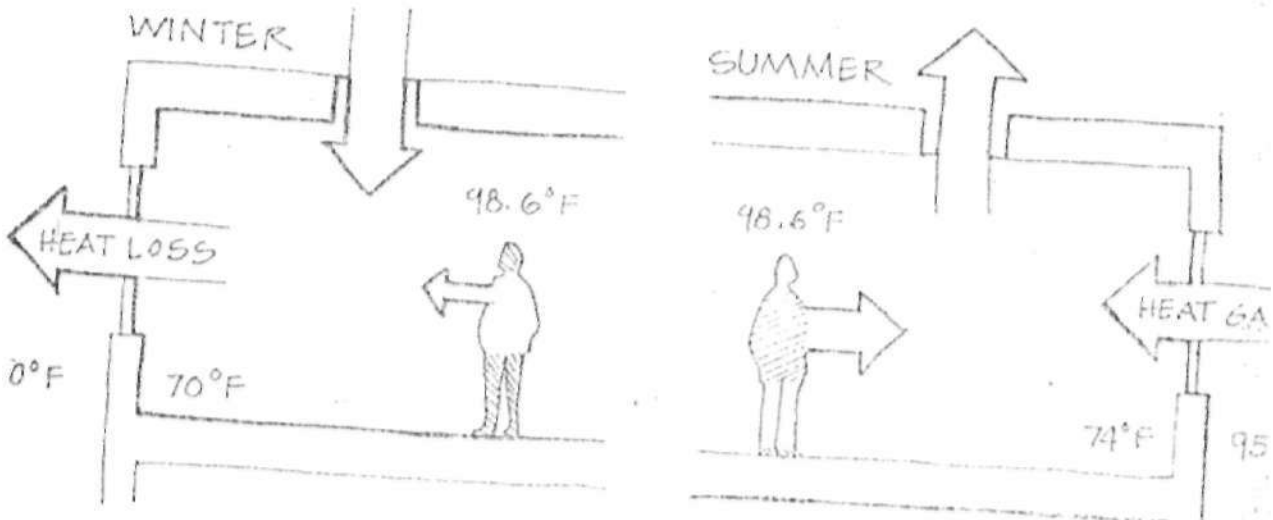


Fig 24 BODY HEAT EXCHANGE.



WARM AIR SUPPLIED, DECREASES RATE OF HEAT LOST BY OCCUPANT TO AMBIENT AIR, THUS INSURING WINTER COMFORT.

COOL AIR SUPPLIED CARRIES OFF HEAT, INCREASING RATE OF HEAT LOST TO AMBIENT AIR, THUS INSURING SUMMER COMFORT.

Fig 25 HEAT FLOW AND COMFORT, WINTER AND SUMMER.

6.4. Conclusion

Climatic zone of site under study:- warm humid zone.

Lay-out:- Orientation of buildings should be North and South with long axis of the building East-West.

Spacing:- Open spacing for breeze penetration.

Air-movement:- Rooms single banked or L shaped building permanent provision for air movement.

Size of Openings:- 40 - 80%

Position of openings:- In North and South walls at body height on wind ward side.

Protection of openings:- Exclude direct sunlight provide protection from rain.

Walls:- light low thermal capacity walls should be used on the site.

Roofs:- The roofs should be light, reflective surface, cavity.

External features:- Adequate rain water drainage system should be provided.

CHAPTER SIX

(1) Koenisberger O.H; Ingersol T.G; Mayhow, A. and Szokolay, Sov; Manual of Tropical Housing and Building; PART ONE:- Climatic design London; Longman group Limited 1973 p.33.

(2) Ibid p34

(3) Ibid p35

(4) Rubenatein H.M; A Guide to site and Environmental Planning. U.S.A. John Willey & Sons Inc. 1980 P.9.

CHAPTER SEVEN

DESIGN CONCEPT AND APPRAISAL

7.1 GENERAL PLANNING PRINCIPLES

7.1.1. - Principle 1

7.1.2. - Principle 2

7.1.3. - Principle 3

7.1.4. - Principle 4

7.1.5. - Principle 5

7.1.6. - Principle 6

7.2. ZONING

7.3. DESIGN CONSIDERATIONS

7.3.1. Choice of the Module

7.3.2. Fire protection

7.3.3. Noise Control

7.3.4. Colour Scheme

7.3.5. Lighting and ventilation

7.4. CONSTRUCTIONAL CONSIDERATIONS FOR THE FACTORY

- Structural frame work
- Roof plane
- Site and foundations
- Floors
- Walls and Ceiling
- Doors and windows

7.5. MAINTENANCE

- Pest control
- Waste disposal

CHAPTER SEVEN

DESIGN CONCEPT AND APPRAISAL

7.1. GENERAL PLANNING PRINCIPLES:-

To produce a good design proposal, a well structural criticism of the design is necessary as it develops, to ensure that the primary objectives are not being subordinated by unintentional overemphasis of any part of the design.

The following objectives will form the basis of such criticism for this thesis.

7.1.1 PRINCIPLE 1

Maximum flexibility and expansion possibilities with minimum effort and least disruption of operations (Production).

Proposals

(a) Modular Co-ordination and use of prefabricated demountable building elements.

(b) Develop independent systems for the different elements of the complex (structure, cladding, services; circulation e.t.c) rather than adopting a monolithic approach to the design.

(c) Establish a permanent facade, along which permanent and obstructive service elements would be located.

(d) Adopt an open ended approach to the design to facilitate expansion.

7.1.2. PRINCIPLE 2

Maintaining desired hierachies between the parts of the complex as well as concentration of similar activities into functional sub-complexes.

Proposals

(a) Each part should be checked continually with others.

(b) Overall zoning of the entire site into functional and interrlated areas according to noise levels, degree of privacy required and any other environmental consideration such as wind direction.

7.1.3 PRINCIPLE 3:

Maximum close communication between the individual functional areas of the centre with minimum vehicular traffic hazard and to maintain the tranquil environment necessary for industry.

Proposal

(a) Development of a completely pedestrian intra-centre traffic with no through or cross-vehicular traffic.

7.1.4. PRINCIPLE 4:

Optimum orientation to reduce solar heat gains.

Proposal

As much as possible buildings should be orientated with the longer facades facing north - south.

7.1.5. PRINCIPLE 5:

Proper zoning of facilities with due regards to prevailing wind directions.

Proposal:

The prevailing South West wind should be utilised to best advantage, taking into consideration problems of wind borne noise and shouts from the workshops, production hall and waste disposal facilities.

7.1.6. PRINCIPLE 6

Maintaining clarity of expression in the design.

Proposal

Design buildings to state clearly in visual terms the order of importance of the parts and to direct people in their use of the buildings.

7.2. ZONING

Proper zoning is the arrangement of the various activities that take place within the environment such that in the long run an efficient system of flow of all activities is achieved.

Having gone through the client's brief and programme, the factory can therefore be divided into 4 zones based on the functions they perform:-

(1) Administrative Zone:- Where management staff do their work and the buyers and suppliers go to negotiate business.

