PLANT LAYOUT OF CEMENT INDUSTRY FOR MASS PRODUCTION

by

Md.Ekhtiar Alam

A project report submitted to the Department of Mechanical Engineering in partial fulfillment of the requirements for the degree of Master of Science in Mechanical Engineering.

Khulna University of Engineering & Technology
Khulna 9203, Bangladesh

August 2010

Declaration

This is to certify that the project work entitled "*Plant Layout of Cement Industry for Mass Production*" has been carried out by *Md.Ekhtiar Alam* in the Department of *Mechanical Engineering*, Khulna University of Engineering & Technology, Khulna, Bangladesh. The above research work or any part of the work has not been submitted anywhere for the award of any degree or diploma.

Md. Ekhtiar Alam.

Signature of Supervisor
Dr.Tarapada Bhowmick
Professor
Department of Mechanical Engineering
Khulna University of Engineering & Technology

Signature of the candidate
Md.Ekhtiar Alam
Roll No: 0805551

Approval

This is to certify that the project work submitted by *Md.Ekhtiar Alam* entitled "*Plant Layout of Cement Industry for Mass Production*" has been approved by the board of examiners for the partial fulfillment of the requirements for the degree of *M.Sc Engineering* in the Department of *Mechanical Engineering*, Khulna University of Engineering & Technology, Khulna, Bangladesh in August 2010.

BOARD OF EXAMINERS

1. ....

Dr. Tarapada Bhowmick
Professor
Department of Mechanical Engineering
Khulna University of Engineering & Technology, Khulna — Chairman (Supervisor)

2. ....

Dr. Mihir Ranjan Halder
Professor & Head
Department of Mechanical Engineering
Khulna University of Engineering & Technology, Khulna — Member

3. ....

Dr. Naseem Ahmed
Professor
Department of Mechanical Engineering
Khulna University of Engineering & Technology, Khulna — Member

4. ....

Mr. Md. Golam Kader
Associate Professor
Department of Mechanical Engineering
Khulna University of Engineering & Technology, Khulna — Member

5. ....

Dr. N. R. Dhar
Professor
Department of IPE
Bangladesh University of Engineering & Technology, Dhaka — Member (External)

ACKNOWLEDGEMENT

First of all, the author would like to convey his gratitude to the Almighty God without whose blessing not a single activity on earth comes to the success.

The author expresses his deep sense of gratitude, regard and sincere thanks to Dr. Tarapada Bhowmick, Professor, Department of Mechanical Engineering, Khulna University of Engineering & Technology (KUET), for his magnanimous guidance and valuable counsel in execution of the completion of the project work and immense help during the preparation of the report, without which it would have been simply impossible to complete work. After all without his support this work would not have taken this shape.

The author is very much delighted and thankful to Dr. Mohammad Mashud, Associate Professor, Department of Mechanical Engineering Khulna University of Engineering & Technology (KUET), for his closest assistance in every stage to complete the work. The author also has got various academic helps and inspiration from him.

Thanks are also due to all other teachers of the Department of Mechanical Engineering, Khulna University of Engineering & Technology (KUET) for their necessary and cordial cooperation during the period of study and work. The author would like to thank post graduate students of this department for their help in many respects.

The author is indebted to all those who have been associated with him during the course of his work and for all those who have prayed for him.

Finally, the author expresses his heartfelt gratitude to his parents for their blessings and moral support.

Khulna **The Author**

ABSTRACT

Plant layout is the lifeblood of an industry as well as of any cement industry for its manufacturing process and layout design. A cement industry uses various types of machinery and equipment for its smooth operation. Appropriate plant layout and location of facilities are crucial for enhancing the productivity and safety of the industry. Plant layout planning, however, is a complex problem, and researchers have attempted to solve it using a variety of techniques. It refers to the arrangement of physical facilities such as machineries, buildings, equipments, work places and other facilities of production in order to process the product in the most efficient manner. An ideal plant layout for any cement industry should provide the optimum relationship among output, machinery, equipments, floor area and manufacturing processes. It facilitates the production process, minimizes material handling, time and cost, and allows flexibility of operations, easy production flow, makes economic use of the building, promotes effective utilization of manpower. It also provides for employee's convenience, safety, comfort at work, maximum exposure to natural light and ventilation. Based on the proposed layout model a comprehensive system for planning is developed.

