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PLANNING, DESIGN AND CONSTRUCTION OF INDUSTRIAL ESTATES WITH PARTICULAR REFERENCE TO AFRICA

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UNITED NATIONS SEMINAR ON INDUSTRIAL ESTATES IN AFRICA - ADDIS ABABA

PLANNING, DESIGN AND CONSTRUCTION OF INDUSTRIAL ESTATES WITH PARTICULAR REFERENCE TO AFRICA

by

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INTRODUCTION

> "The urgent need of many developing countries to accelerate industrialization and to raise living standards has made it imperative to undertake practical programmes designed to further social and economic progress. The industrial estate is a recent addition to the many techniques which have been successfully applied in order to encourage industrial development in the developing countries." (The Physical Planning of Industrial Estates, United Nations publication, Sales No.: 62.II.B.4.)

1. An industrial estate consists of an area of land allocated for factory buildings, which are sold or leased for manufacturing purposes. The land is developed in accordance with a comprehensive plan, which includes roads and other means of communication, services and site preparation, carried out in advance of building work. Factory buildings are erected either as standard units of various types or to meet the specific requirements of a particular industry. Industrial estates are areas of controlled development in the town planning pattern, and, by means of zoning, restrictive convenants and other devices, their form and growth is regulated, for the benefit of both the occupants and the community at large.

2. The industrial estate can play an important role encouraging and expanding small-scale and medium-sized industries within the framework of a national industrialization programme. For this reason, among others, the concept is particularly relevant to the developing countries of the world, which cannot only benefit from the experience of the already highly industrialized countries such as the United Kingdom and the United States of America, but who can, at the same time, avoid some of their more obvious mistakes.

3. The idea of the industrial estate is now over 70 years old, and the experience gained not only in Europe and America but also in Africa, India, the West Indies and other parts of the world is available to aid new ventures in the developing countries.

A. PHYSICAL PLANNING

(1) Location

4. One of the most important factors contributing to the success or failure of an industrial estate is its physical location. It is vital, therefore, that any broad siting decisions should be made in the light of national and regional planning policies. In this respect, industrial estates can be regarded as one of the means of organizing land use in an economical way, and ensuring the proper segregation of the various uses. However, the haphazard establishment of industrial estates can never be an adequate alternative to a national economic development programme; the proper integration of local projects with over-all development plans is vital if the establishment of industrial estates is to be fully effective.

5. Before any detailed consideration is given to location, a regional development survey is essential; this must determine the economic and industrial potential of a given area in the light of national needs. Such basic investigations should include a study of existing and potential resources in relation to raw material, labour, communications and consumer demand. Existing industry, its variety, technical and economic problems and gross possibilities, will provide indications of the needs of the region and the type of development best suited to those needs.

6. Research surveys must be thorough and can be of great value, particularly when industrial estates are intended to encourage the industrial development of rural areas. Such areas are generally difficult to develop industrially, and a regional survey will often reveal that essential basic requirements for industry cannot be provided economically. Any rural development project must therefore be regarded, initially, as being purely experimental, and might well consist of a group of small local industries and handicrafts,

based on the traditional materials and skills of the district. These could then develop as local technical difficulties and prejudices are overcome.

7. At the other extreme, industrial estates located near large centres of urban population readily attract industrialists both large and small, since the resources of materials, power and labour are easily available. One of the objects of the establishments of industrial estates is the transfer of industry from congested urban areas, to encourage expansion and provide more congenial working condition. These conditions can often be met near established urban centres, and such developments should be co-ordinated with clearance schemes in the existing built-up areas, so that unplanned urban industrial slums can be cleared and the land redeveloped for other purposes. For urban projects, the basic survey is of vital importance, to ensure that over-concentration of population is avoided, and care is taken that the demands of existing industries do not curtail the establishment of new enterprises.

8. To avoid the heavy concentration of industry around major towns, serious consideration should be given to the development of industrial estates in relation to the smaller urban centres, where land is cheaper and additional population can be more readily absorbed. In many countries experience has shown that the siting of industrial estates near smaller towns has encouraged the establishment of new industries and made the planned development of the township a practical proposition. Such growth may be slower than can be expected near the large urban centres, but nevertheless it is well worthwhile in relation to an over-all pattern of industrialization.

9. The location of certain industries is conditioned by special considerations, heavy industry such as steel mills, chemical plants or oil refineries will need to be sited near ports for easy shipment of raw materials and finished products. Cement works and similar plants must, of necessity, be planned adjacent to the deposits of raw materials for economic working, and power production units will often need to be near the source of fuel supply.

Industrial estates can frequently be developed in relation to such major groupings to encourage the growth of smaller ancillary industries working in close collaboration with the major plants.

10. In some cases, by-products from the major industries can be successfully exploited, and in others, allied industries can be usefully developed on a neighbourly basis. In Uganda, for example, a cement works, situated adjacent to limestone deposits, has resulted in the establishment of a growing asbestos-cement factory on an adjoining site, and the establishment of a phosphate plant following the discovery of local mineral deposits.

11. The location pattern of industrial estates must inevitably be a flexible one if the full industrial potential of a country is to be realized. By means of comprehensive national and regional planning, the location of industrial estates can assist in the development of urbanization policies, encouraging industrial decentralization, planned concentration or rural growth, according to specific needs.

(2) Physical factors

12. Following the general determination of location, the choice of a particular parcel of land must be decided by the physical factors of the sites available. Seemingly unsuitable sites can be successfully developed where special needs and considerations compel this course of action. Generally, poor sites burden a project with abnormal initial costs to such an extent that the scheme never becomes economically viable and the ultimate objective is seldom realized.

13. A site selected for development as an industrial estate should be level or capable of being levelled at a reasonable cost. Site falls should not normally exceed 1 in 10. The sub-soil should be stable, to provide adequate foundations for buildings and plant without recourse to expensive ground works, such as piling, and it should not be swampy or liable to flooding or subsidence. Land which may require considerable site works should not normally be chosen, but where other important considerations exist, modern

engineering technology can overcome apparently serious disadvantages. Modern piling techniques, chemical soil consolidation, large-scale earth-moving and other possibilities are available, and can be employed in special cases.

14. The shape and size of a piece of land in relation to its development is of particular importance in any tropical region. It must allow the proper orientation of any buildings to be erected on it and be of adequate area to allow an estate of economic size. Normally the cost of land is not the largest financial consideration in the total development outlay of an industrial estate, and cheap land which is inaccessible for goods or workers, or likely to entail considerable development charges is a poor bargain.

15. Local site investigations are essential before the final choice of a plot of land is made; these should include test bores to determine sub-soil conditions, a site survey to determine levels and the collection and analysis of relevant data, such as records of earthquakes, floods, abnormal weather or any other natural conditions. All these will assist in reaching a final decision concerning the suitability of the site for development.

(3) Communications

16. In parts of the world, such as Africa, where the distances between centres of population can be considerable, the question of communications is important. This is particularly true where industrial development is concerned. However advantageous the physical characteristics of a site, if it cannot be conveniently reached by one of the major means of transport, its value is greatly reduced for industrial purposes. It may be possible to create new road or rail access, but this will be costly and time consuming.

17. Industrial developments need railways, roads, harbours, waterways and airports, and the type of transport facilities available in any given area will help to determine the type of industry an estate may hope to attract. All industries need transport to bring raw materials to them, to carry finished products away and to facilitate the movement of labour.

18. Because of its flexibility and economy, road transport is often most suitable for industries which are concerned with raw materials and finished goods which are not bulky. Since industries of this type are often located on an industrial estate, the importance of an adequate highway system linking the estate to the main centre or a national highway network must be underlined. Good roads to the nearest town are also of importance for workers, to provide them with easy access to their homes, whether they travel on foot, by cycle, motor car or public conveyance.

19. Rail transport is mainly needed by heavy industries with bulky raw materials and finished goods. If such industries are expected to develop in a chosen area, the possibility of linking with an existing railway network is important. If sidings are to be linked with the estate, then the railway users should be grouped together to avoid unnecessary rail track and crossings. If a rail spur is not to be provided on to the actual site, then easy road access to the nearest railway goods yard is essential.

20. In most parts of the world, water transport is still the cheapest method of conveying bulky loads and for certain industries, such as petroleum, flour, heavy engineering, sites for industrial estates adjoining a deep water canal or port, can offer economic advantages which will often counter-balance any disadvantages. Rail, road and water access, such as the Trafford Park Industrial Estate in England possesses, make this one of the most successful schemes of its kind.

21. River access can also be useful, but the possibility of seasonal changes in water level should be examined. In some areas, even large natural water courses disappear completely in the dry season.

22. Although the role of air transport in industry is still in its infancy, a site with easy access to an airstrip will grow increasingly important in the future. Already, industrialists in East Africa are finding air transport for sales representatives, executives and customers an economic

proposition, and the urgent delivery of smaller goods can well be made at reasonable cost by air. In Jamaica, the Industrial Development Corporation has established its own strip in conjunction with the Kingston Industrial Zone, and the international airport is only a short distance away. There is no doubt that air transport, particularly in Africa, where considerable distances often have to be covered, will play a much greater part in the future in relation to industry. This factor should be considered when the choice of sites for industrial estates is being made.

23. Few sites will have all the communications advantages described, but a survey of the means of access is part of the basic evaluation of any area under consideration, which must not be discounted.

(4) Services

24. All industries need services of some sort and unless an estate is so large that it can conveniently create its own supplies, it must depend upon existing sources. The establishment of an industrial estate in an area may well over-tax existing facilities, and these must be carefully examined before a final siting decision is made. The three major needs are electricity, water and drainage, and if supplies of any of these are inadequate, the success of any industrial undertaking is seriously jeopardized.

25. Electricity is the principal source of power for most forms of manufacture. If adequate supplies are available from existing power lines, or new lines can easily be run from the generating plant, this is a great advantage. If existing power plant has to be extended, this will be costly, and the alternative of generation on the site for the benefit of the estate may be worth consideration. High voltage supply from a national power grid by overhead line to local transformers is the most economical solution. A project such as the Owen Falls Hydro-Electric Scheme in Uganda illustrates what can be done in many parts of Africa. Interrupted or erratic electricity supplies can dislocate production programmes and a growing industrial estate will have increasing demands for power which must be envisaged at the planning stage of any new project.

26. Any development, whether urban or industrial, needs water, and however desirable a site may be for industrial development, a shortage of water can be a very serious drawback. The amount of water required by different industries varies considerably; the chemical industry, for example, uses considerable quantities for production, cooling and general purposes. Available sources of supply include existing public supplies, rivers, lakes, canals or wells. Water from rivers or lakes may need local purification. Before an industrial estate is planned, careful estimation of possible water requirements must be made, and, if supplies are limited, heavy users of water should not be located on the estate. Water conservation needs to be practised in many parts of Africa. Storage of storm water in the rainy seasons may be practical in some areas.

27. Plans must be made at an early stage for drainage facilities in any proposed industrial area. This factor has a bearing on the choice of a factory estate site. Land which cannot be drained economically can be a serious liability. Industry needs three types of drainage, which must be kept separate. They are: (a) soil drainage; (b) storm water drainage; (c) trade effluent disposal. Factory estates near large urban areas may well be able to utilize existing sewage systems if they are able to take the additional load. In relatively under-developed areas, local facilities may need to be provided for the specific use of the estate. A separate treatment system for soil drainage will be needed, and industrial effluents must be treated by the producing industry before discharge into any sewage system.

28. In areas of heavy rainfall, inadequate storm drainage can be a serious nuisance. If proper drains are not available, roads and even buildings become flooded, causing damage to plant and goods.

29. Other services which may be required by individual factories are usually provided locally, preferably on a group basis for economy, such as steam and compressed air. Gas may not always be available, but it can

usually be provided in bottled form if it is essential. Telephone communication is important; in outlying areas, a local exchange may be useful to serve the industrial estate if an existing exchange is not available.

(5)Economic factors

30. These can be grouped under one heading since their importance will vary with the pattern of the estate. A rural estate may well be dependent upon local raw materials, and, to some extent, markets within reasonable distance. An urban estate, with its improved communications, can draw raw materials from a greater distance and send finished goods further afield. Where food processing units are envisaged, the proximity of the producing areas to the processing plant is of importance; for example, the sugar factories of Jamaica are situated near the plantations for obvious economic reasons. Similar factors will apply to plants using minerals and other bulky materials. Final costs can be materially reduced if raw materials of this kind have only a short distance to travel before processing.