(2) Production Zone:- Where the finished products are manufactured ie., where the production processes take place.

(3) Workers' Facilities Zone: This is the zone with the facilities such as clinic canteen and so on necessary for workers' comfort.

(4) Auxilliary Zone:- This is basically the engineering and maintenance section.

7.3 DESIGN CONSIDERATIONS

Factors of paramount importance in the design of production halls include:-

(i) flexibility
(ii) number of floors
(iii) shape of building
(iv) possibility of conclusion of basement or/and balcony.
(v) Provision of window openings
(vi) type of floors
(vii) type of roof and ceiling
(viii) structural support systems
(ix) layout.

In addition to these, features of the site on which the building stands often affect the layout. Where this is so the designer must include them in planning.

These features might include:

(i) rail lines and siding
(ii) highways and road ways
(iii) canals or streams
(iv) bridges
(v) yard areas for storing, parking, lawn, gardens, etc.
(vi) Out buildings such as storage tanks, water tower, well, pump house, incinerator dump or burning area.
(vii) platforms, docks, ramps, truck or rail ways.

The design of an effective plant layout is a problem of defining and responding to the analysis. It is a system of dimensioning analysis and evaluation. From the imput developed by the internal organisation, the architect can analyse the existing flow activity, space requirements, primary and secondary adjacencies and so on. A plant can have a layout based on production or on a process. If a company produces a large quantity of a few products, then the function is based on product layout, while if a company produces a great number of products, each relatively small but similar processes, then you design on a product layout.

In casesof the proposed factory, the design is based on product layout. In the design of a factory the architect has to bear in mind the following:

(1) Head room required

(2) Loads to be carried

(3) Ventilation and heating

(4) Service and waste disposal

(5) Special process requirements.

In the proposed factory, the production process flows in the horizontal direction with expansion in the vertical direction. The raw material store is at one end while the finished product store is at the other end. The production line is straight. There are 2 bays namely the unloading bay which is for the raw material store and the despatch bay which is for the finished product store.

. When designing the unloading bay, the following have to be taken into consideration:

(1) Transport and methods of delivery

(2) form of material

(3) Unit bulk of material

(4) Quantity of single delivery

(5) Packing materials to be discarded

(6) Handling method from delivery to storage.

(7) Frequencies of deliveries

(8) Checking and security measures necessary.

While for the despatch bay, the following have been taken into consideration.

(1) size and function of finished goods store that is whether it is a holding store or main ware-houses

(2) form of transport after despatch

(3) fragility or risks of breakages

(4) security and accounting

(5) bulk and form of goods.

The storage and production areas are a single level for easy circulation and flexibility with mezzazine floors due to the production process and supervision. In order to provide adequate lighting and ventilation there are side windows on the walls and roof lighting operable windows on the roof. To remove fumes and heat the production hall needs air extractors.

Shape of Building:-

Early buildings were narrow because they needed natural light.

They expanded by extending their ends and by adding cross building in a rectangular fashion. Today artificial lighting is relatively less expensive. The number and frequency of production changes are greater. Therefore emphasis today is on production halls that are relatively square and not honey-combed or obstructed by walls. Such production halls are built in rectangular sections, and expansion is by building additional sections onto the sides.

However where land is limited, as in river valleys or where property lines run at curious angles the building must conform with the limitation of the land itself.

The following lists are useful guides for decision in the matter of building shape.

A relatively square building should be used when there are:

(1) frequent changes in product design

(2) frequent improvement in process

(3) frequent rearrangement of layout

(4) Restrictions on building materials or savings in desired in amount of materials used.

Other building shapes should be used where there are:-

(1) Physical limitations of the land

(2) Property lines at curious angle

(3) Buildings that house auxilliary operations.

Auxilliary facilities block

The production area forms the core of the accommodation, that is the hub of the plan. But it functions due to the courtesy of the auxilliary parts which is turn must be designed for optimum efficiency of the factory considered as a whole.

Since these facilities are by nature permanent and expensive installation they should not be placed in the way of any possible expansion. As in the case of internal engineering, this extended engineering facilities should be placed along a fixed facade.

Since these buildings do not directly participate in the flow of operations they can have more 'flexible' shapes.

WORKERS FACILITIES BLOCK

Both the quantity and quality of product depend not only on the sequence, precision and efficiency of the factories, tools and machines but on the proficiency pride and fitness-both mental and physical of the personnel. The development of factory design in recent years has become more and more concerned with creative comforts for the employees.

The facilities should be near the workspace so that no time is lost getting back and fourth, but they should be sufficienty insulated from the sights and sounds of the workspace itself so that a real change of scene is provided.

If a pleasant outside view is available the workers facilities block should be sited here. In order to compensate the workers for these industrial inconveniences their comfort once outside the production hall must be a point of focus.

Amongst the facilities provided in the factory are senior and junior staff canteens, changing rooms and toilets, for both female and male workers, clinic, clock in room, training school and a common room where the workers can rest between shifts. Adequate parking has been provided for the workers.

Administrative block

This is where the white collar job is done. This block should be away from the production hall because it is a quiet zone and these should be separated by a buffer zone or proper landscaping.

In the research conducted, it has been shown beyond reasonable doubts that 70% of the visitors who come to the administrative building, go to sales department hence this should be placed on the ground floor, along with the Accounts department while the management section ie. personnel, general managers office,General office, Conference room, and library should be placed on the first floor.

The administrative building should be a storey building. This is to create a balance between the very high production hall and the single storey workers block. It should be situated near the factory entrance with its workers' car park nearby and visitors' car park

outside the factory complex. There should be a waiting room by the gate house and a receptionist in the administrative block.

The administrative block should be connected to the workers block and all linked to the industry by a security post so as to control all traffic into the factory.

Service buildings used for administration, personnel offices and workers facilities block that do not directly participate in the flow of operations can have more 'flexible' shapes.

7.3.1. CHOICE OF THE MODULE

Approximate agreement does exist on the basic module M=100mm. Although the U.S.A. uses M=4in = 101.6mm.

The most critical dimensions are those of the small rooms found in the offices, mostly $7.5m^2$ $15m^2$, $20m^2$, $25m^2$ and $30m^2$.

Acceptable room proportions should not exceed ratio of 1:1.5. Thus 1.5m is minimum feasible grid 3.0m and 6.0m grids are too large for some small offices Also multimodules of 1.5m results in 3.0m and 6.0m grids. Hence the 1.5m grid is the module adopted in this design.

7.3.2 FIRE PROTECTION

The hazards caused by fire in a factory or any other type of building cannot be over-emphasised hence fire control should be a major priority in the designer's brief.

Legal and other requirements

The factory acts primarily provide for the safety of the occupants while the building bye-laws provide protection for both the factory and adjoining buildings.

These principles of guidance contain recommendations for the reduction of fire hazards under the following:-

Maximum headroom heights

Accessibility of sites

Limitation of area and extent of division within the building.

Separation of Occupancies

Protection of adjacent buildings

Staircases and fire resisting doors

Boiler house and fuel storage

Fire extinguishing equipments

There are two major causes of fire out break in factories namely internal and external fire hazards.