The present work includes study of layout design and their production system of various cement industries such as Meghna cement, Mongla Cement, Five Rings Cement, CEMEX Cement, and Akij Cement industries. Their scientific planning and design which is related to plant layout design for mass production system are analyzed. The optimum plant layout design has been developed from the need to create or modify cement industry design and to meet new market demands. Since the relayout design of industries is highly expensive and disruptive especially when the entire factory has to be shut down resulting production to be stopped, an optimum plant layout is very much essential for their manufacturing.

Contents

List of Figures

CHAPTER 1

INTRODUCTION

1.1 Introduction

Plant layout refers to the arrangement of physical facilities such as machinery, buildings, equipments, work places and other facilities of production in order to process the product in the most efficient manner. It is very much needful for any type of mass production industry. In mass production, same type of product is manufactured to meet the continuous demand of the product. Usually demand of the product is very high and market is going to sustain same demand for sufficiently long time. Cement industry is one type of mass production industry which has an important role to the development and modernization of cities and infrastructures.

Plant layout for cement industry is an important factor as it represents long-term commitment. As the change of a layout is expensive and difficult, it is better to get it also right from the very beginning. An ideal plant layout for any cement industry should provide the optimum relationship among output, floor area and manufacturing process. It facilitates the production process, minimizes material handling, time and cost, allows flexibility of operation and easy production flow, makes economic use of the building, promotes effective utilization of manpower and provides employee's convenience, safety, comfort at work, maximum exposure to natural light and ventilation. It is also important because it affects the flow of material and processes, labour efficiency, supervision and control, use of space and expansion possibilities etc **[1]**.

The optimum plant layout of cement industry proceeds quickest flow of material at the right quantity and quality of output at the lowest possible cost of manufacturing and with the least amount of handling in processing the product from the receipt of material to the shipment of the finished product, that most economically meets the required output quantity. The efficiency of production depends on how well the various machines, production facilities and employee's amenities are located in a plant.

1.2 The nature of the plant layout design process

The design of plant layout involves a decision process, which, in general, due to its complexity, has again to be decomposed into several sub-problems. When specifying these sub problems, their boundaries must be defined so as to minimize the interactions among them. Since such interactions cannot be eliminated, the different stages in which the overall process is tackled do not follow a rigid sequence.

The optimum plant layout design process derives from the need to create or modify cement industry design, to meet new market demands. In most cases, such a process is triggered by the detection of changes in the product demand mix (which may imply changes in the product outputs, the introduction of new products or the modification of existing ones) or the need for upgrading the current technological processes or for introducing new ones. Engineering design is developed together with process planning and it includes the synthesis, analysis and assessment of the product against specifications. Process planning which is the final stage prior to those dealt with by the covers, for each part to be produced, the specification of all the manufacturing operations required to obtain the characteristics defined by the engineering design, and for deferent set of parts, the specification of the assembly operations required to obtain the final product [**2**].

1.3 Concept of plant layout

Under the manufacturing concept, plant layout may be defined as, "Plant layout ideally involves allocation of space and arrangement of equipment in such a manner that overall operating costs are minimized", according to J. L. Zundi. The best to the plant layout problem is important for two reasons. Firstly, the material handling cost can comprise between 30% and 70% of the total manufacturing costs, dependent on whether the facility is planned on a product or process basis or the other types. Secondly, plant layout is a long-term, costly proposition, and any modification or rearrangement of an existing plant represents a large expense both in terms of relocation and lost processing time and can often not be accomplished easily (Sule, 1994). "Effective planning can reduce these costs by at least 10% to 30% and thus increase productivity" [**Tompkins and White, 1984**]. Engineers are often assigned for one of two major tasks, either redesign an existing plant to meet current market demands, or design a new plant layout. One of the most effective methods for increasing plant productivity and reducing costs is to reduce or eliminate all activities that are unnecessary or wasteful. A plant design should accomplish this goal in terms of material handling, personnel and equipment utilization, reduced inventories and increased quality. Today, existing layout configurations will not meet the expectations and needs of the multi-product organizations. It is a necessary that there is a need for a new generation of factory layouts that are more flexible, modular and more easily reconfigurable. Re layout can be highly expensive and disruptive, especially when the entire factory has to be shut down and production stopped. The current choices of layout, such as product, process, fixed position layout and hybrid layouts do not adequately address the above needs because they tend to be designed for a specific product mix and production volume, both assumed to last for a sufficiently long period. In addition to these layouts, there are some next generation layouts such as distributed layouts, modular layouts, reconfigurable layouts and agile layouts. As a result, layout performance tends to deteriorate significantly with fluctuation in design parameters such as product volumes, mix, routings or product life-cycles [**3**].