31. To ensure a successful enterprise, labour must be available and long journeys to and from work should be avoided since they are both tiring and expensive. If a selected site has all the advantages listed and yet cannot draw upon an adequate labour force, the chances of success are strictly limited. The creation of new industrial communities with housing and the necessary social amenities is an expensive proposition.

32. New townships can be created with their own industry and commerce; this has been the policy in Great Britain in relation to the development of the New Towns, but, even in such cases as Stevenage, Harlow and Crawley, they have been based on existing communities. This policy has been necessary to deal with the overspill of the large cities of Britain.

33. In Africa, the right pattern would seem to be the planned expansion of the existing smaller urban areas, strategically placed in appropriate regions against the background of a national plan. By such means, existing

housing and social amenities would be available for the labour force of the industrial estate, and planned growth of community facilities can run parallel with the development of the industrial zone.

B. DESIGN

(1) Types of estates

34. Assuming the successful location of a factory estate project following the surveys previously mentioned, the type of estate must be determined according to the local and regional needs. This decision can be reached after careful consideration of development trends in the area which will have been investigated before the location is finally settled.

35. The three broad categories are: (a) single type estates; (b) mixed type estates; (c) single industry estates.

36. Single type estates may be a group of simple workshops for local handicrafts or similar work in a rural area, an estate of standard nursery factories to encourage new industries near a small urban community or an estate of standard factories, with communal facilities, to rehouse dispossessed industries from slum areas of a large town.

37. A mixed type estate may consist of custom-built factories for specific industries, standard factories and nursery units with a wide variety of services to improve productivity and lower manufacturing costs. Such estates will usually require a large site and need to be located near an established centre of population with a wide range of facilities available.

38. Single industry estates are usually located in certain areas because of specific needs or conditions; examples such as special raw materials, particular forms of transport or long-standing local traditions have already been quoted. An example in England is the original establishment of the potteries in the Midlands, where the ready availability of cheap local coal was the determining factor one hundred years ago.

(2) Estate layout

39. Whatever type of factory estate is established in a given location, the layout can materially affect its success or failure. Good estate planning is vital; inadequate planning is ultimately expensive, inhibiting growth and causing perpetual frustration. Expert architectural and planning advice on the problem of estate layout is a sound investment.

40. Layout problems can be divided into four categories: (a) road systems; (b) services; (c) factory plots; (d) communal facilities and open spaces. The right relationship of these elements will vary with the different types of industrial estates.

41. General principles can be broadly stated, but, before any detailed design work is commenced, the necessary design data must be collected and properly analysed. The information needed will include: (a) a physical and geological survey of the actual site; (b) a district survey covering communications, available services, population and local facilities; (c) an estimation of manufacturing needs based on the types of industry envisaged, their water, power and services needs, labour requirements, possible hazards and other similar factors.

42. The size of any given estate cannot be a subject for generalization, and will vary from case to case. Such points as availability and cost of land, number and size of firms to be accommodated and other local and regional factors will determine the general pattern. However, over-all provision for planned expansion is always an important consideration and must be regarded as a basic planning factor.

43. Road systems and services should be considered as allied problems. Basic road patterns must be determined as a first step to estate layout, and electricity cables, drainage runs, water mains and other services planned to follow the road pattern. Such services must be installed at the same time as the road construction to avoid subsequent and costly

engineering work. Road widths will be determined on the basis of estimated traffic flows, with main routes, secondary and service roads according to needs. An economic proportion of roads to total estate area is in the region of 25 per cent, and one-way systems have much to commend them.

44. For ease of repair and connection, main services run under soft strips between road and footway are to be recommended in principal traffic routes. Over-dimensioned roads are wasteful of space, but congested roads, due to inadequate size, are a constant source of delay and annoyance, and inhibit expansion. The initial development of a site may not include a complete road system, but the ultimate pattern must be determined at the outset, so that growth can be orderly and in accordance with a master plan.

45. One of the most serious contributions to congestion in any road system is vehicle loading and unloading. This must never be allowed to take place from the circulation routes of a factory estate. Hard standings or loading bays must therefore be provided within the curtilage of the individual factory sites, with adequate facilities for vehicle turning. This requirement can be satisfied by determining reasonable "building lines", which set the actual building back from the rear of the pavement and by planning service roads within the site for side or rear offloading.

46. In many countries, car parking is a serious problem. In the United States of America, car parks often cover larger areas than the factory, and, while this problem may not yet have reached unmanageable proportions outside large townships in Africa, rising standards of living will bring an increase in car ownership. Development plans must envisage this eventuality and land be reserved for this purpose.

47. Cycle and scooter parking space can best be arranged immediately adjacent to the factory buildings, but cars, apart from a minimum space for visitors, etc., should be parked in communal areas serving the whole estate. Standards vary, but one car space per 1,000 square feet (93 square metres) of factory area is a useful basis for calculation. In the first

stage of development, car space will be needed only for senior staff and visitors, say two or three spaces per factory unit.

48. Services have been referred to in relation to drainage runs, etc., but basic plant for service supplies may be needed, such as sewage treatment plant and similar utilities. These must be planned in a central position so that pipe runs are kept to economical lengths and, at the same time, care must be taken to avoid nuisance from smells, smoke, etc.

49. The car parks and some utilities may well be planned in relation to designed open space in a factory estate. They are not alternatives to open space, which is essential to provide both visual relief and breathing space. If natural features exist on the site, such as mature trees, a small hillock or similar feature, these can often be preserved as a basis for landscaping. Approximately 10 per cent of a site area should be reserved for permanent open space to avoid overcrowding. This must be provided separately. The preservation of existing mature trees is important, as the shade they give is valuable in tropical countries.

50. Expansion and natural growth must be considered at the initial planning stage, and can be catered for in three ways: (a) additional land for the expansion of the estate area; (b) individual factory growth; (c) movement within the estate for growing enterprises from a small unit to a larger one. The last two alternatives will be considered later.

51. Additional site area for over-all expansion should be acquired at the same time as the basic land area. If this is not done, land values will rise and increased costs affect the economics of the project at a later stage. Services must be planned to cater for expansion. Reserve land should also be acquired for the ultimate expansion of non-manufacturing facilities.

52. Communal facilities, when these are to be provided, should be planned so that they can serve the entire estate efficiently. They will be described

in detail later, but, at the layout stage, it is important that they should be considered and convenient space allocated to them, even if they are not erected in the first phase of the development.

(3) Types of factory buildings

53. Types of factory buildings on any estate will be determined by the industries to be housed, and this will involve either a selection policy in relation to the prospective occupants, or a survey of potential users as a guide to design standards. The two major categories of buildings will be the custom-built factory and the standard factory.

54. Custom-built factories are those designed specifically for a particular firm and planned to suit their detailed needs. These can either be designed and erected by the Estate Authority, if they have the necessary professional skills, or undertaken by architects, appointed by the firm concerned. This type of development is usually confined to large industrial concerns and it is usual for the Authority to lease "prepared" or improved sites for this purpose. Such sites are levelled and provided with roads and services laid to the site boundary. On mixed estates, referred to earlier, larger sites on the perimeter are often reserved for this purpose.

55. Standard factories, however, are those designed and built by the Estate Authority to a general pattern, to achieve maximum construction economy. They can vary in size according to their purpose.

56. Nursery factories are small-scale standard factories, designed for new but potentially expandable firms; they will usually be the smallest unit of an estate. The first nursery factories in Great Britain consisted of single buildings of 6,000 square feet (557 square metres) in area, divided into four 1,500 square feet units, designed so that a manufacturer could have from one to four units. More recent examples average about 2,000 square feet (186 square metres) each unit, 70 feet x 30 feet (21 metres x 9 metres) in terraces, allowing a firm to have one or more units as needs demand.

57. This pattern appears to be applicable to African conditions; when an industry outgrows the nursery stage, it moves to a larger standard factory. Small terraces of nursery factories of this type would also be particularly suitable for experimental rural or village workshops. A small estate of nursery factories at Yaba in Nigeria was the first African example, and its success has led to further developments of a similar kind in Nigeria.

58. Crafts workshops or "worksheds", even smaller in size, have been built in rural areas of India and are proposed for Nigeria, to house local craft and service industries usually found in overcrowded residential areas.

59. Standard factories, which can house the growing manufacturer from the nursery estate, the developing industry from the overcrowded urban area or the new industry, must be of simple design to allow easy expansion. This type of factory will be built before its occupier is known. The basic unit will vary, but the objective should be to provide any floor area from 2,000 square feet to 20,000 square feet or more.

60. Standard factory designs should be capable of providing floor area as needed without a variety of alternative patterns - the number of types must be kept to a minimum. If the smallest standard factory area is 6,000 square feet, (557 square metres), then a nursery factory tenant who is too large for two nursery bays of 4,000 square feet (372 square metres) can take the smallest standard factory, and thereafter increase in size according to his plot area by planned units. This form of modular progression allows flexibility within a standardized range. Standard factories of this kind are suitable for light industry and should be designed with reasonably clear open floor area, good lighting and ventilation and easy extendability. When the actual land area is selected for the standard factory, it will be chosen to allow for expansion. Site coverage must be controlled by the Authority by specifying plot ratio of land to buildings and by determining building lines, side and front setbacks, etc.

(4) Factory layout

61. Any type of factory building must be designed for the efficient performance of the process to be carried out within its walls. A standard factory must be capable of being laid out within the external walls in a logical manner, so that the work carried out can follow a natural flow.

62. The simplest natural flow is: Delivery - raw materials - processing - packing - finished product - dispatch. This simple route is the basis of even the most complicated manufacturing process. There can be many permutations and elaborations, but this is the foundation of them all.

63. Internal divisions in any standard factory are normally provided by the occupant, to his own specifications, and the basic "shell" shape must therefore allow a simple variation of internal layout. Theoretically, a square basic unit has much to commend it because it needs the minimum wall area in relation to floor area. However, other problems, such as roof spans, arise, and a basic module of 60 feet x 30 feet (18 metres x 9 metres, a double square) for a nursery factory could be the basis of a useful additive pattern. Half modules, say 30 feet square, could be usefully considered as workshop units.

64. All factories will require lavatory accommodation for both sexes, and the location of this needs careful consideration. There is a strong case for separated toilet blocks, and these can be as elaborate or simple as the industry needs. For example, dirty industries will need shower accommodation, where clean industries will not. The toilet blocks can be linked by covered way to the main factory building.

(5) Building design

65. Circulation has already been mentioned as an important factor in the design of any factory building. It is a basic factor in all types of building. The circulation of personnel, of raw materials, of products in the course of manufacture, of finished products must all be considered and traffic flows

arranged so that a free flow at all stages is maintained, without obstruction or confusion. Cross traffic should be avoided, and circulation routes should be as direct as possible.

66. Climatic considerations play a very important part in the design of buildings in the tropics. The three major problems are sun, rain and wind. The tropical sun is hot and bright, and overheats the wall, roof and window surfaces on which it shines, and paving surrounding a building reflects the heat on to the structure. Buildings must, therefore, be designed so that walls and windows have the minimum exposure to the sun by placing the long axis on the average path of the sun and providing wide overhanging eaves to create shade. If the walls are built of material which does not readily transmit heat from outside to inside, and are well protected from direct sun, reasonable comfort can be obtained.

67. The greatest area of a building exposed to direct sun is the roof, and means must be employed to reflect the heat from the surface and reduce heat transmission as much as possible by the right choice of materials and carefully detailed design. Care must be taken to avoid creating a heat reservoir which stores the heat during the day and gradually emits it; a light roof structure therefore has much to commend it.

68. Any glazed area in roof or walls acts quickly as a means of transmitting heat. Unprotected glass allows heat into a building and retains it. Glass surfaces must, accordingly, be shaded by means of louvres, sunbreakers or other ways, to prevent the heating-up of the glazing. Corrugated sheets of glassfibre reinforced polyester resin can be a useful alternative to glass for roof and high-level wall glazing.