Internal fire hazards arise from the building structure, its contents and production process. External fire hazards. Fire can spread from one factory to another in a compact layout. So it is the work of the fire brigade after safety of life has been ensured to prevent fire spread. External hazards depends on the distances between buildings, the construction of the external walls and roofs. and the amount of openings in them, the size of building and nature of their content.

PRECAUTIONS AGAINST INTERNAL FIRE HAZARDS

(1) Structural Fire Protection

The over-all protection against fire, of a building depends upon two kinds of precautions namely

(a) Precautions designed to prevent fire from starting

(b) Precautions designed to reduce or prevent fire spread which includes

(i) Methods involving the design and construction of the building itself

(ii) Installation of fire alarm and extinguishing equipments

(iii) Means of escape

In steel-framed single storey structures, the columns can usually be protected without much difficulty. The large-span steel trusses are more difficult to deal with as per fire protection even though sprayed coating provides a convenient method of precaution. The initial cost of protecting steel work by means of spread coating may be largely offset by saving the maintenance cost by painting.

In concrete structures, fire resistant material can be used in construction.

(2) Interal Planning

Where division is not possible use should be made of other means of reducing fire risks. One method is large-span single storey factories with pitched or barrel vaults roof is by dividing the roof space with non-combustible curtains which provide some barrier to the lateral flow of smoke and hot gases rising from the floor.

To be effective the curtain must be non-combustible and form a close joint with the underside of the roof covering. They should extend downwards as far as possible but must not reduce the intensity of the curtain as a barrier to fire spread.

(3) Means of Escape

Escape in the event of fire spread depends on the escape routes provided in the building. The distance between been them and the provision of alarms. In any building the maximum distance between escape doors is about 30m. In a storey building, escape staircase should be provided at every 30m and made very prominent and accessible so that even in time of maximum panic, one would not need a guide.

(4) Fire Warning Systems

Due to the nature of most factories, the use of fire alarm system is very encouraged. It must be placed so that it can be operated without undue risk. It must also be very audible and quite distinct from all other noises in the factory and its meaning understood by all. In factories with very high noise level, a visible warning system should be used.

(5) Fire Fighting Systems

The event of a fire outbreak, there should be adequate fire fighting systems in all factory to quickly stop the fire and avoid spreading it. Amongst these we have stir-up pumps, buckets of sand and sprinkler system which is proposed to be used in this factory.

The sprinkler system pipes out water automatically with all intend to extinguish fire. The type to be used is the most common, least expensive called the fixed temperature wet system. Water pressure fills the entire system and water is released from individual sprinkler heads fixed at regular intervals of 15m in the event of fire. The sprinkler heads are fitted with heat sensitive fusible plugs set to realese the water at a predetermined temperature. The sprinkler heads sprinkles water with a radius of 15m and are placed both outside and inside the factory.

Precautions against external hazards

(1) Site Planning:- In the siting of factories in relation to fire protection, factors must be taken into consideration.

(a) Access road for fire brigade appliances:-
There should be fire roads in the factory an emergency roads so that in the event of fire outbreak, there would be no obstruction for the fire fighting cars from reaching the fire target.

(b) distances between buildings to reduce fire spread between buildings.
The buildings should not be too close so that the fire would not spread easily.
The buildings should be seperated by proper landscaping.

(c) Access roads and open spaces in the buildings

(d) All liquids of a flash point lower than 32°c should be stored alone in an inflammable store or underground

7.3.3 NOISE CONTROL

The amount of noise generated in a factory depends on its production process and this differs between factories. The problem of noise and its control in factories is not the sole responsibility of the architect. While the architect is concerned with sound absorption (that is providing the building with adequate sound absorbing materials) the engineer is concerned with the noise reduction right from the source and where the noise level is still very high despite all these precautions, it is then the duty of the management to provide its workers with sound protective materials such as ear plugs or ear muffs.

Sources of Noise in Factories

The most intense source of noise is generally caused by machines, tools and by operations involved in the production process. The sources of noise can be classified into 4 groups namely:

(1) Impact

(2) Reciprocation

(3) Friction and

(4) Air turbulence

(1) Impact:- Processes like hammering, riveting, chipping, pressing and so on, produce one of the most intensive and widespread industrial noise. The noise spectrum depends on the nature and size of the object being worked upon and the tool.

(2) Reciprocation:- Whenever a machine vibrates or reciprocates at a frequency above the lower amible limit, the moving surface will radiate noise directly.

(3) Friction:- Occurs when metal surface come in contact with metal or other surfaces, example are grinding, sanding, sawing. The amount of noise produced in friction depends on the nature of the 2 surfaces and the force involved. But this can be reduced by lubrication hence the noise level is reduced.

(4) Air Turbulence:- This is the noise generated as a result of rapid variation in air pressure caused by turbulence from high velocity air and steam. In this proposed factory, the 2 major sources of noise are impact and Reciprocation.

Effect of Noise

As the level of noise increases, its effect on people first of all will be annoyance, after which it will lead to interference with verbal communication and finally damage to hearing. Not only does this vibrational noise weaken the structure of factory, it also introduces cracks in some places. It is obvious that noise can actually influence workers welfare and safety thereby reducing, albeit indirectly their efficiency hence reduction in production output.

Noise reduction and layout

(1) (i) Site layout:- High frequency noise which in any case is more directional can be screened off by buildings and low branched trees which will act as butter.

(ii) Factory layout:- The factory buildings should be built out according to the noise level generated in the building. The noisest zone should be placed seperately and/preferably shielded by low branched trees and proper landscaping while the quite zone should be placed infront with a buffer zone between them.

(iii) Use of sound absorb. materials. In an open air, the direct sound decreases with increase in distance. This phenomenon is the same even with enclosure up to the boundaries, so this reverberant sound in built up as a result and the only way to take care of it is by the introduction of a good sound absorbing material hence the use of an acoustic:- Cebtex and polyethane material.

(iv) Ear protection:- There are some cases such as the generator house where no matter what measure against noise is taken, the noise level is still high hence the management provides ear protection. Two main types are:

(a) Ear muffs

(b) Ear plugs

310019

(a) Ear muffs: These are available in various sizes and must be correctly fitted to the ear to give a good seal.

(b) Ear plugs:- These are small and inconspicious when worn and are very common because they are cheap.

7.3.4 COLOUR SCHEME

The mistaken, assumption that the primary function of colours in factories like elesewhere is decorative is not true. While colour functions in a factory is to develop a pleasant, invigoratory and orderly appearance, its mass functions is to aid vision. That is why lack of properly designed scheme not only lead to drab, depressing and confused appearances, no matter how much effort is spent on cleaning but will also put an unecessary handicap to vision and hence retard quickness, accuracy and safety of work.

Colour as aid vision:-

An important function of colouring in factories inconjuction with good lighting is to promote comfortable and efficient vision of work point and in the whole environment.