1.4 Characteristics of mass production system

The followings are the important characteristics of mass production system:

- As same product is manufactured for sufficiently long time, machines can be laid down in order of processing sequence. Product type layout is most appropriate for mass production system.
- Standard methods and machines are used during part manufacture.
- Most of the equipments are semi automatic or automatic in nature.
- Material handling is also automatic (such as conveyors).
- Semi skilled workers are normally employed as most of the facilities are automatic.
- As product flows along a pre defined line, planning and control of the system is much easier.
- Cost of production is low owing to the high rate of production.
- In process inventories are low as production scheduling is simple and can be implemented with ease.

1.5 Factors influencing layout

While deciding the factory or unit or establishment or store, a small-scale businessman should keep the following factors in mind [**1**].

a) *Factory building:* The nature and size of the building determines the floor space available for layout. While designing the special requirements, e.g. air conditioning, dust control, humidity control etc. must be kept in mind.

b) *Nature of product*: product layout is suitable for uniform products whereas process layout is more appropriate for custom-made products and also considerable this product is more or less in the market to the customer demand.

c) *Production process*: In assembly line industries, product layout is better. In job order or intermittent manufacturing on the other hand, process layout is desirable.

d) *Type of machinery*: General purpose machines are often arranged as per process layout while special purpose machines is needed to arrange according to product layout

e) *Repairs and maintenance*: Machines should be so arranged that adequate space is available between them for movement of equipment and people required for repairing the machines.

f) *Human needs*: Adequate arrangement should be made for cloakroom, washroom, lockers, drinking water, toilets and other employee facilities, proper provision should be made for disposal of effluents, if any.

g) *Plant environment*: Heat, light, noise, ventilation and other aspects should be duly considered, e.g. paint shops and plating section should be located in another hall so that dangerous fumes can be removed through proper ventilation etc. Adequate safety arrangement should also be made.

Thus, the layout should be conducive to health and safety of employees. It should ensure free and efficient flow of men and materials. Future expansion and diversification may also be considered while planning factory layout.

1.6 Selection criteria of location for cement industry

The important considerations for selecting a suitable location are given as follows [4]:

- Natural or climatic conditions.
- Availability and nearness to the sources of raw material.
- Transport costs-in obtaining raw material and also distribution or marketing finished products to the ultimate users.
- Access to market such as small businesses in retail or wholesale or services should be located within the vicinity of densely populated areas.
- Availability of Infrastructural facilities such as developed industrial sheds or sites, link roads, nearness to railway stations, airports or sea ports, availability of electricity, water, public utilities, civil amenities and means of communication are important, especially for small scale businesses.
- Availability of skilled and non-skilled labor and technically qualified and trained managers.
- Banking and financial institutions are located nearby.
- Locations with links: To develop industrial areas or business centers result in savings and cost reductions in transport overheads, miscellaneous expenses.
- Strategic considerations of safety and security should be given due importance.
- Government influences: Both positive and negative incentives to motivate an entrepreneur to choose a particular location are made available. Positive includes cheap overhead facilities like electricity, banking transport, tax relief, subsidies and liberalization. Negative incentives are in form of restrictions for setting up industries in urban areas for reasons of pollution control and decentralization of industries.

It is revealed on the considerations of the location for an industry that the native place or homelands of the entrepreneur was the most important factor. Heavy preference to homeland suggests that small-scale enterprise is not freely mobile. Low preference for Government Incentives suggests that concessions and incentives cannot compensate for poor infrastructure.