69. Rain in the tropics can be sudden, heavy and windborne. Building design must, therefore, cater for an abnormally high water run off. The wind-driven rain, which can reach almost hurricane force in parts of Africa, becomes practically horizontal at times, and can force its way through water checks, louvres and rebates, necessitating very careful detail design. Heavy

rainfall can cause soil erosion around a building which could damage foundations and other parts of the structure. In many areas, roof gutters are prohibited, or at least discouraged, because of the possibility of mosquito breeding. Where gutters are designed on industrial buildings, they should be generously dimensioned, easily accessible and with adequate falls, preferably to water chutes rather than down pipes. By careful planning, storm water can be collected in the wet season and stored in underground tanks for use after suitable treatment. This has been done successfully in West Africa and elsewhere.

70. Wind can be both a blessing and a curse, and driving rain has already been mentioned. Ventilation of buildings in the tropics is most important and particularly in industrial buildings. Air movement is needed to create comfort conditions, and, while electric fans can do the job, they are second best to natural air movement. In Africa, the draughts that are a nuisance in England become highly desirable.

71. Buildings in any hot climate should be designed with cross ventilation. In hot, humid regions windows and permanent ventilation openings should be planned to encourage a through breeze at working level. In arid regions, where winds are hot and dry in the summer and cold in winter, ventilation openings, windows, etc. can be reduced for comfort.

72. Few industrial undertakings on the average estate will be able to afford costly artificial ventilation plant; natural breezes must therefore be exploited for ventilation purposes.

73. Natural lighting must be carefully considered in all industrial buildings. Buildings orientated so that the main axis runs from east to west have already been recommended, and, where the width of the factory is not more than 30 to 40 feet (9 to 12 metres), wall glazing can provide adequate daylighting for a small building. The window area will vary from 10 to 20 per cent of the floor area. With larger buildings, roof lighting will be necessary to achieve an even level of natural illumination. This can be achieved in a

variety of ways, but the most economic and efficient for general purposes is the double pitched roof with glazing along the slopes or with a monitor. The problem, however, is the reduction of heat transmission through the glass from direct sun, and so northlight roofs are worth consideration. The area of rooflighting needed will vary with the level of daylight required and this will depend on the industry concerned. Problems such as shadowing, glare and heat penetration must be considered in the design of any form of factory glazing.

74. Artificial lighting in factory buildings is largely conditioned by the type of work carried out and the intensity will vary considerably. For example, at one extreme, the recommended value of illumination for an assembly shop for rough work is 7 foot-candles (Grade 6B) and, at the other end, for a very fine instrument assembly shop, 100 foot-candles (Grade 2B).

75. Good lighting, both natural and artificial, can contribute materially to higher production and safer, more accurate and efficient working. Common faults to be avoided are: (a) Glare, due to insufficiently shielded light sources; (b) Too few lighting fittings; (c) Excessive brightness contrast between fittings and background; (d) Ceilings that are too dark in colour; (e) Excessive shadows due to poor layout of fittings; (f) Light sources at incorrect height; (g) Too great a variation of light intensity from one area to another; (h) Unhappy relationship between lighting and colour scheme.

76. Colour in factories is a comparatively new science. The correct use of colour can not only improve standards of appearance and cleanliness, but can reduce accidents, increase production and improve the workers' morale. Background colours should be carefully selected in relation to the work carried out in any given area. White is generally unsuitable as it gives rise to glare; neutral, restful colours which provide a suitable contrast in hue with the work in hand are to be recommended.

77. Machinery colours should provide a suitable brightness contrast with both the task and the immediate background. The working area of the machine should be the brightest spot in the field of vision. Standardized identification colours should be used for marking hazards and service pipe lines.

78. Services in a factory building are like the arteries in a human body. The variety of services will change with the types of industry; a full list would include electricity, gas, water, steam, compressed air, vacuum, drainage, etc. Constant alteration and maintenance of service lines in a factory is inevitable; they must, therefore, be accessible and easily identified. An orderly arrangement which allows easy connexion of plant or machinery is essential and adequately sized mains will make the installation of new and larger plant less difficult. Pipe work should be properly protected, and hot water and steam mains adequately lagged.

79. Water may not only be needed for domestic and process use, but for fire fighting and, in some cases, for sprinkler systems. Each manufacturing unit should have a reasonable standby storage tank for emergency use. An estate water tower for general storage is also of value in case of temporary shortage.

80. Where the factory process produces any form of effluent, this must be treated at source and rendered harmless before discharge into the estate sewage system is allowed. This is of particular importance in the chemical and allied industries. Where considerable quantities of trade effluent are envisaged, a separate estate effluent drainage system is essential. Effluent must never be discharged into rivers, streams or water courses.

81. Where a number of factories require such services as steam, compressed air, etc., these should be located in a position on the site where they can share a common generating plant for efficiency and economy of operation.

82. Most manufacturing processes produce waste products of one sort or another, and where these cannot be consumed within the process, they must be stored for general collection and disposal, in such a manner as to avoid untidiness, smell or other nuisance. The dumping of trade waste must never be allowed on or around the factory estate.

(6) Communal buildings and facilities

83. Communal services for certain users have already been mentioned, but an industrial estate should provide other forms of communal facility, in the shape of amenities which would be uneconomic if provided individually by each factory owner.

84. All tenants on a factory estate will require storage accommodation and where small individual industries are concerned, a co-operative warehouse will provide centralized storage space so that a manufacturer can rent the floor area he needs at any given time. Such communal warehouses must be designed in a central position with good access and carefully planned loading facilities. The size of the building will vary but with the universal use of fork-lift trucks for palletized goods, a clear height of at least 18 to 20 feet (5.5 to 6 metres) is essential. Spans can follow those chosen for the standard buildings on the estate. Daylighting is of little importance. Security against theft and unauthorized entry is vital.

85. Administration facilities will be required for the proper running of all but the smallest industrial estates, and the administration building can be either a simple suite of two or three offices, or contain a variety of amenities for communal use. The most necessary of these amenities are canteens and health facilities. The former should provide simple meals in pleasant surroundings away from the workshop atmosphere; the latter may be only a basic first aid unit (which should be regarded as the minimum provision) but it can be designed to provide more comprehensive medical treatment if the size of the estate warrants it.

86. Other communal facilities should be considered for large and medium-sized industrial estates, and these may include a children's crèche and restroom, bank, post-office, telephone exchanges, training centre and similar units. A trade training centre could well be associated with communal repair and maintenance workshops. A small samples showroom and exhibition space will be welcomed by the individual tenants, since this will enable them to exhibit their goods to potential buyers in attractive surroundings, away from the working area. This facility could be regarded as essential for an estate of any size; even tenants of a rural workshop scheme would benefit by such provision. Lettable office space is sometimes useful for industrialists who prefer to separate the manufacturing and commercial aspects of their work.

87. Even if these amenities are not provided at the initial stage of development of an estate, land should be allocated for them in a convenient, accessible and prominent position, for development as the estate grows. The provision of housing and social amenities may have to be considered in certain special cases, but, in general, it is more satisfactory if an existing community can be expanded.

(7) Design for expansion

88. This has been mentioned several times in various contexts, and should always be kept in mind. If growth and expansion are not considered, then the success of an industrial estate can be materially inhibited. Growth can be catered for by the following means: (a) Provision of adequate land for general expansion; (b) Initial reservation for expansion of car parks, and all communal facilities; (c) Adequate provision of roads, main services and utilities; (d) Sufficient variety of standard factory sizes and prepared sites; (e) Adequate control of plot coverage ratio and other restrictions; (f) Foresight in advising tenants on size of plot in relation to ultimate growth potential; (g) Detailed design of buildings to facilitate extension and modification; (h) Flexible pattern of transfer from nursery factory to standard factory and custom-built factory.

89. Not all industries on an estate will want to expand, but since one of the merits of the factory estate is the flexibility of accommodation, this factor must underlie all design considerations. The estate must aim at attracting healthy, expanding industries as well as those that need assistance. It is probable that 50 per cent of the industries attracted to an industrial estate will grow to some degree in the first five years of their tenancy.

C. CONSTRUCTION

(1) Materials and techniques

90. When considering the choice of materials for the construction of buildings on an industrial estate in Africa, it is important that a careful survey of local materials and building skills should be carried out before any decisions are reached. All buildings require materials and labour to assemble them. Generally speaking, labour costs are low in Africa in comparison with European or American standards, but they will inevitably rise as standards of living rise. Since building costs have a considerable bearing on the economic viability of an industrial estate project, the question of appropriate building materials for construction purposes is of great importance.

91. Imported building materials, because of their high cost, should therefore be limited as far as possible, and local materials and skills developed, both in connexion with traditional building methods and new techniques, adapted for local use. The African craftsman is not only skilled with the materials he has used for generations, but can quickly learn new techniques which can result in speedier and more economic building.

92. Cement is a universal building material and the part it plays in modern construction makes it indispensable. It is now regarded as an essential basic building material. It is rapidly replacing in African

countries traditional materials, such as timber, mud, sun burnt brick and thatch. In comparison with highly industrialized countries, the cost of cement is generally high in Africa. This can be lowered by a greater expansion of domestic production and a corresponding reduction in cement imports.

93. In 1961, for example, the West African region imported over 1 1/2 million tons of cement; domestic production is capable of producing less than 25 per cent of the demand. It is reasonable to assume that this pattern is repeated in other regions of Africa. Cement works already exist in many regions of Africa, and the quality of the material produced is high. With increasing industrial, educational and other building programmes, the establishment of new cement manufacturing plants is of great importance.

94. Road and site works techniques must be briefly considered before discussing materials for buildings. Excavation and levelling can be done by hand or machine; the choice of technique will be decided by economic factors. In the developing countries, where unskilled labour is plentiful and wage rates low, the use of expensive machinery may not show any advantage in either speed or cost over traditional handwork. As labour costs rise and competition for labour becomes more acute, the machine will gradually prove to be a more economic proposition for bulk earth moving, levelling and excavation.

95. Road construction alternatives will vary under different circumstances, but the three major road materials are: (a) concrete; (b) tar-macadam; and (c) soil-cement. The costs decline in the order given. The cheapest form of road construction is the soil-cement technique, which has been used in Kenya on experimental highways. Results suggest that this has been very successful and a similar specification could be considered suitable for roads on medium-sized factory estates. All roads, whatever their construction, must have a firm, consolidated bed; otherwise they will fail and need constant maintenance. If the sub-soil is not solid, suitable hard

material must be imported, laid to an appropriate thickness and well consolidated before the topping of concrete, tar-macadam or other material is applied. Drains can be of stoneware, concrete or pitch fibre, according to the cost and availability of supplies, bearing in mind the purpose for which the system is to be used.

96. The design of the structure of an industrial building dictates the type of materials to be used in its erection. The earlier recommendations concerning spans, open planning and flexibility all pre-suppose some form of framed structure where the walls are non-load-bearing and the roof is carried on an independent frame. Such a frame is essential if the building is to be capable of adaptation, extension and modification without expensive rebuilding. Structural frames can be in timber, steel, aluminium or concrete. Of these alternatives, timber is best used for roof trusses only, because of the danger of termite attack. Even then, it is only suitable for small craft workshops, with a low fire hazard and relatively short spans, in conjunction with load-bearing walls. Hardwoods must be used, and, although long span techniques such as lamination or the use of bolted connectors are available, the problems of fungus and insect attack, and fire hazard need serious consideration.

97. Steel is generally expensive since it is an imported material, and aluminium for structural purposes, apart from roof trusses, is not practical. When steel is used, it must be employed economically, and such developments as light-weight space frames, using light tube sections, have much to commend them. Deep beams and trusses, using small section material with welded joints, show considerable savings in cost for both manufacture and erection over heavy section steelwork. All steel must be protected from corrosion, which can be rapid in hot, wet areas if adequate precautions have not been taken.