Principles for the design of good colouring soft, middle and strong

In the design of colouring in accordance with functional requirements, contrasts of colours is very important, contrast are bold or gentle according to the differences of hue, value and chroma, contrasts of brightness, as distinct from constrasts of colour, are the results of variations of light and shade and to prevent these from being expessive, some adjustments to the colouring, particular values is always required.

Colours can aid alternation on the work, improve safety and reduce glare from windows or light fittings. The aims are achieved by controlling the contrasts of brightness caused by lighting and colour in combination. Work should be seen against a simple, unobstructive and unconfusing background.

In conclusion then, we can draw the followings:

(a) Opportunities usually exist; and should be exploited for introducing some limited chroma colour in position where

it is readily seen but does not conflict with the other functions of the colouring.

(b) Generally the good and the bad colouring all cost about the same. The factories act stipulates regular cleaning and repainting, but good appearance depends also on choice of suitable materials and colours which are appropriate and reward the effort spent on cleaning.

7.3.5 Lighting and Ventilation

Whenever lighting system is employed in a factory either natural or artificial, the amount of light must be sufficient for the nature and requirement of the process.

In every factory there is a special lighting requirement arising from the nature of production taking place, for example, colour - matching process are most easily carried out in daylight, whilst some photographic process require a complete absence of light. Whenever possible it seems desirable to provide natural lighting with a sight of outside world, so that blend offices and department are best avoided. Care must be taken to control glare and brick walls are favoured for this purpose.

Both the accident rate and the productivity are affected by lighting, and so lighting must be ample for the task to be carried out at the same time avoiding excessive contrasts. Artificial lighting can give rise to undesirable effect other than the obvious difficulties of colour rendering, flourescent lamps, now very widely used because of their light efficiency can produce an initiating flicker and if used in conjuction with rotating machinery a stroboneşfic effect which may appear to slow down or even stop a machine.

This illusion is, at best, trying and at worst highly dangerous. By using a number of lamps and designing the power supply to them correctly the strobonefic effect can be reduced or even completely avoided.

be
The effectiveness of lighting can /improved by choosing light colours in the walls and ceiling and also by the use of contrasting colours of plant and fittings.

Dirt will rapidly reduce the output of any lighting fitting and so all fittings should be placed in such a way that it can be cleaned safely and easily.

Ventilation:

Most of the time, due to the width of the factory natural means of ventilation is not always adequate hence the introduction of mechanical means of ventilation.

(1) Natural means of ventilation.

(a) By providing a reasonable amount of openable windows taking security into consideration.

(b) By providing openable roof lighting windows.

(2) Mechanical means of ventilation.

(a) By providing suitable fans located at some convenient central point, the air being moved that is fresh air blows in and used air extracted.

(b) By pyoviding individual extractor units mounted on the roof (usually at the highest point).

7.4 Constructural Considerations

Structural Framework

Generally, the type of materials used for the construction of a facto depend on

(a) The span of the factory.

(b) The height of the factory which is determined by the types and heights of the machines.

(c) Climate of its location for example, it will be unwise to use steel in a very humid and hot climate because this will aid corrosion very quickly.

(d) The loads to be carried by the building structures.

The materials must be able to withstand.

(a) Effect of acids, alkalis, water vapour e.tc. and the fumes produced by the production process.

(b) Must not aid the breeding of bacteria, fungi and other organisms.

(c) Effect of weathering.

Criteria for selection of structural type.

- fire resistance
- weight
- Cost and mode of construction
- optimisation of production layout
- exploitation of modern mechanical handling techniques.
- services & thermal insulation
- head room required.

Roof plane:

The roof plane is a buildings prime sheltering element protecting its interior from climatic elements. The roof form is determined by geometry and materials of its structure and the manner in which its spans across space and bears on its supports.

As a visual design element, the roof plane is a building's 'hat' and can have significant impact on the buildings form and silhonette. The roof plane can be hidden from view by the building's walls or it can merge with the walls to emphasize the buildings volume and mass or it can be expressed as a horizon or sloping plane.

There are various ways of arranging structural members used to support the external cladding and other loads. The main roof shapes and methods of framing are shown below:

See fig. for the factory roof shapes and framing methods.

The barrel vault chosen as the type of structural system for the proposed factory, ensures clean continuous sweeping lines affording good reflecting surfaces because they don't collect dirt easily and clear space free of obstruction. Essentially designed to support comparatively light, uniformly distributing loading, the application of part loads of any magnitude is restricted to main stiffering beams and diphragm walls which can also act as supports for the overhead conveyer belts to be used in the production process.

While, the main material used in the framework of the factory is reinforced concrete. The factory building has varing heights due to the production process. The walls are not load bearing walls hence they can easily be extended (that is good flexibility). The whole internal space of the factory is free of internal columns because these affect movements of both traffic and material.

Site and foundation

The anaylsis carried out on the site showed that, the soil can carry any heavy structure without requiring any special form of foundation.

The load developed in a work area does not mean only the weight of the production machines, but also the load of the raw materials and finished goods and the load of any material handling equipment (trucks, forklifts etc.) likely to be used in conjuction with the plant. The foundation should support all these loads and also eliminate the danger of cracks in the floor and walls.

The functional expectations of factory foundations are:-

(a) Support all the applied loads.

(b) Resist lateral forces.

(c) Resist tensional forces.

(d) Transmit vibrations to lower levels without causing discomfort.

The foundation plan is influenced by

(a) Gradient or slope of the land.

(b) Type of soil: The bearing capacity of the soil will determine the type of foundation and the strenght.

(c) Height and type of the building construction. A multi storey building means more weight per square meter with corresponding larger foundation and footing.

The various techniques that have been applied in foundation design to counteract these expectations are:

(a) Application of more reinforcement in several plans. This can be used when the site is slopey.

(b) Use of vibration absorbing pads is most useful when machines ribrates and generate noise.

(c) Varied constructional and design techniques that include common generalisation. Application of the above steps either singly or collectively would overcome any problems involved in the design of any particular foundation.

FLOORS

The floor is one of the most important and essential tool in factory design. It provides interalia, the means of efficient transportation for men and materials; the platform for men, machines and work-in-progress. It usually takes heavy wear because of its constant and varied use, and probably receives less maintenance than is due if. The specification of the floor should be carefully considered in this light with both the structure and finish making due allowance for the nature of the loads to be carried and traffic. Also, the floor finish should be designed as carefully as the mechanical equipment that operates over it.

The rule for flooring in a factory is to have a well prepared base caculated to accept the wheel loadings of plant such as turrent trucks and narrow aisle order pickers.

If wheeled tanker forklifts are to be used along with the other equipments, plan for loadins of 7-8 tonnes per meter squares.

The properties required from factory flooring are

(a) Protection of the building structure from traffic and effluent. The floor finish might be able to withstand the loads of wheel loadings such as forklifts which have been known to break them up very fast and also be resistance to any spillage.

(b) Must be able to carry all the loads. The floor finish must be designed in such a way that both the imposed and dead loads can be carried without any wear and tear on the floor.