1.7 Dynamics of plant layout

Plant layout is a dynamic rather than a static concept meaning thereby if once done it is not permanent in nature rather improvement or revision in the existing plant layout must be made by keeping a track with development of new machines or equipment, improvements in Manufacturing process, changes in materials handling devices etc. But, any revision in layout must be made only when the savings resulting from revision exceed the costs involved in such revision [**1**]. Revision in plant layout may become necessary on account of the following reasons:

- Increase in the output of the existing product.
- Introduction of a new product and diversification.
- Technological advancements in machinery, material, processes, product design, fuel etc.
- Deficiencies in the layout unnoticed by the layout engineer in the beginning.

1.8 Application of plant layout for cement industry

Plant layout is applicable for cement industry or plant. This plant requires special arrangements which, when incorporated make the layout look distinct from the types already discussed above. In case of the manufacturing of cement industry, a multi-storey building is specially constructed to some machinery. Materials are stored and poured into the silos or house at different stages on different floors. Other facilities are also provided around the equipments at different stations. A plant layout applies besides the grouping of machinery, to an arrangement for other facilities as well. Such facilities include receiving and dispatching points, inspection facilities, employee facilities, storage etc. So in the cement industry the application of the cement industry is more important [1].

1.9 Objectives of the present work

The main objectives of this present work are as follows:

a) Study the existing production system and recommend a best plant layout for a cement industry, to optimize the product handling cost and operating cost.

b) Improve the existing production system and plant layout design of cement industry.

c) Proposed the placement of machineries and equipments at the right place by optimum layout design.

d) Minimize the manufacturing cost and the investment also be optimum.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter deals with the presentation of all the market analysis, raw material storage system, environmental significance, industrial ecology, transportation, energy consumption, emission and how the clinker are manufactured also considered for design plant layout of the cement industry. The layout of cement industry can be analyzed in a first step by using part routing information, material storage requirements, material handling equipment specifications and part packaging information etc. The shortest distance between any two points, the closest incoming dock and storage area to a part's point of use have to be identified. Material flow studies have to be performed on alternate layout configurations and layout options compared in order to find the best layout and to improve production efficiency. The mass production industries are emerged in a market situation whose characteristic is functional products, and its predictable demand and high degree of standardization; also it's towards resource utilization. The discipline, accuracy, skilled manpower, enough technical person are important to market analysis, site selection and other activities. But all the employees of industry must be engaged in accordance with plans with fixed order of sequence always is updated.

The resources (machines, equipment, personnel land etc) for the cement industry are organized in functional domains. The resource is that where the market demand is properly fulfilled the production demand, supply and customer view which varies efficiently in stable market situations. Site selection also highly depends on the resources such as initial assumption, transportation, climate feature, industrial ecology, emission and its control system, energy consumption etc.

2.2 Present state-of-the-art

Plant layout refers to the arrangement of physical facilities such as machinery, buildings, equipments, work places and other facilities of production in order to process the product in the most efficient manner. It is most important for any type of mass production industry. In mass production, same type of product is manufactured to meet the continuous demand of the product. Usually demand of the product is very high and market is going to sustain same demand for sufficiently long time [**5-6**]. Cement industry is the one type of mass production industry which has the important role to the development and modernization of cities and infrastructures. Many Scientists and Researchers are continuously trying to improve its performance by optimizing the use of natural resources and reducing its overall energy consumption [**7-8**]. Under the manufacturing concept, plant layout of cement industry is the process of obtaining the optimal disposition of the physical facilities for a manufacturing unit. To achieve commercial benefits and to operate economically, proper planning of the cement industry is very much essential [**9**]. Cement is the major ingredient of concrete, which is the most important consumed material on the planet. It is used to build houses, roads, bridges and concrete structure etc. However, in common with all industrial activities, the manufacturing of cement can pollute the environment, if it is not managed properly. So, a statutory responsibility for protecting and enhancing the environment is necessary [**10**].Cement production industry inherently consumes a significant amount of resource than the other mass production industry if it is low price and high volume material, and therefore the average material and energy through output is relatively high [**11**]. Plant layout for cement industry is an important decision as it represents long-term commitment. An ideal plant layout for any cement industry should provide the optimum relationship among output, floor area and manufacturing process. It facilitates the production process, minimizes material handling, time and cost, and allows flexibility of operations, easy production flow, makes economic use of the building, promotes effective utilization of manpower, and provides for employee's convenience, safety, comfort at work, maximum exposure to natural light and ventilation. It is also important because it affects the flow of material and processes, labour efficiency, supervision and control, use of space and expansion possibilities etc [**8**]. Most of the Bangladeshi cement industries face their problems for optimum plant layout design because of their ignorance, lack of knowledge, space restriction, monetary problem etc.; due to which they cannot fulfill their requirements according to the production within the budget. As a result actual output cannot be achieved.