98. Pre-cast concrete has many advantages for industrial structures, both for structural frames and roof trusses. Pre-cast concrete portal frames with pre-cast concrete purlins and sheeting rails can be made to standard patterns and for spans of 30 to 40 feet are economical to cast and erect. Larger spans can be achieved without difficulty. Pre-cast frames can be made in reasonably manoeuvrable units which can be quickly erected, either with cranes or simple lifting tackle. A wide variety of units is possible and standardization of dimensions and types leads to considerable economy. To reduce steel content, the technique of pre-stressing can be employed for standard beam and roof truss manufacture. Pre-stressing techniques are not complicated and trained work teams can quickly master the necessary skills under experienced supervision. Pre-cast concrete framing members have a high fire resistance, are not affected unduly by changing climatic conditions, do not suffer from insect or fungal attack and require little maintenance or protective treatment.

99. Walls in a framed structure are non-load-bearing and can, therefore, be made of any material which can support itself or be hung from the frame. Walling materials must be robust to withstand accidental damage and be able to keep out the weather and suffer no deterioration. The most suitable materials are burnt brick (where suitable basic material is available), concrete block or stabilized earth blocks. Suitable materials for brick-making are not always readily available and, therefore, hand or machine made concrete blocks to standard sizes have become a universal walling material in all parts of Africa. They have few disadvantages, stand up well to tropical climatic conditions and need only a colour wash finish. Stabilized earth blocks have been used experimentally in West Africa with success and, providing suitable "laterite" is available, they may well offer a cheaper alternative to concrete blocks for walling to simple industrial buildings, particularly in rural areas. They can be made to standard sizes either by hand in wooden moulds or by machine. Stabilized earth blocks have been used for housing in many parts of the world, and a considerable amount of technical information is available.

100. Roofing materials for factory buildings will vary with the local supply position. The three principal alternatives are: (a) corrugated galvanized iron sheeting; (b) corrugated aluminium alloy sheeting; and (c) corrugated asbestos cement sheeting. For standard factory buildings of the type normally erected on an industrial estate, the flat reinforced concrete roof slab is expensive and has other disadvantages, such as the retention of solar heat. A light, sheeted roof, on purlins supported on trusses or portal frames, has the advantages of cheapness and adaptability. The shape can vary according to design considerations, but the materials remain constant. Purlins of steel, timber or pre-cast concrete are all suitable under different circumstances depending upon the spacing of trusses or frames and the span of the building. Of the alternative roof coverings, aluminium is light in weight, giving good solar reflection, but noisy during rain; it is generally expensive as it has to be imported. Asbestos cement is cheaper, especially if locally manufactured; it gives reasonably good solar reflection, but its brittleness tends to make it easily damaged in transport. Galvanized corrugated iron is the cheapest roof sheeting; it is tough, but noisy in rain and needs protective treatment to prevent rapid corrosion. It is not a good solar reflector.

101. Floors in all types of buildings on an industrial estate warrant careful thought for they constitute a large part of the building cost and often receive heavy wear. It is important that factory floors should be strong enough to take machine loads, be resistant to shock, abrasion and vibration, and provide a surface which is easy to clean, non-slippery and reasonably comfortable to the feet.

102. No one floor will meet all the requirements, but the base on which the floor is to be laid is common to all finishes. It must be solid; a 6 inch (15.24 centimetre) slab is usually adequate, laid on a well-consolidated base of hard material. Where heavy machinery is envisaged, this must be provided with separate foundations designed to spread the load from the machine. Floor toppings will range from a simple 2 inch (5.08 centimetre) cement screed to concrete tiles, or special floor finishes which will stand up to the processes carried out in a particular factory.

103. Termite protection must be considered in relation to floor design. Any timber must either be termite resistant or treated with one of the available preservatives (preferably under pressure). The floor and sub-floor must be properly designed by the inclusion of constructional barriers, near the ground, at changes of level and at joints, to prevent the entry of termites. If timber can be avoided at ground level, this is advisable. However, termites will attack timber packing cases, composition boards, books, etc. if they can reach the inside of a building, and adequate protection against them is essential.

104. Other structural parts of an industrial building, such as windows, doors, louvres, will also need consideration in relation to the materials used and their general design. These will be needed in considerable quantities even on a moderately sized industrial estate and should, therefore, be standardized and dimensionally co-ordinated to ensure economy of production and easy interchangeability. This aspect of the problem will be dealt with in detail later.

105. Windows, doors and shutters will be either of metal or wood. If local supplies of suitable termite-resistant timber, such as iroko, mvuli, teak or mahogany are available, these will be most suitable; even with these, sapwood should be avoided and metal or concrete stools provided to avoid door frames, etc. making contact with the ground level. Metal windows, doors and shutters are usually expensive since they have to be imported and need protection against corrosion. Louvres and sun breakers can be made of asbestos cement; in this material they do not need protection from corrosion, termites or any other attack. Corrugated sheets of glass fibre reinforced resin are a useful alternative to glass for roof glazing. They give a good diffused light and do not transmit solar heat as readily as glass. They are made to match the standard corrugation of other sheeting material and are in production in several parts of Africa. The lightweight quality and the fact that they do not break easily make them readily transportable.

106. Other materials and fittings will vary according to the type of building envisaged, the process to be carried out and the economic situation. Custom-built factories for established concerns may well be able to afford to use highly specialized forms of building construction and large quantities of imported material. These fall outside the scope of this paper, which is primarily concerned with simple easy-to-build factories, which can be made available at low rents.

(2). Building standards

107. Experience has shown, in many parts of Africa, that, given the materials and technical advice, African building labour can produce buildings of a quality and standard of finish equal to those of most of the more highly developed countries. However, in order to achieve economy in building basic factory structures, certain design techniques can be employed.

108. Roof and floor spans relate closely to building costs and, while unlimited clear spans are attractive for industrial buildings, they are also expensive. The larger the span, the greater the cost. Spans of 30 to 40 feet, already mentioned, appear to be the most reasonable compromise, and portal frame structures with a bay spacing of 15 feet and a span of 30 feet will meet most of the requirements of the average standard factory, a nursery factory or an industrial estate. This unit can easily be used as a module for the entire development. A typical pattern is developed in diagrammatic form on the basis of this module in the illustration in Appendix 1. Even if a single standard span is not established, the number of alternatives should be reduced to the minimum for economy. Heights may vary, but they should also be restricted; for example, given a minimum height of 16 feet, they could rise by increments of 2 feet to 24 feet as a maximum where portal frames are used. Load-bearing walls can be of any height, based on the standard coursing of the blockwork used; cutting of blocks should be avoided as wasteful.

109. Building components of many kinds will be needed on even the smallest factory structure, and, for ease of construction and economy, a complete range of well-designed standardized building components should be created. These could be mass-produced regionally or locally according to particular needs. The components - doors, windows, shutters, louvres, partitions, sunshades, etc. - must be simple and robust in design and capable of easy installation.

110. Dimensions of all components must be properly related and co-ordinated so that the various units fit together easily without cutting or waste, and so that non-standard make-up pieces are not required. If the correct dimensional pattern is chosen, it should be possible to build up any number of composite units from one or two simple basic units, just as a wide variety of buildings can be built with a standard block. Windows are a useful example. From a single basic unit of suitable size, with appropriate couplers, a considerable variety of window walls can be built up, and, given two or three basic units, the alternative arrangements are considerable. At the same time, the window units should be related to the door units, the chosen bay sizes and the individual walling block sizes, so that everything fits together. The development of a dimensionally co-ordinated range of standardized building components for the construction of all buildings on an industrial estate can be a very important contribution to building economy, and, if such standards can be accepted regionally or even nationally, the economic value can be immense.

111. There is no reason why such a standard pattern should not be agreed among all the African countries; such an undertaking would need expert advice and would take some time, as it should be based on local investigation and research, but the opportunity of discussion on such a project at the United Nations Addis Ababa Seminar should not be missed.

(3) Building economics

112. Factory fabrication or site fabrication? This is a question which is being raised in the developed countries of the world and, while it is of less importance at the present in Africa, it must be briefly mentioned. Much

building work in Africa is most economically carried out on the building site to reduce transport and other costs. Even concrete pre-casting, block making and joinery work is efficiently carried out under simple temporary protection. For many industrial estates, this may still be the desirable technique, but, with standardization, there is a strong case for manufacture of components, such as pre-cast frames and trusses, blocks, doors and windows, etc., in centralized factories or yards, to serve a region in which several industrial estates are to be built. With careful design, all or some of the components can also be suitable for other buildings, such as schools, churches, hospital blocks and even housing.

113. With the rapidly developing transport systems in African countries, the conveyance of units ceases to be an insuperable problem and building component manufacturing units, such as timber mills, cement works or steel mills, could be established by Governments near the raw material source, thus providing work on the spot of a permanent nature and for local labour. This would reduce the casual labour on site to a minimum, to cover site preparation, erection work and specialist trades.

114. Building economies are closely linked with the questions of standardization, dimensional co-ordination and prefabrication. The use of labour has already been mentioned and the choice between site labour and workshop or factory labour. The latter can be offered more continuous employment, better working conditions, better machinery and plant and greater freedom from weather variations. The result should be a higher standard of workmanship, a better understanding of the job in hand, with opportunities for apprentice training and the development of specific craft skills. Even site labour needs to be used with forethought and construction phasing and site organization to this end will be dealt with later.

115. Maintenance of any form of building has a bearing on its economics; a building which requires constant minor repair soon becomes a liability rather than an asset, and the industrial estate as a whole must be properly

maintained to present a clean, tidy and attractive appearance, and proper facilities must be provided for such maintenance at design stage. Suitable simple accommodation for maintenance staff should be attached to any administration building with storage for equipment adjoining.

116. Individual factory building maintenance will be the responsibility of the respective tenants or owners and this will be minimized if the buildings are properly designed and the correct materials chosen. Short-lived materials should be avoided and those which can be quickly affected by weather, fungal or insect attack should be properly treated when installed and regularly maintained, or avoided altogether. Gutters, if any, should be regularly cleaned out, painted surfaces should be periodically repainted and water storage tanks cleaned out and suitably treated. In this way, the life of the buildings will be extended and their appearance maintained.

D. COSTS AND PROGRAMMING

(1) Master plan

117. The detailed plan of any industrial estate must be completed before the work is carried out on the site, and this master plan must not only lay down the zoning pattern for the immediate development area, but must plan in broad outline the future pattern of growth. The master plan must present on paper, and preferably in model form also, the total layout, the grouping of industries, the allocation of space to communal facilities and must lay down the directives which will be needed to preserve the visual appearance of the finished estate.

118. By means of the carefully prepared master plan and strict adherence to it, a well-planned estate can be moulded into a visual as well as a functional unity. Too often the question of visual design is dismissed as of little importance on the assumption that industry and ugliness are

inevitable companions. At last, industrialists in the highly industrialized countries are beginning to realize that well-designed factories, attractive landscape, good colour schemes and orderly industrial estates materially contribute to higher productivity and fewer accidents, because of better factory housekeeping, less absenteeism and a higher morale among the workers. Good design in factory buildings means simple, uncluttered structures, well chosen colours and lettering, pleasant facing materials, no untidy additions or advertizing hoardings and the preservation of trees and landscape. These things are not expensive but they need planning, forethought and adherence to the rules laid down.

119. Industrial development is urgently needed and this fact can often lead to skimping of preparation work and commencement of work on site before all the plans are completed and a proper programme prepared. Time spent in thorough preparation is never wasted; in fact, more time spent by a few people before building work is commenced often means time saved by many workers on the construction site. The preliminary surveys and studies of site, surroundings and needs must be carried out thoroughly.

120. The master plan, detailed layouts, design drawings, details and specifications must all be finalized before work commences and a comprehensive time and progress chart prepared for the whole of the activity: surveys, design, construction and completion. In this way the efforts of all concerned can be co-ordinated and problems of supplies, of information and of manpower can be solved before they occur on site, when time and effort is especially valuable.

121. Any building programme must take into account the proper phasing of the entire building development. The erection of elaborate community facilities before any factory buildings would obviously be uneconomic. The rule must be "essentials first". Main roads and essential services always have priority, followed by the central utilities and the factory buildings. Care must be taken when temporary communal accommodation is provided to

ensure that it has a specified limited life. Wherever possible, the core of permanent communal buildings should be erected for later expansion and elaboration when circumstances permit. Generally, temporary buildings are not cheap and they usually last too long, finally becoming inefficient and expensive eyesores.