(c) Comfort and safety of users. The effect of accidental spillage should not be severe. Trucks with small front rollers can be made dangerously unstable by bumping on expansion point hence a poor floor can dramatically increase type and castor bills.

(d) Good apperance and the ease to maintain it. The floor finish should be pleasing to the eye and not to expensive to maintain.

TYPES OF FLOOR SPECIFICATIONS.

There are two main types of flooring namely

a. Jointed floor

b. Jointless floor

c. Jointed floor:- examples are Tiles, wooden blocks Although they are as efficient between joints and jointless flooring, these may bread up along the joints, where handling plant with phyure than wheels and roll pallets with metal castors abvade the edges. These jointed floors are more expensive than Jointless ones.

(b) Jointless floor: examples are granite screed for general purpose, high use factories a screed of granite chippings 12mm thick, set is a mixture of cold bituminous mastic and portland cement has proved effective and

durable but there's the need for constant maintenance.

Concrete: Another type of flooring is to lay the whole floor ~~slab~~ gravity 200mm thick road mix concrete with a rod paving machine, finishing with a 12mm hardened granolithic screed. This tightens tolerances. The lack of expansion joints is a great advantage.

Spoxy Jointless floor:- An accurate and long lasting finish. This is handweaving, can be laid to tight tolerance and are resistant enough to stand continuous heavy impact from metal objects. It can also handle heavy block stacks and its jointlessness makes it ideal for food processing factories. This is the type of flooring proposed to be used in the cocoa factory.

Walls and Ceilings

Clear iternal height: The plant must be accommodated with sufficient clearance for its in installation, removal and naintenances mobile equipments such as fork-lifts may call for special headroom for efficient working. Any tendency for a given type of production machinery to increase in height should also be considered when deciding on the clear height for the framework of a factory building.

Heights of the wall is determined by the following.

a. Working height of process
b. Clear height of overhead conveyors, crames e.t.c
c. Accessibility and maintenance
d. Gravity feed system
e. Crossed circulation
f. High level supervision
g. High level service distribution

Storage buildings (that is both raw materials and finished products) should be -stored for flexibility of layout, heavy duty floors at minimum cost economics in handling machines and plant layout. There should be clearance for structure, and services to obtain overall building height.

Due to the production process which requires different heights, the factory will consist of mezzanine floors. This also will give additional inherent flexibility, make supervision easy because offices can be sited on the upper floors where the process can be supervised without realy leaving the office.

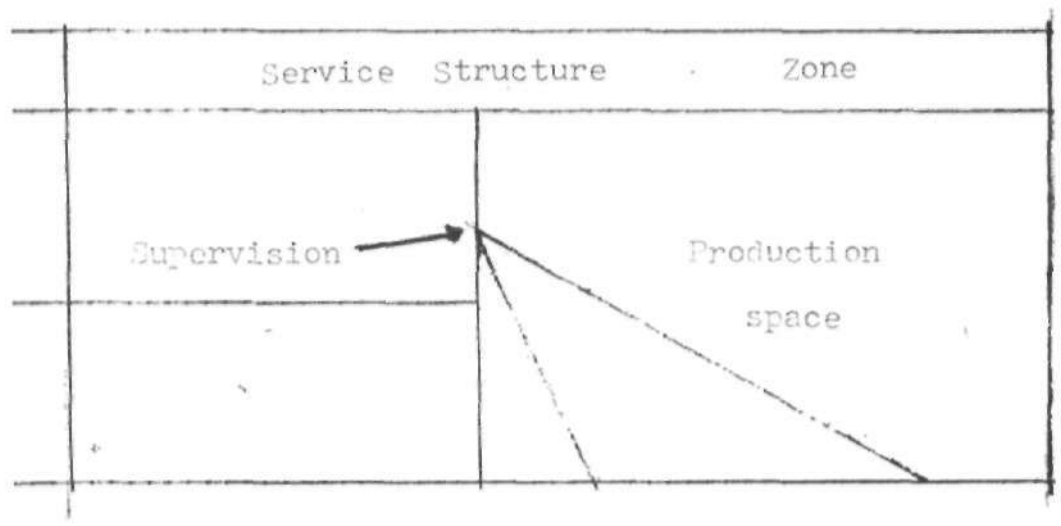


Fig Shows how mezzanine floor aids Supervision
Illustrate

The ceiling should be designed such that it can accommodate the services (in fact the ceiling is known as the service structure zone) and also is should be able to support any overhead equipment,

Both the ceiling and wall should be properly acoustically insulated so as not to spread noise. They should also be properly protected by fire resistance materials because they are one of the quickest ways of spreading fire. The ceiling material should not be the type that accumulates dusts and dirts and should be easy to maintain.

Doors and Windows

While doors to industrial buildings are primarily for access, they also have to provide security, weather protection, thermal and acoustic insulation as well.

There is a wide range of door types and sizes with specifications tailored to particular applications. But there are basically two types of industrial doors depending on the functions they perform.

a. Those enclosing a ground level loading area through which vehicles pass for over-the-side loading

b. And those attached to the loading banks.

Ground level doors for wide opening can be

sliding, sliding-folding or vertical roller shutter. The horizontal sliding doors are useful where handling plant will pass through frequently and only need open to the width of vehicle/machines passing through so the minimum area is open to elements while the vertical resting doors need to open to the full width and height of the vehicle/machines, resulting in greater heat loss, more dust and rain intrusion. Also, if a panel of a sliding door is damaged, it's usually still operable whereas, if a nesting door is damaged the whole door jams.

Ground level doors should have an external canopy for weather protection extending at least 5m forward of the opening and 3m on either side. This will reduce the amount of water brought into the warehouse factory by delivery vehicles.

Windows serve the main purpose of natural lighting and ventilation.

MAINTENANCE

The need for a maintenance department in a factory cannot be over - emphasized because it is like a 'hospital' to a factory. The type of maintenance required depends largely on the production process(es) carried on in the factory since this determines the type of machines used and this varies from a clearner's room to complex workshops.

For most factories, maintenance department consists of metal works section, carpentry electrical and mechanical sections.

A cocoa factory needs a pest control department for the control of pests, carpentry, electrical mechanical workshops with skilled labour where all the machinery and vehicles can be quickly serviced or repaired when the need arises there is an environmental control department which consists of cleaners and gardners to keep the factory and its environs clean.

In this factory, where the control is ensure the exactness of the process the need for a laboratory in the Quality Control department arises, because of the production process and the need to monitor at intermidiate stages the state of the 'product' in the making, the size and equipment capacity of the laboratory becomes large and should be quite close to the production hall.

7.5.1 Pest Control

The need for a pest control unit in food can processing industry cannot be over emphasized. This is because, pests such as Rats, Cockroaches, e.t.c have always be found whenever there is food. The pests are mostly found in the processing room and stores especially raw material store. These pests conterminate the food if care is not taken. To guard against this, the pest control unit must ensure.

(a) Personal hygiene and public health of all personel especially production workers

(b) That wastes are properly and quickly disposed of.