The optimum plant layout design has many advantages over the conventional design. It improves product quality, increases production rate, and reduces operating cost as well as minimizes the initial investment.

Now days, the layout design becomes one of the most important part of installation in cement industry. It is an important task to make an optimum plant layout of cement industry which will be more efficient, effective and more reliable.

2.3 Market analysis

The optimum plant layout for any type of cement industry is one of the most important part market analyses according to their production system. The importance of production and logistic performance for company competitiveness has increased during the last decade. Today, logistic performance and flexibility can be developed into major competitive advantages. The demand for standard products is declining, product life cycle becomes shorter, and customers continuously demand qualitative products in which they can identify. The service content in products is increasing and customers now prefer companies that can customize products. When design a new cement industry then some companies already offer their best "service with a product", rather than new company "products with a service". At the same time customer focus on cost-efficiency and service which is better. These trends generate a new market situation for any type of cement industry. Sometimes customers can change their choice for a short time which is depended on their personnel demand, supply of product, market area projection, cost of the product etc. The assessment of market feasibility for economic uses and development of the industries then the most important priority their commercial districts according to their target sometimes best way improves the existing plant or design a new plant. In this must be considerable their joining and project design for land use, project and site planning, also cost-efficiency etc. The quantitative and qualitative methods applied for abroad their position which includes analysis of demand and supply, analysis of special conditions, opportunities and market segments, integrate analysis to define target markets, type of products implement, and level of unmet demand etc **[12]**.

Demand analysis of market

The market demand of cement industry depends on the following criteria:

- Market or trade area.
- Number of households and total uses of customer in current market.
- Estimating square feet of retail space supportable by resulting sales.
- Profile economy to identify major sectors and industries in market area.
- Review data on key industries to identify unique local conditions and location factors.
- Analysis at both site or local and regional level.
- Local goals and concerns, site issues and surrounding use are factors in deciding on potential uses and industries to target.
- Generation of findings on feasible types of space, target industries, and property type or characteristic.
- Specialized needs or non-traditional users that can be served.
- Overview previous data whether it is increased or decrease.

Supply analysis of market

The supply of market for cement industry depends on some criteria which are given below:-

- To identify competing stores in and near trade area.
- To consider planned or potential cement industry that may enter the market area national and regional retail trends are important.
- To calculate the dollar value of this market share.
- To translate these sales levels into supportable supply use industry data on average sales in every year.
- To collect data from planning officials on projects under construction and proposed projects that will expand supply.

- To compare existing and planned supply to expected demand for each supply.
- To identify under-served markets and supply gaps that market is not serving.
- To integrate supply and demand analysis to assess overall market potential for different uses, target industries or users, property or project characteristics.
- To overview previous supply data and maintain the target or goal for the next supply.

Customer survey

The customer survey of market for cement industry provides some key information on several issues:

- To understand customer use of the location.
- To identify important market segments served and underserved.
- To customer perceptions and evaluation of the area.
- To competing areas for different products and services.
- To test customer response to various improvements.
- To test customer response to different value propositions or marketing themes.
- To by this product the customer opinion, it's positive or negative.