122. Proper phasing of the development will allow early occupation of at least part of the estate, with obvious economic benefits, but, even this can be dangerous since access to a factory across unmade roads and through half-completed buildings is both discouraging and leads to untidiness. The pattern of erection should therefore be planned so that those who occupy buildings finished early in the programme do not have to pass through areas under construction.

123. Design economies have been mentioned earlier several times, and can be usefully summarized as follows:

(a) Adequate over-all pre-planning
(b) Right choice of site
(c) Functional layout
(d) Adequate provision of services and communications
(e) Proper communal facilities
(f) Careful choice of materials
(g) Simple structural design
(h) Provision for expansion in all aspects of the estate
(i) Adequate plans for maintenance
(j) Legislation to control the completed estate and its surroundings

124. Standardization has also been emphasized earlier; this can play an important part in the economics of any project. Standardized interrelated components, which take advantage of the essentially repetitive nature of the buildings and their separate parts, can not only cheapen building costs, but also increase speed of building erection, thus ensuring earlier financial returns. Not only should locally available or readily made materials and

components be used, but the range limited as much as possible. If this limited range is well chosen, and the individual design is good, the final over-all design will have a unity which is visually satisfying and financially advantageous.

(2) Contracting

125. In most parts of Africa, reliable building contractors can be found to carry out building work of considerable size. In another field, the author has recently been responsible for the design of the Cathedral of St. Andrew at Mbale, in Uganda, which was built by a local contractor (as opposed to a foreign firm) using entirely African labour. The result was a simple but impressive building, of high craft quality at a low cost, which could not have been achieved if imported labour and material had been employed. If the initial design processes take into account the skills and materials available, the local contracting experience can produce good buildings cheaply. Contractors exploiting traditional skills can usually learn new ones as the occasion demands and, with experience and training, will build in new ways as economically and skilfully as in the old ones.

126. The best advice is always the cheapest in the long run, particularly when repetition allows it to be spread over an extensive programme.

127. An alternative to the use of local contracting facilities, especially where these are limited, is for the Estate Development Corporation to develop a direct labour programme whereby labour is engaged locally and materials are bulk purchased direct from manufacturers or supply sources. This will necessitate the organization of a proper site planning and supervision department, staffed by trained personnel.

128. Whichever method is adopted, proper site organization is essential so that labour is not ungainfully employed and time and material wasted. A site operations programme is essential so that the entire construction programme runs smoothly from start to finish. Labour must be available when it is required, and proper facilities provided for it. Materials and

components must be ordered and delivered to the site according to programme, and contract pre-planning carefully arranged so that the right materials are available at the right time. For each job a properly planned progress chart should be prepared which sets out the sequence and time schedule for all the stages of the various building operations. Adequate storage facilities must be provided for tools, equipment and materials on the site, to prevent damage, deterioration or pilfering. Proper security measures are essential since building materials are valuable and often in great demand.

129. In many parts of Africa, modern building plant is in short supply, but labour is plentiful. Excavation, site levelling and clearance can therefore usually be most economically carried out by traditional hand methods. For good quality work, concrete must be mechanically mixed and carefully controlled. Cranes and hoists may not be available, but with an adequate labour force and considered design, pre-cast concrete units can be accurately erected using hand techniques, with a simple block and tackle and sheer legs. Where only inexperienced labour is available, workers can be trained to carry out the unskilled tasks under the supervision of skilled building craftsmen, and, with the use of standardized components, the assembly work can be efficiently executed with the minimum of expert supervision.

130. On a large project, a training unit can be set up and a trial assembly bay established for this purpose. Team working is important, and gangs who work well together should be kept as a unit throughout the contract.

131. There is a great deal of useful work to be done in the field of design and construction research for industrial building in Africa. Studies should be made of the problems of the design of tropical buildings and the experience already gained in various parts of the Continent classified and evaluated. Trial erections should be built and their suitability for tropical use tested under the varying conditions to be found in the hot, wet zones and the hot, dry zones. The Building Research Stations in Africa can

help in this way and, together with the knowledge and experience of experts in factory design and construction from the developed countries, a pattern of activity can be established for the African situation.

(3) Management techniques

132. While this paper is not concerned with the management of an industrial estate after it is occupied, the management of the activities through which its completion is achieved is important. The application of management techniques to the building industry is being studied in many countries, and although there is the danger of creating a mystique out of something basically simple, important lessons can be learned.

133. Team work, and its value, is one of these lessons. Any building project requires the skills of many people, both professional and technical, and the successful completion of a national programme of industrial estates will call for a variety of skills. The list will include architects, town planners, engineers, geologists, surveyors, economists, geographers and builders, to name a few. The essential is that they should work together as a team, each contributing his own skill. Every team needs a leader who not only makes his own contribution, but co-ordinates the work of the other team members, and the architect-planner can usually fill this role most successfully, for he is the person who should be concerned with the entire project, from its initial inception to its final completion. His skill and training in both practical and aesthetic matters make him the key figure, and the appointment of an experienced architect can be a material advantage to any project.

134. Another of the lessionof management studies is the importance of clear channels of communication between the working team members, a careful demarcation of areas of responsibility and the establishment of a basis of understanding. Given good will and a desire to co-operate, a well-organized team can work efficiently and harmoniously.

135. Costs have been discussed in this paper by inference rather than by direct statement. This is due to the fact that over such a vast area as

the African continent, the differences in labour costs, material prices and other economic factors make it useless to attempt any over-all comparison. The tables in Appendix 2 may be of some assistance, but comprehensive building cost studies, based on African experience, have rarely been carefully documented. With all new projects it is important that cost information should be collected and properly analysed so that this information is available for subsequent projects.

136. Cost analysis can play an important part in the design process of an industrial estate or a factory building. The figures in Appendix 2, based on English experience, are of interest, but detailed studies of African examples would be of greater value. It can readily be seen that, at the design stage, a team working to a determined budget can allocate expenditure and thus design in such a way as to match the pre-determined cost pattern.

137. Cost control is the tool used while the building work is under way. Here, the quantity surveyor plays an important role as the "building accountant". A careful check must be kept on the cost pattern as any work proceeds; variations, alterations and changes of mind must not be allowed once the building work has commenced. If this rule is broken, it is impossible to keep an adequate check on costs, and, inevitably, the final expenditure will exceed the budget. Time is money in building as elsewhere, and if delays are caused by alterations to plans, not only will completion be delayed, but site overheads will increase and costs rise. Undoubtedly, costs will vary, labour rates may increase and materials prices or delivery charges rise, and the quantity surveyor can check the accuracy of such claims and forecast the likely effect on the final cost, so that any budget revisions can be made.

138. Good costing records during a building contract and a thorough analysis after completion can together provide valuable data for future design use.

E. LEGISLATION

(1) Planning and construction

139. The planning of industrial estates should be linked with the preparation of development plans for urban and rural areas. In many parts of Africa, such plans already exist and with them the legislation to ensure that they are followed. Wherever necessary, the existing town planning legislation should be strengthened to ensure that industry, whether in estates or as large individual units, is confined to areas zoned for industrial use. Zoning laws should be designed to encourage a good neighbour policy as between industry and other land users. High standards for industrial development can make a relatively close relationship between industrial and residential buildings possible. Zoning must always take into account the need for expansion and the importance of communications.

140. Any planning legislation should be designed to indicate what may be done in a particular area, a positive approach always being more satisfactory than a negative one. If an analysis of industrial performance is made, it will be seen that this can be broadly expressed in terms of needs, hazards and nuisances. Needs cover such things already mentioned under planning, such as transport, labour, space and utilities. Hazards will include traffic, fire and explosion risks. Nuisances will include noise, smells, waste products and smoke. Using these three categories, industries can be roughly classified and their effect on neighbouring non-industrial development estimated. By this means, a zoning pattern can be created so that a proper relationship between industry and both town and country established.

141. Strict control by means of estate regulations must be maintained over the industrial estate to ensure that unauthorized development is prevented and that the estate is properly maintained. Bye-laws relating to refuse clearance, unauthorized building additions, preservation of landscape, building and road maintenance, smoke and nuisance control, effluent disposal and approved processes are vital to ensure that the original planning and aesthetic standards established for the estate are maintained.

142. Fringe development must also be restricted, especially when the estate borders on a main highway. Unauthorized building outside the estate must be prevented; shack dwellings, substandard factory buildings and squatting trading slums can grow quickly on the boundaries of a thriving estate and, once established, they are difficult to eradicate. Appropriate land use controls must therefore be rigidly exercised in order to avoid such unwanted development, which is not only unsightly but is usually unhygienic.

143. Building construction regulations exist in most urban areas of Africa and their scope extends over many rural areas also. In many cases, these regulations were based on the "Home" building regulations of the original colonial powers concerned. These have served a useful purpose in the past, but have often not been brought up to date. It is therefore possible to find building regulations in parts of Africa which are far more restrictive than those in developed countries.

144. Building regulations should therefore receive regular scrutiny to ensure that they are not inhibiting progress by failing to take into account new building materials and techniques. Close liaison with established Building Research Stations is essential so that economy of construction can be achieved, by allowing the use of the most up-to-date building methods. In many countries building regulations are being re-written, based on "performance standards". These specify what building materials and construction must do rather than what they should be. For example, instead of specifying materials and thickness for walls and roofs, the desired degree of fire resistance, of strength and weatherproofness can be set out, to

allow freedom of choice among the variety of alternatives available. Such performance standards will encompass both traditional methods and allow for new ones. To help the builder who does not wish to break away from known materials, "deemed to satisfy" clauses can be included which are, in fact, examples showing how the required performance standards can be reached with traditional techniques. Such building codes cater for the present and the future, and need less frequent revision than normal mandatory ones.

145. When building regulation revisions are under consideration, these factors should be borne in mind and the collaboration of Building Research Stations, with their testing facilities, sought. The creation of building research facilities where they do not already exist should be regarded as an important step in any national industrialization programme.

146. Safety regulations during building construction require only brief mention. If they do not exist, then simple safety rules, based on experience in the developed countries, should be devised. They should deal with the use of machinery, the protection of workers, precautions against fire or explosion and the storage of inflammable and dangerous materials. They must be rigidly enforced. The building industry in all countries has a bad accident record, and safety on building sites is a good investment, for injured workmen and damaged building work are luxuries no project can afford.

(2) Industrial regulations

147. This paper is not primarily concerned with the running of an industrial estate after completion, but industrial regulations have a bearing on building design and maintenance.

148. Health regulations are concerned not only with the factory buildings after occupation, but should apply to the building operations as well, in relation to the provision of first aid units, sanitary accommodation, canteens and similar facilities. These must be regarded as obligatory on all construction sites.

149. Factories Acts are concerned with buildings and amenities as well as purely industrial matters. Appendix III lists the sections of the Factories Acts of 1937 and 1948, of the United Kingdom, which have a particular bearing on matters relating to buildings for manufacturing purposes. Because of their comprehensive nature, they can be regarded not only as a guide to specific issues but also as a pattern which could be followed in developing countries which have the task of framing similar legislation.

CONCLUSION

150. The future prosperity of any country depends to a large extent on the production efficiency of its industry. This in turn depends upon the efficiency of the buildings used for industrial purposes and the manner in which they are related to each other and their neighbours on individual sites or industrial estates. No country can afford unplanned factories or badly laid out factory estates. In the past, in all countries of the world, many factories have grown up in a haphazard fashion, and little consideration has been given to either the comfort of the workers or the efficiency of the operations to be carried out.

151. The developing African nations, with their plans for rapid industrialization, can benefit greatly from the experience of the highly industrialized countries of the world, and they can also learn from their mistakes. An "industrial revolution" need not leave for posterity squalor, ugliness and chaos; these things are difficult to eradicate once established, but can easily be avoided if imagination and skill are applied to the task. The United Nations Seminar on Industrial Estates in Africa is a valuable contribution towards this end, and it is hoped that this paper will provide a useful and practical basis for discussion and action.

152. Experience has shown that well-designed factories on imaginatively planned industrial estates can encourage a higher level of productivity, stimulate better workmanship and result in happier and healthier workers.