(c) Good housekeeping in and about the plant

(d) That spillages and fallen bits of food are quickly cleaned

(e) Unnecessary holes should be blocked so as not to act as breeding ground for the pests

(f) Traps should be set.

7.5.2 (ii) Waste Disposal

All material which enter the site that don't leave in the form of finished goods must either accumulate as waste or leave it as effluent. The accumulation of waste can impact the efficiency of the process andin time become a hazard either within the factory or outside hence waste disposal is very necessary in a factory design.

References.

1. Agger H.V. - Factory Structures
Great Britain, Lund Humprices publishers Ltd. 1979

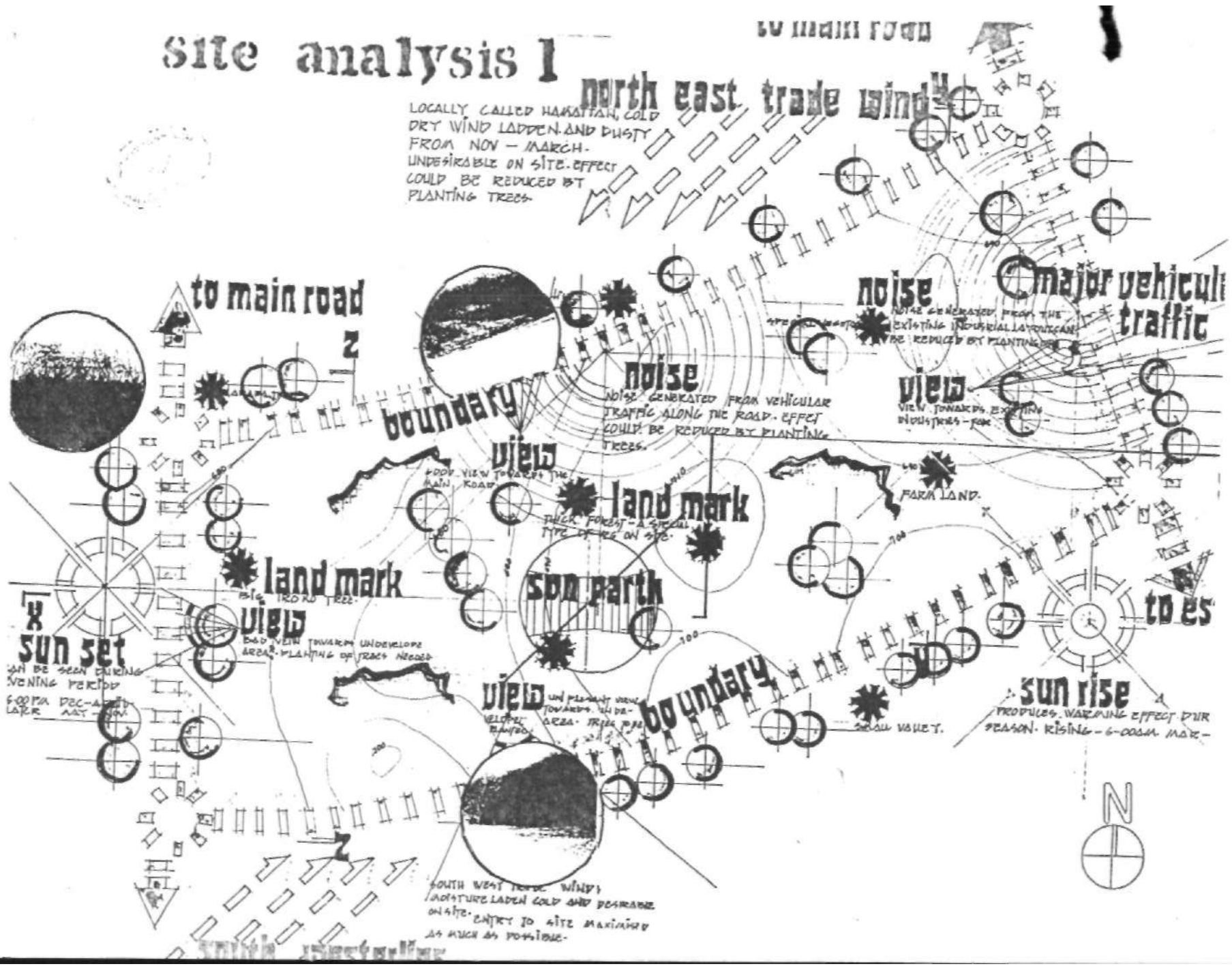
2. [illegible]. O.H. - Industrial Building and Factories
England, Cambridge University Press, 1961.

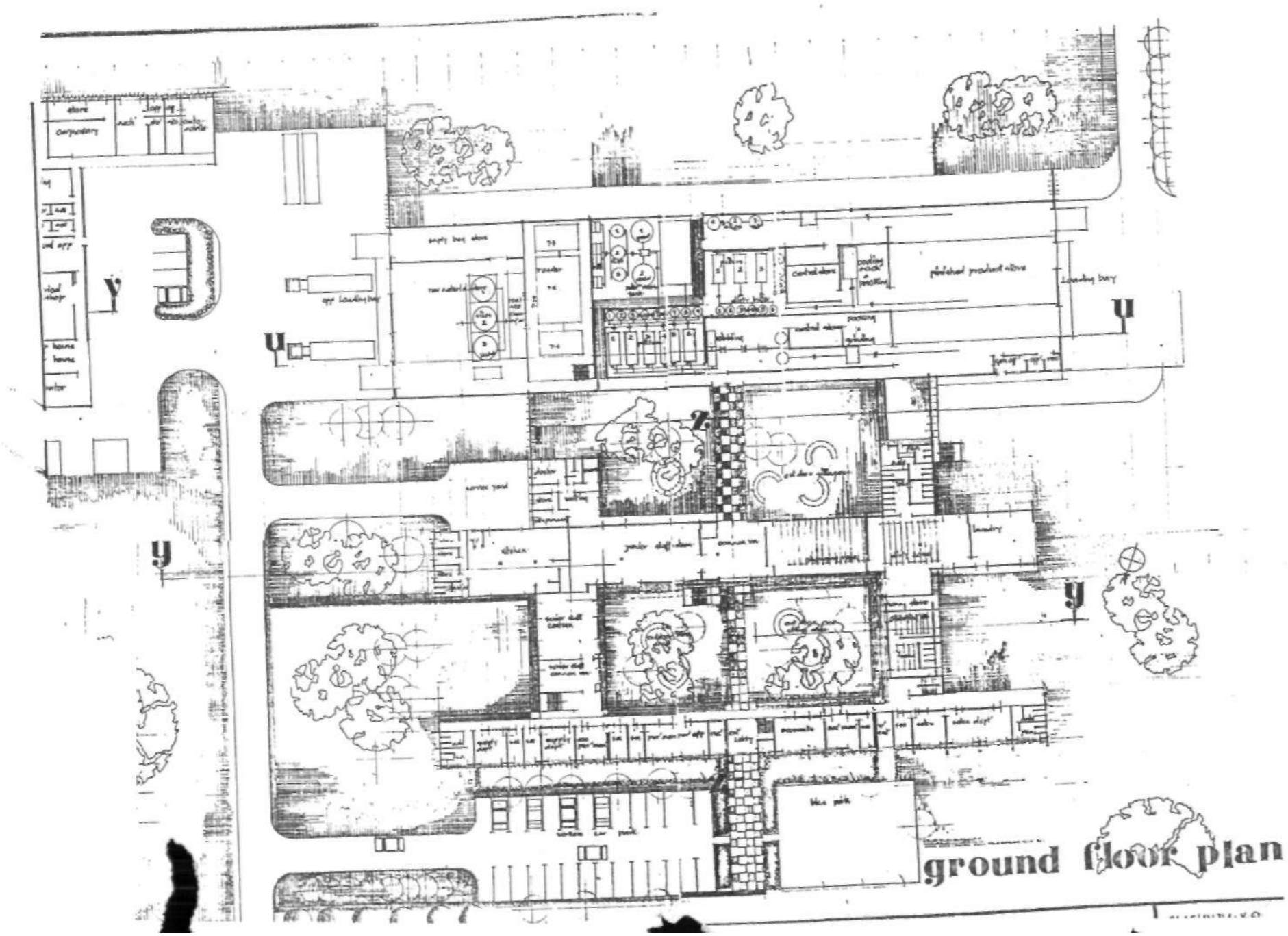
3. Lunce J.F. - Buildings for industries
Architectural record. Industrial architecture analysis 1982. Dec.