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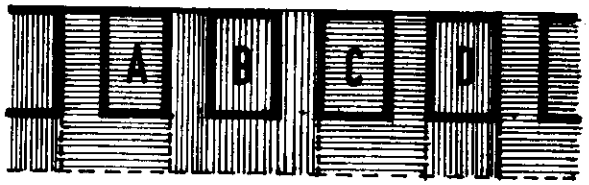
APPENDIX I

DRAWINGS AND DIAGRAMS

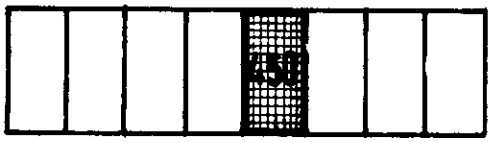
1. Factory Estate Plant Layout Designed to Facilitate Individual Expansion
2. Basic Modular Factory Bay Unit Capable of a Variety of Planning Arrangements
3. Diagrammatic Layout of Small Rural Industrial Group based on 30 ft. x 15 ft. Module
4. Planning of Industrial Estate - Harlow New Town, Great Britain
5. Layout of Industrial Estate - Ja-Ela, Ceylon
6. Expansion Plan for Industrial Area - Nairobi, Kenya
7. Climatic Factors Influencing Building Design in the Tropics
8. Alternative Sections for Portal Frame to Modular Bay



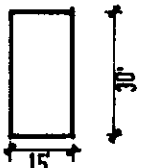
FACTORY ESTATE PLANT LAYOUT DESIGNED TO FACILITATE INDIVIDUAL EXPANSION

METHOD OF OPERATION

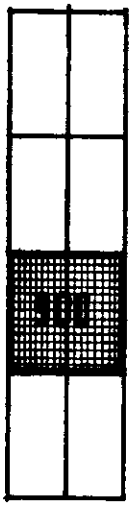
The plots are laid out so that there is a gap between factories equal to half the width of a factory and a space at the rear equal to half the depth of the factory. If factory B wants to expand it can do so to three times its original extent without having to move. Having done so, its neighbours A and C can only expand 125 %. A factory such as D which is flanked by neighbours which have both expanded is limited to a 50 % expansion at the rear.



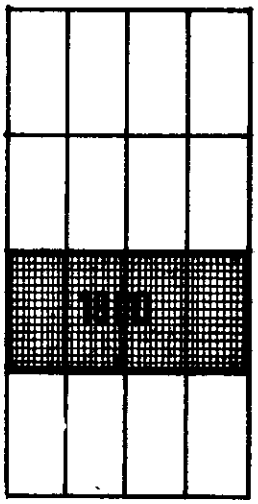
rural terrace craft unit



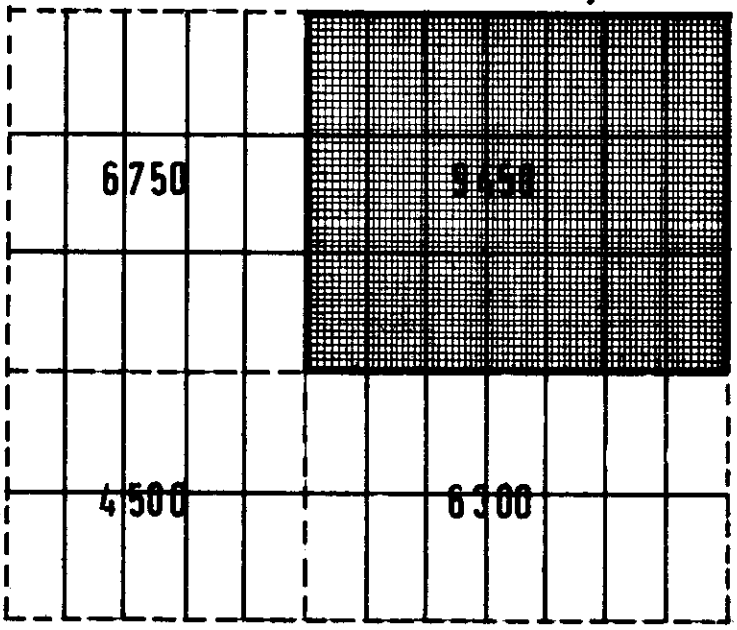
standard bay module



terrace workshop unit



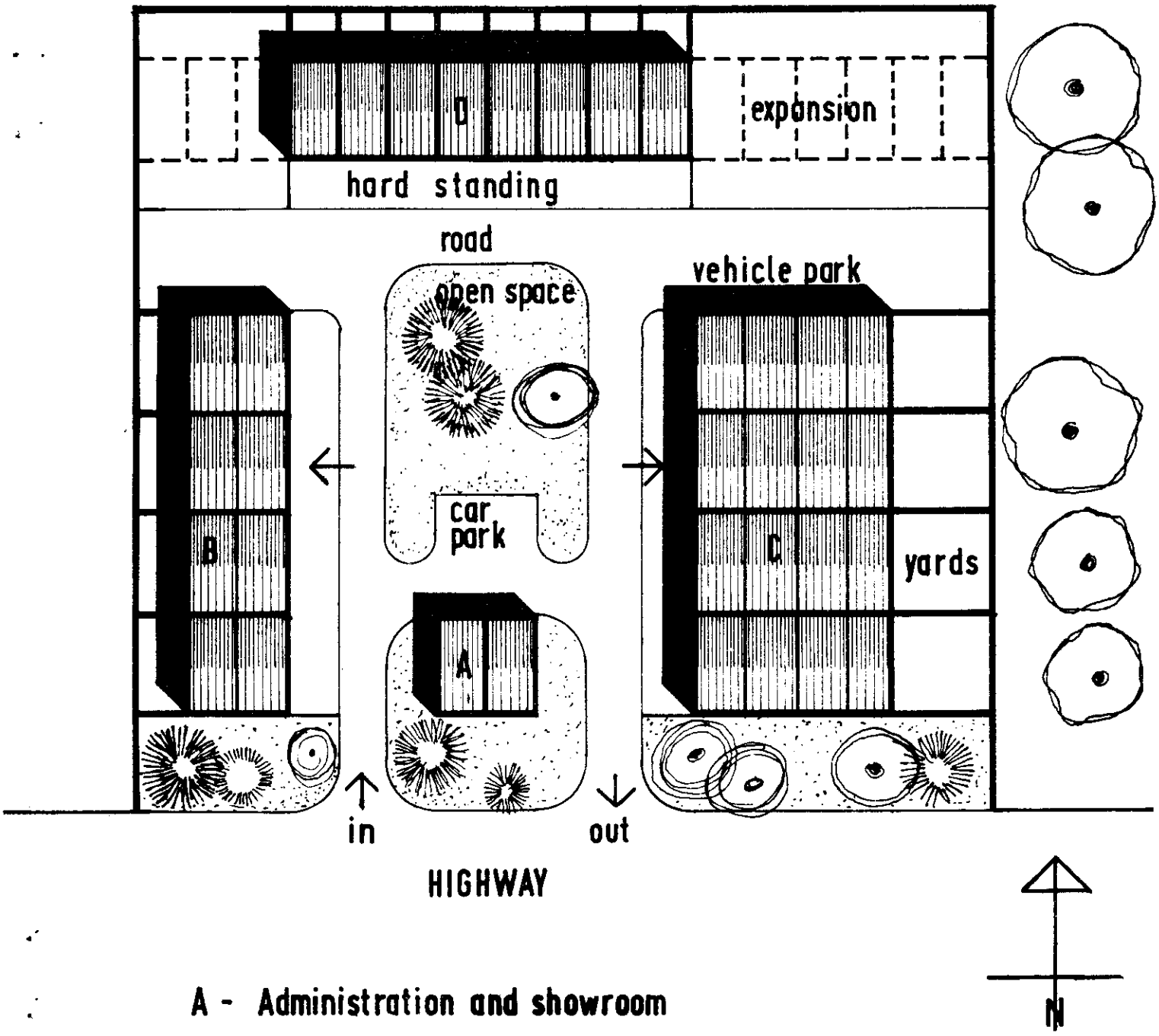
terrace nursery factory unit



TYPICAL STANDARD FACTORY - expanded in four stages from 9 450 f.s. to 27 000 f.s.

BASIC MODULAR FACTORY BAY UNIT CAPABLE OF A VARIETY OF PLANNING ARRANGEMENTS

3



A - Administration and showroom

B - Workshop units

C - Nursery factories

D - Craft units

DIAGRAMMATIC LAYOUT OF SMALL RURAL INDUSTRIAL GROUP BASED ON 30'x 15' MODULE

4

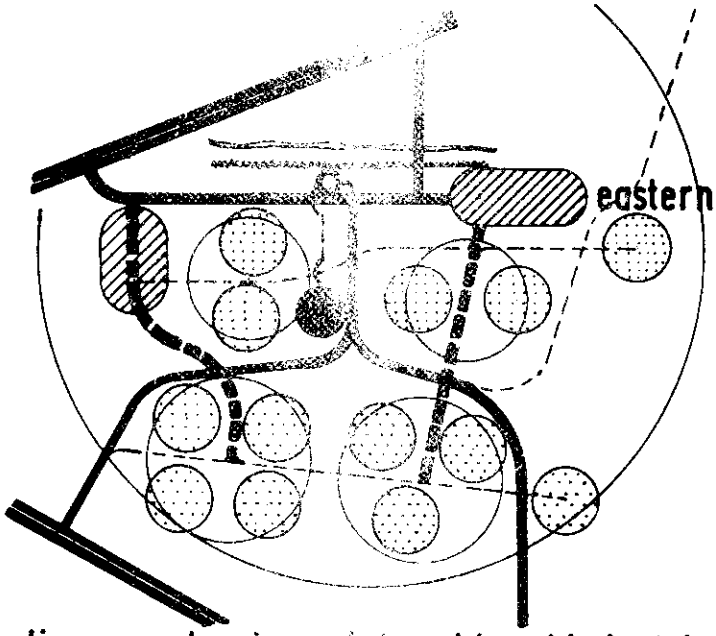
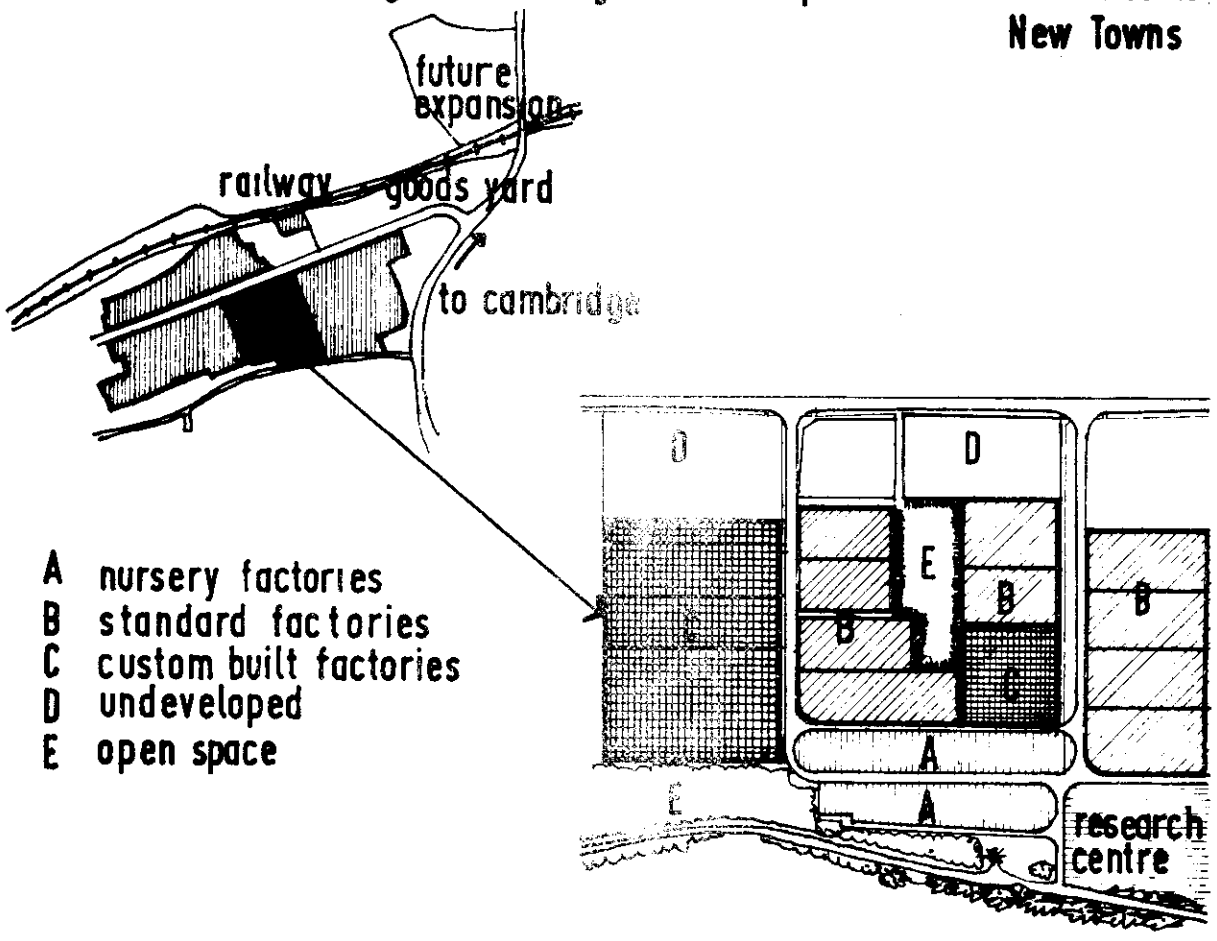
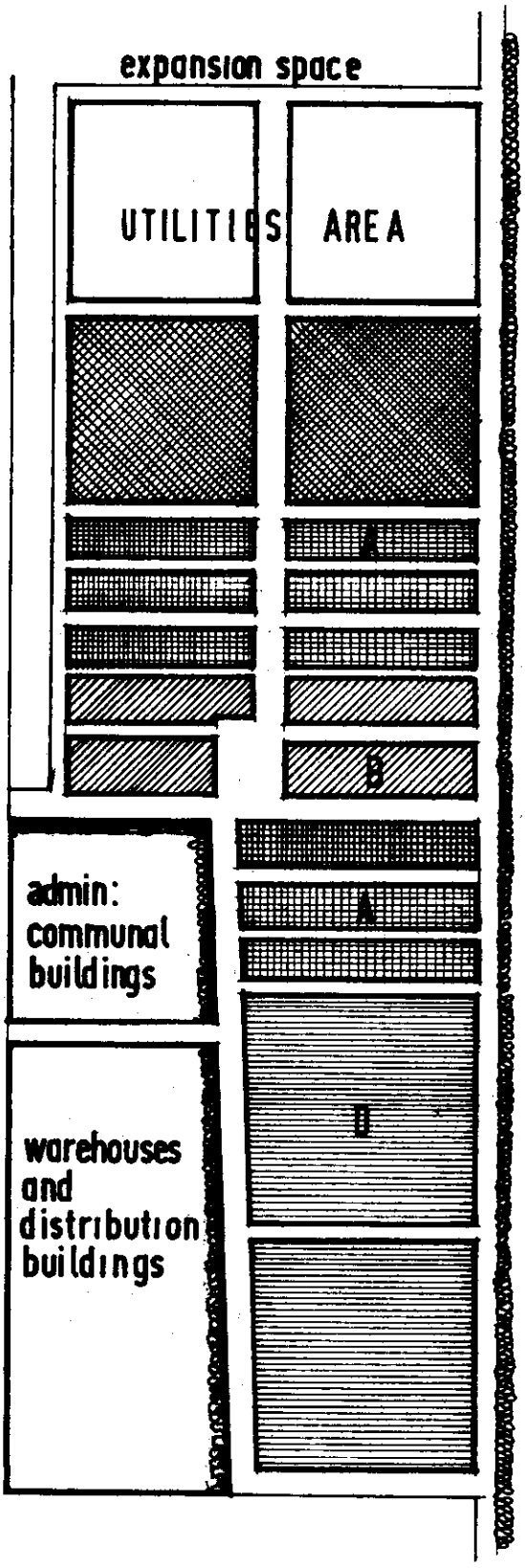


diagram showing relationship of industrial estates to New Towns



PLANNING OF INDUSTRIAL ESTATE – HARLOW NEW TOWN GREAT BRITAIN

5



N

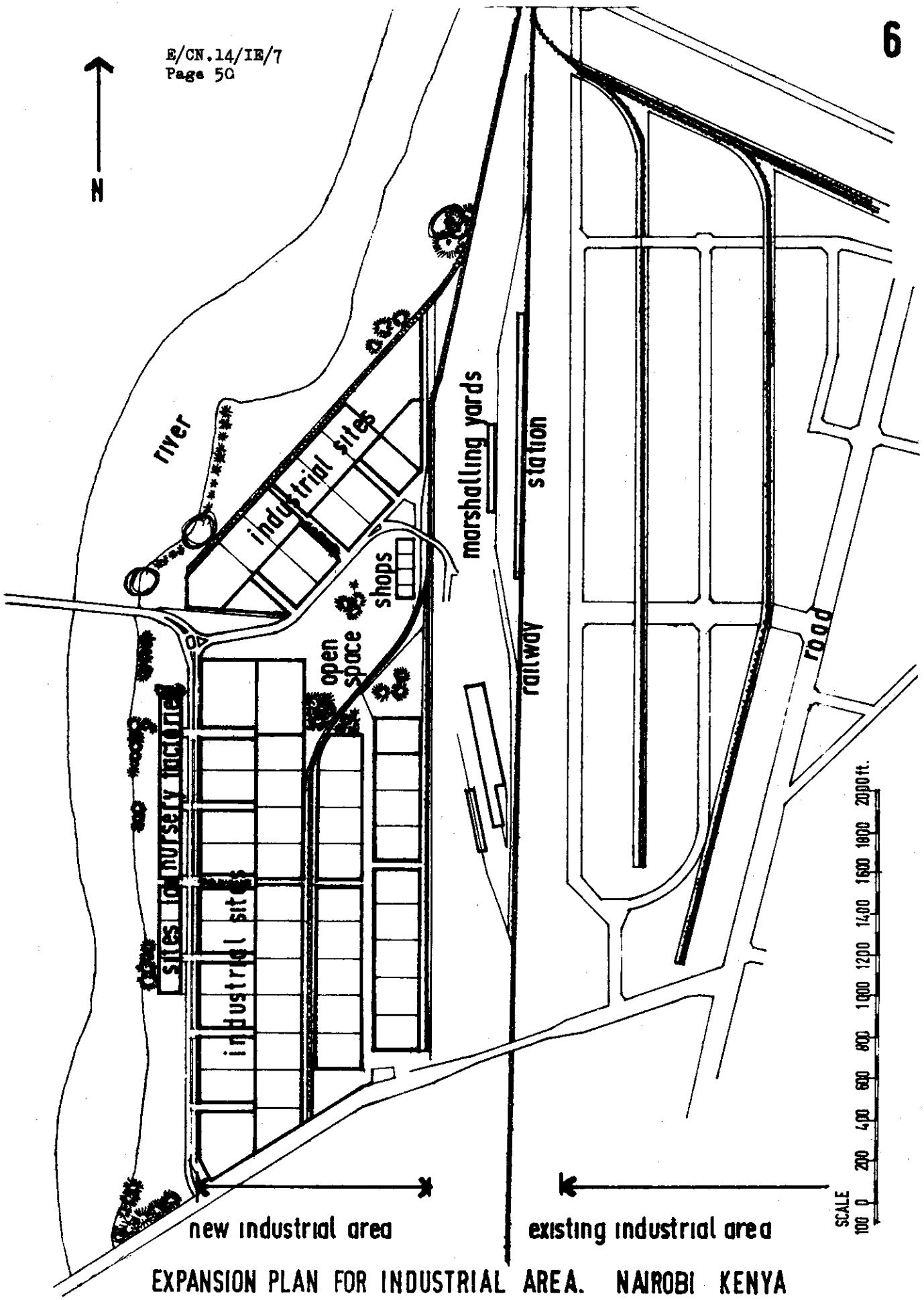
A Nursery factories
B Standard factories
C Custom built factories
D Non-Compatible factories

SCALE

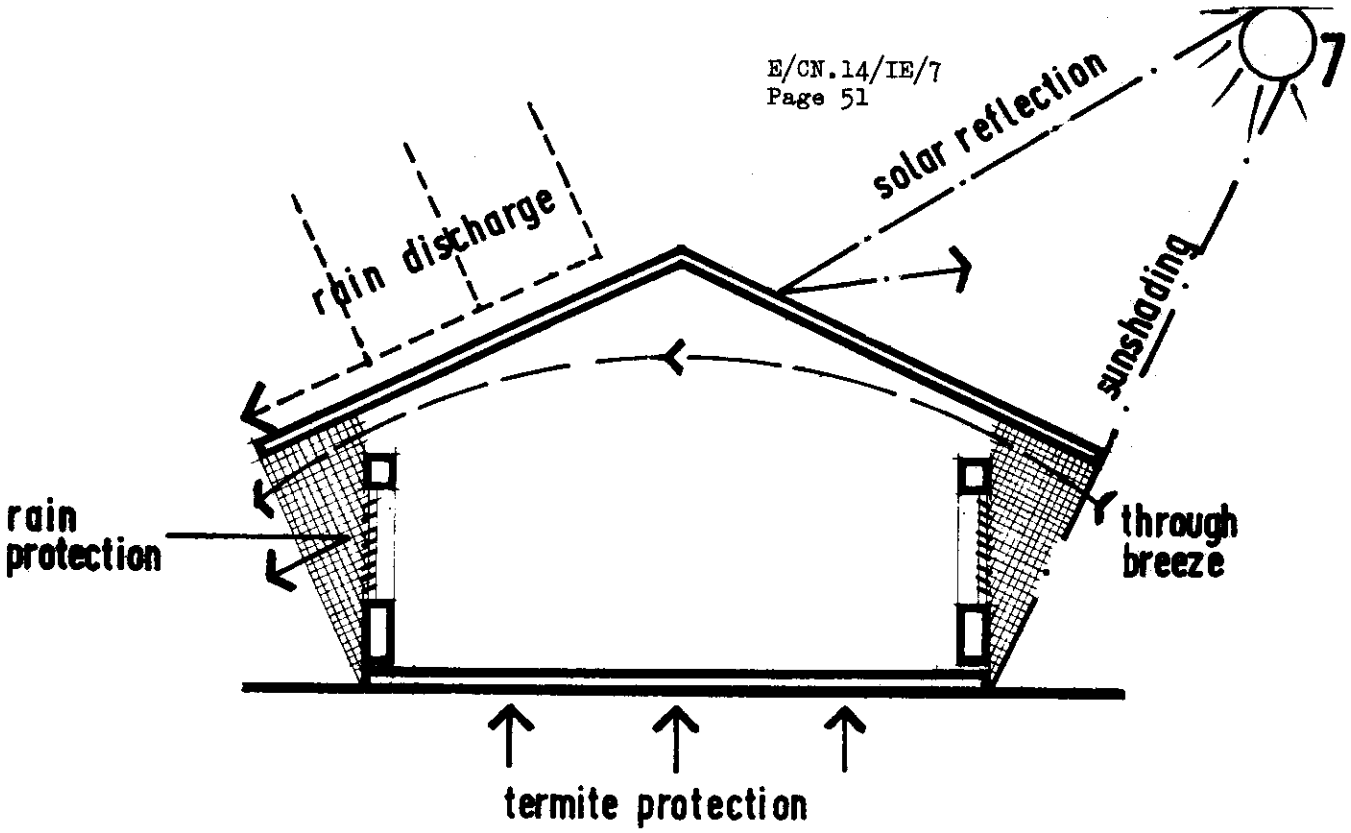
0 100 200 300 400 500ft.