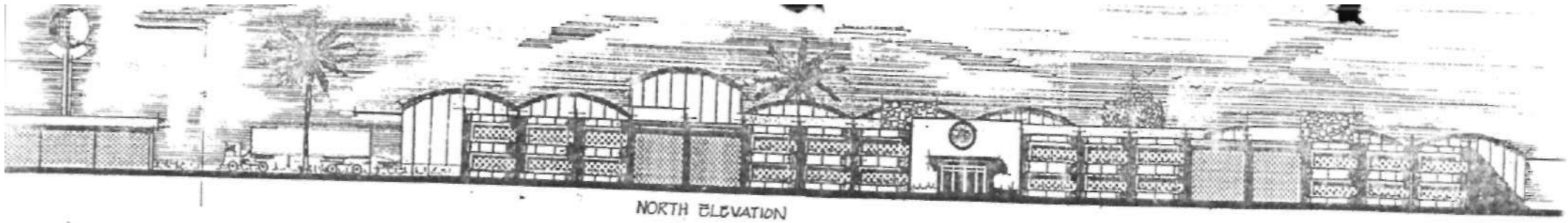
4. Hissen H. - Industrialize Building and Modular Design
Grosvenor Gardens, London; Cement and Concrete Association, 1972

5. [illegible] O.F - Building for Industry
Factory environment. London. L.U.Press 1982.