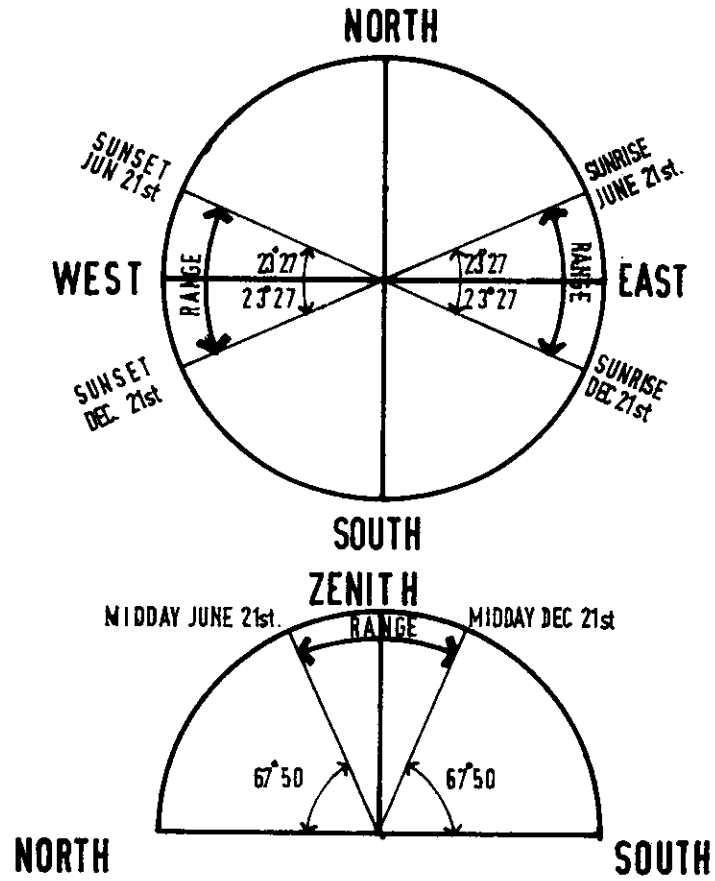
0 50 100m.

LAYOUTOF INDUSTRIAL ESTATE JA-ELA CEYLON



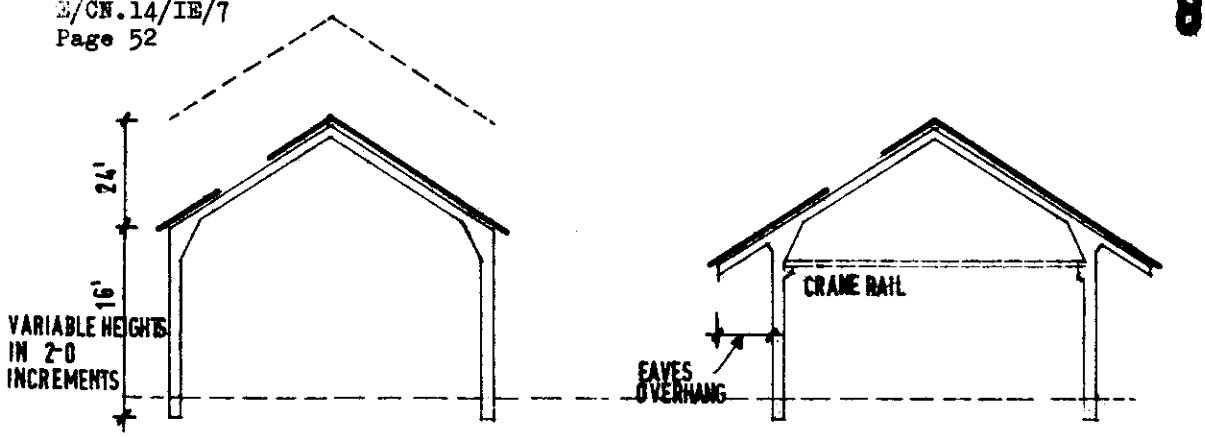
EXPANSION PLAN FOR INDUSTRIAL AREA. NAIROBI KENYA





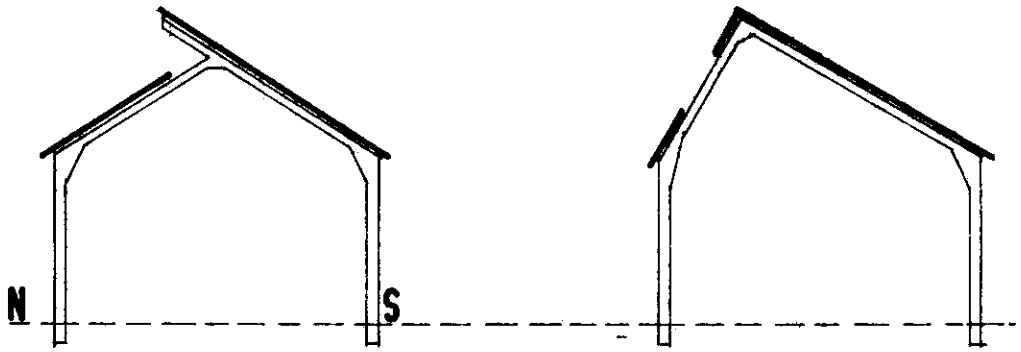
Angle of sun diagram for Nairobi Kenya

CLIMATIC FACTORS INFLUENCING BUILDING DESIGN IN THE TROPICS



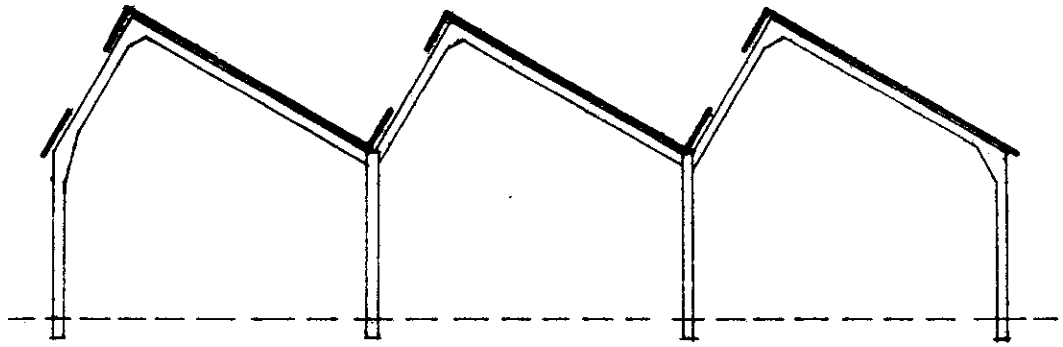
1. basic portal frame

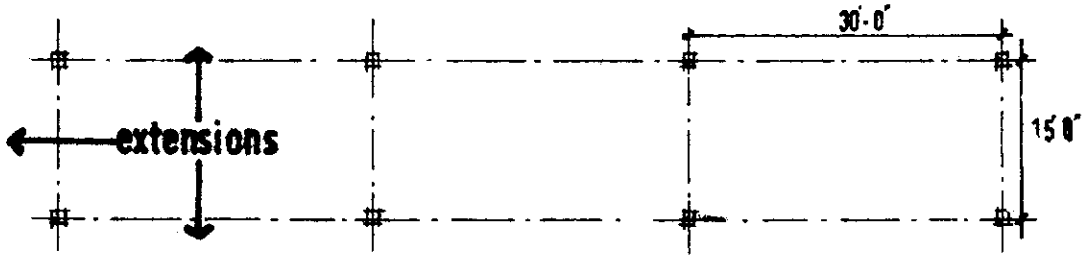
2. basic frame with modifications



3. basic frame with monitor rooflight

4. north light frame





plan

ALTERNATIVE SECTIONS FOR PORTAL FRAME TO MODULAR BAY

APPENDIX II

TABLES AND SCHEDULES

Table 1. Areas of Industrial Estates in Various Countries

Country	Size of estate		
	Small (acres)	Medium (acres)	Large (acres)
United States of America	50-100	100-500	500-1000 and over
Great Britain	up to 50	50-100	100-500 and over
India	2-10	10-30	over 30

Table 2. Comparative Average Road Dimensions for Industrial Estates (Paved Widths)

Country	Main Roads (feet)	Secondary (feet)	Service (feet)
United States of America	75-320	80-100	40
United Kingdom	50	36-38	20-22
India	40	30	22
Singapore	30	22	18
Pakistan	24	16	10
India	24	16	10

Table 3. Comparative Building Labour Rates in Africa, 1963

Country	Skilled	Unskilled	Official rate of exchange for one U.S. dollar
	(U.S. dollars per month)		
Ethiopia	60	...	2.5 Ethiopian dollars
Guinea Ivory Coast	...	40-50	250 CFA francs
Kenya	70	20	7 shillings
Morocco	72	36	5 dirhams
Nigeria	36	24	7 shillings
Senegal	...	40-50	250 CFA francs
Sierra Leone	60	35	7 shillings
Somalia	29	17	7 somalos
South Africa	105	55	0.7 rand
Sudan	40-43	17-20	0.35 Sudanese £
Tanganyika	23	17	7 shillings
United Arab Republic	34	18	0.44 Egyptian £

Costs given in U.S. dollars to facilitate comparison. £1 sterling = U.S. $ 2.70.

Compiled from "Housing in Africa", document E/CN.14/HOU/2, mimeographed.

Table 4. Cost Analysis for Terrace of 9 Nursery Factories (United Kingdo

Single storey each 32'-6" x 92'-0" x 12'-0" to eaves.

Construction: Pre-cast concrete frame, asbestos tile roof, brick walls, concrete floor, metal windows.

Completion: 1959

Element			Percentage
1. External elements	(a)	Preliminaries, excavations, foundations, ground slab	17.5
	(b)	Yardwalls, paving and gates	5.0
	(c)	Rainwater and soil drainage	7.5
2. Primary elements		Frame, walls, roof structure, doors and windows	35.0
3. Secondary elements		Internal partitions, doors and fittings	10.0
4. Finishes		Wall, floor and roof finishings and decoration	15.0
5. Services installations		Plumbing, electrical installations, hot and cold water	10.0
		TOTAL:	100

APPENDIX III

SUMMARY OF PARTS OF THE UNITED KINGDOM FACTORIES ACT, 1937, HAVING PARTICULAR RELEVANCE TO INDUSTRIAL BUILDINGS

THE FACTORIES ACT 1937 (U.K.)

Part I. Health (General Provisions)

1. Cleanliness 2. Over-crowding 3. Temperature 4. Ventilation 5. Lighting 6. Drainage of floors 7. Sanitary convenience 8. Enforcement by district councils of certain provisions of Part I 9. Powers of inspector as to sanitary defects remediable by district council 10. Powers in case of default of a district council 11. Power to require medical supervision.

Part II. Safety (General Provisions)

12. Prime movers 13. Transmission machinery 14. Other machinery 15. Provisions as to unfenced machinery 16. Construction and maintenance of fencing 17. Construction and sale of new machinery 18. Vessels containing dangerous liquids 19. Self-acting machines 22. Hoists and lifts 23. Chains, ropes and lifting tackle 24. Cranes and other lifting machines 25. Construction and maintenance of floors, passages and stairs 26. Safe means of access and safe place of employment 27. Precautions in places where dangerous fumes are liable to be present 28. Precautions with respect to explosive or inflammable dust, gas, vapour or substance 29. Steam boilers 30. Air receivers 31. Steam receivers and steam containers 32. Exceptions as to steam boilers, steam receivers and containers, and air receivers 33. Precautions as regards water-sealed gasholders 34. Means of escape in case of fire 35. Regulations and by-laws as to means of escape in case of fire 36. Safety provisions in case of fire 37. Instruction as to use of means of escape in case of fire 38. Power of Secretary of State to require special safety

arrangements for the prevention of accidents 39. Power of court of summary jurisdiction to make orders as to dangerous conditions and practices 40. Power of court of summary jurisdiction to make orders as to dangerous factory.

Part III. Welfare (General Provisions)

41. Supply of drinking water 42. Washing facilities 43. Accommodation for clothing 44. Facilities for sitting 45. First-aid 46. Welfare regulations

Part IV. Health, Safety and Welfare (Special Provisions and Regulations)

Special Provisions

47. Removal of dust or fumes 52. Humid factories 53. Underground rooms 54. Basement bakehouses 55. Laundries.

Special Regulations for Safety and Health

Supplementary Provisions

63. Certificates required before approval of building plans relating to cotton cloth factories.

Part VII. Special Applications and Extensions

Works of Building and Engineering Construction

107. Building operations 108. Works of engineering construction.

Note: The numbers quoted above are the section numbers of the original Acts of Parliament.