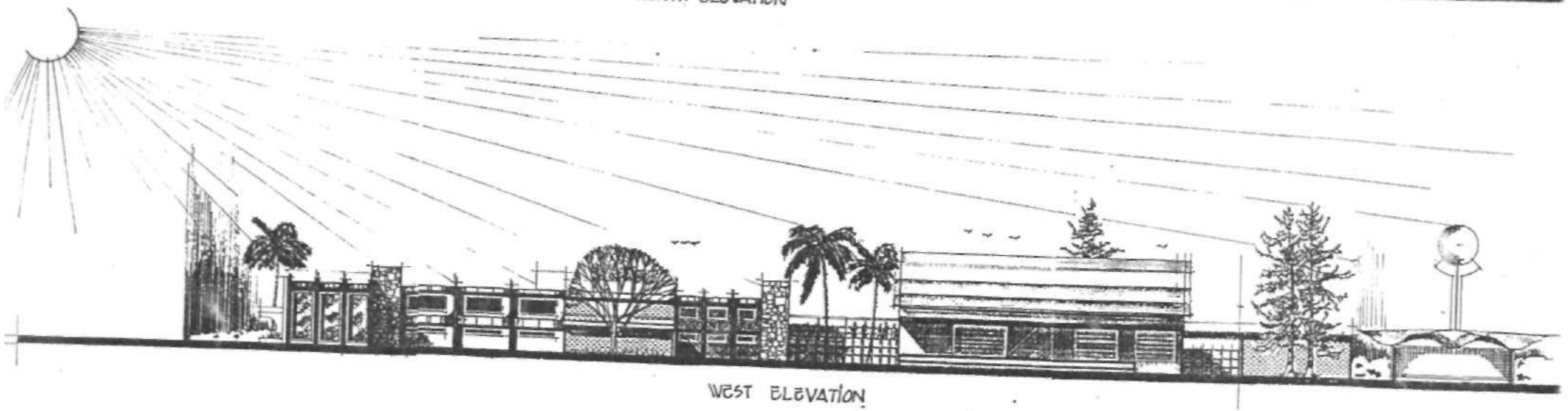
site analysis I



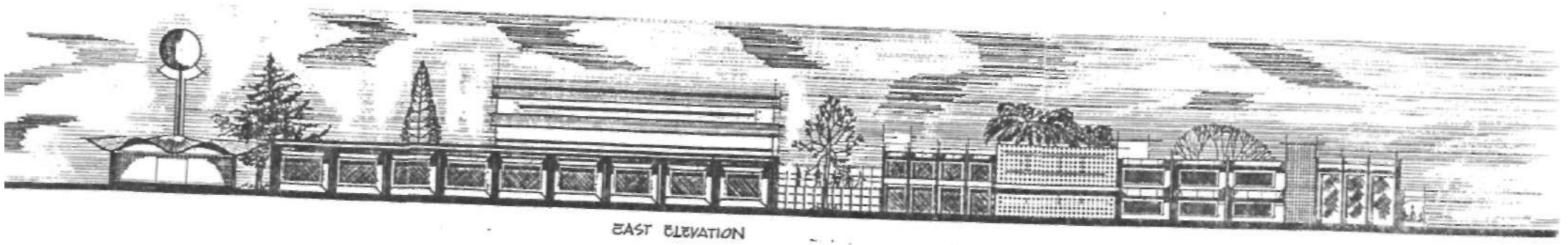

ground floor plan



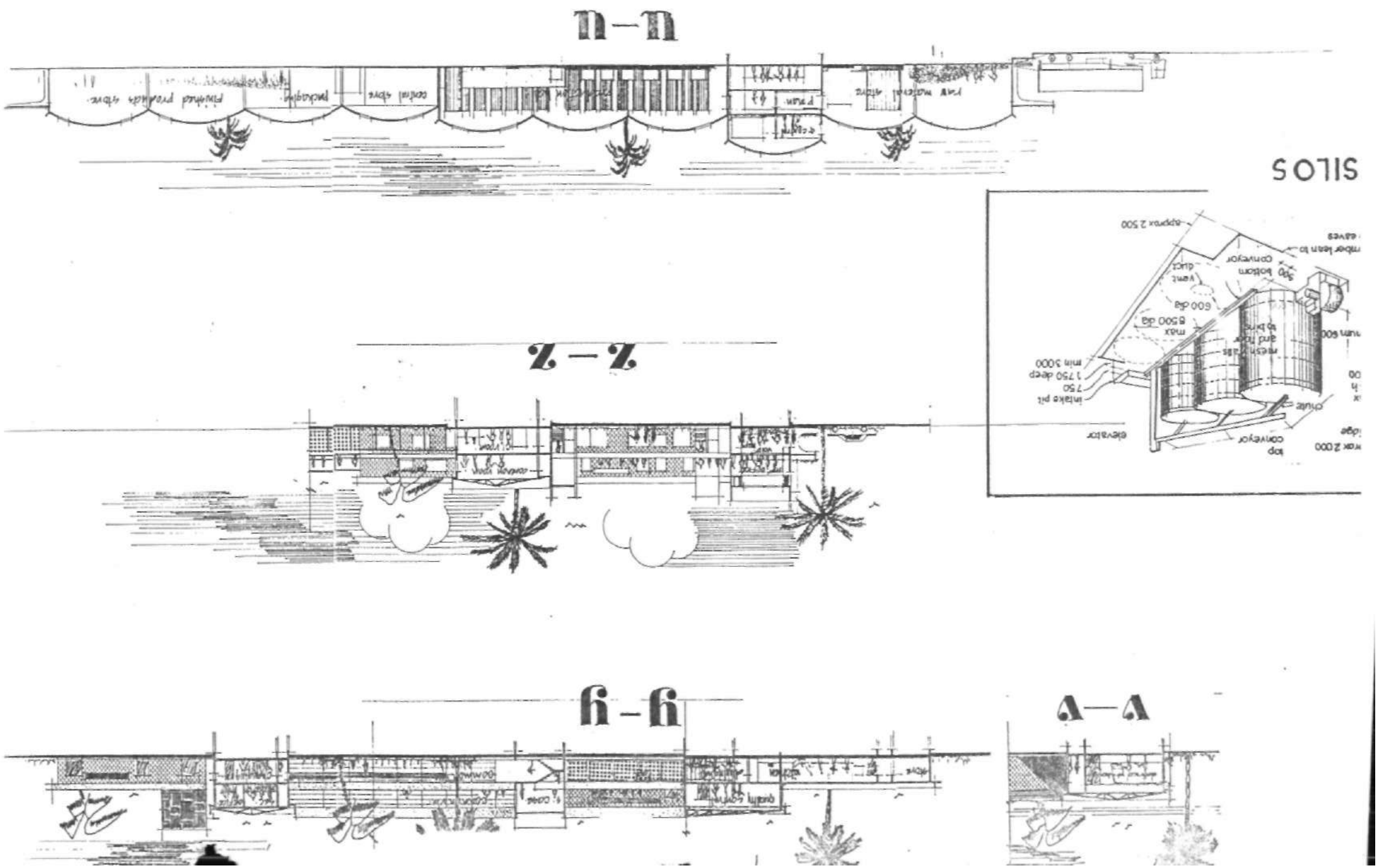
NORTH ELEVATION



WEST ELEVATION



EAST ELEVATION


SILOS
U–U
Z–Z
Y–Y
A–A

BIBLIOGRAPHY

1. Advisory Pamphlet No 1 (May 1986) - Harvesting fermentation and drying of cocoa. Cocoa Research Institute of Nigeria. p.4

2. Advisory Pamphlet No 6 (1986) - Harvesting fermentation and drying of cocoa. Cocoa Research Institute of Nigeria p.1

3. Alexander, C. (1964) - Notes on the synthesis of form Cambridge, Mass: Harvard University Press, pp. 7 - 10

4. Alfred M. Kemper (1979) - Architectural handbook pp. 74 - 79.

5. Ahoe, W. (1978) - Architecture and Critical imagenation. Chichester, England John Wiley and Sons pp. 11 - pp. 18

6. Apcer, H. V. (1976) - Factory Structures

7. Barham, R. (1969) - The architecture of the well - tempered environment. London: Architectural Press.

8. Bonta, J.P. (1979) - Architecture and its interpretation. Credit Britain. Lund Humphries Publishers Ltd.

9. Callender, J.H. (1974) - Time-Saver Standards for building types. U.S.A McGraw Hill Book Company

10. Callender, J. H. (1974) - Time-Saver standards for Architectural Design. U.S.A. McGraw-Hill Book Company.

11. Dufby, F. (1976) - Planning Office Space Great Britain. The Architectural Press, Ltd,

12. Egan, M.D. (1975) - Concepts in thermal comfort. Englewood Cliffs N.J. Prentice Hall, Inc.

13. Falconer, P & Drury, J (1966) - Building and Planning for industrial sterage and distribution.

14. Grube, O.W. (1977) - Industrial buildings and factories. Archi recorda

15. Henn, Walter (1969) - Buildings for industries

16. Jones, J.C. (1970) - Design methods. London John Wiley and Sons.

17. Koenigsberger, O.H., Ingerso. I.T.G. Mayhew, A and Szokolay, S.V. (1973) - Manual of Tropical housing and building part one: Climatic design. London Longman Group Ltd.

18. Lippsmeier, G. (1969) - Building in the tropics Germany: Veclag George D.W Callway, Miinhen.

19. Minife, B.W. (1973) - Chocolate, Cocoa and confectionery science & Tech Archi Recorda.

20. Munce, J.F. (1962) - Laboratory Planning. London Butterworth & Co. Publishers Ltd.

21. Munce, J.F. (1976) - Building for Industries Architectural Record. Industrial Architecture analysis.

22. Neufert, F. (1980) - Architects Data. London Granada Publishing Ltd.,

23. Nissen, H. (1972) - Industrial building and Modern design. Grosvenor Garden, London. Cement and Concrete Association.

24. Olgyay, V. (1963) - Design with Climate Princeton Princeto University Press.

25. Porter, T. (1979) - How Architects Visualize London. Studio Vista.

26. Prentice-Hall Editorial Staff (1964) - Encyclopaedia dictionary of production and production Control. Englewood Cliffs; N.J. Prentice-Hall Inc.

27. Rubenstein, H.M (1980) - A guide to site and environmental planning. U.A.S John Wiley & Sons Inc.

28. Rohan, T.A. (1970) - Processing of raw cocoa for the market. CRIN IBADAN

29. Simmons J. (1974) - Cocoa production. Economic and botonatical perspective CRIN, IBADAN.

30. Simmons, J.C. (1961) - Landscape Architecture New York, McGraw-Hill.

31. Tuh, P and Adler, D (1979)- New Metric Handbook. London Architectural Press.

32. Utgikar, S.S. (1982) - Building for Industry and Factory environment. New York, McGraw-Hill.

33. Wade, J. (1977) - Architecture, problems and purposes. New York: John Wiley and Sons.

34. Wild, R. (1979) - Production and operations management. St. Arnes' Road, Eastbourne, East Susse. Holt, Rinehart and Winston Ltd.