2.4 Raw material acquisition

Clinker is the main composition for cement production where gypsum, limestone, slack, fly ash etc are used with clinker. The primary raw material for clinker production is limestone, but other material such as marl, clay, bauxite, iron ore or sand is also commonly used. As rules of thumb, approximately 1.5-1.6 tones of dry raw material are required to produce one tone of clinker. Most of the raw materials used are extracted from the earth through mining and quarrying and can be divided into the following groups: lime (calcareous), silica (siliceous), alumina (argillaceous), and iron (ferriferous). Since a form of calcium carbonate, usually limestone, is the predominant raw material, most plants are situated near a limestone quarry or receive this material from a source via inexpensive transportation. The plant must minimize the transportation cost since one third of the limestone is converted to CO_2 during the pyroprocessing and is subsequently lost. Quarry operations consist of drilling, blasting, excavating, handling, loading, hauling, crushing, screening, stockpiling, and storing. During raw material acquisition the primary air pollutant emitted is particulate matter. Particulate matter is also emitted from the handling, loading, unloading, and transport of raw materials such as coal, purchased from another source. In certain areas, exhaust from portable equipment may also be a consideration. The following methods are used to control particulate emissions generated from the quarry and handling of purchased raw materials:

- Fabric filters (pulse-jet or reverse-air/shaker)
- Equipment enclosures
- Water sprays (with and without surfactants)
- Enclosures
- Silos (with and without exhaust venting to wind screens fabric filters)
- Foams
- Mechanical collectors
- Chemical dust suppressants
- Material storage buildings

Dust that is collected by these means is restored to the process. For quarry operations, newer plants typically use the pulse-jet fabric filters while older plants employ the reverse-air or shaker-type fabric filters.

2.5 Environmental significance of cement production

The main environmental impacts in the manufacture of cement are related to the following categories (i) Dust from stack emissions and fugitive sources, (ii) Gaseous atmospheric emissions of NOx, SO_2, CO_2, VOC and others, (iii) Other emissions like noise and vibrations, odour, process water, production waste, etc. and (iv) Resources consumption of energy and raw materials.

The manufacture of cement generates large quantities of dust. Historically, the emission of dust particularly from kiln stacks has been the main environmental concern in cement manufacture. "Point source" dust emissions originate mainly from the raw mills, the kiln system, the clinker cooler, and the cement mills. A general feature of these process steps is that hot exhaust gas or exhaust air is passing through pulverized material resulting in an intimately dispersed mixture of gas and particulates. Primary reduction measures are therefore hardly available. The nature of the particulates generated is linked to the source material itself, i.e. raw materials (partly calcined), clinker or cement. Dust from dispersed sources in the plant area ("fugitive dust") may originate mainly from materials storage and handling, i.e. transport systems, stockpiles, crane driving, bagging, etc., and from traffic movement on unpaved roads. Techniques for control and containment of fugitive dust include de-dusting of material transfer points, closed storage installations with proper ventilation, or vacuum cleaning equipment, etc. As the chemical and mineralogical composition of dust in a cement plant is similar to that of natural rocks, it is commonly considered as a "nuisance" and not as a toxic product in applicable health and safety regulations. Reduction and control of dust emissions in a modern cement plant requires both investments and adequate management practices but is not a technical problem. Kiln dust collected from the gas cleaning devices is highly alkaline and may contain trace elements such as heavy metals corresponding to the contents in the source materials. Usually, kiln dust is completely returned to the process either to the kiln system or to the cement mill. In rare cases, it is not possible to recycle kiln dust or bypass dust completely in the process. This residual dust is disposed of onsite (or in controlled landfills) or is treated and sold to other industries, i.e. as binder for waste stabilization or even as fertilizer. Heavy metals delivered by either conventional raw materials or fuels or by alternative raw materials and fuels from industrial sources will be mainly incorporated in clinker or to a lesser extent in kiln dust. Bypass dust extracted from the kiln system may be highly enriched in alkalis, sulphates and chlorides and similarly to filter dust in some cases cannot be completely recycled to the process. For both types of dust, conditioning and safe disposal avoiding contamination of groundwater or soil is a site-specific requirement [**15**].

Gaseous emissions from the kiln system released to the atmosphere are the primary environmental concern in cement manufacture today. Major gaseous emissions are NOx and SO_2. Other emissions of less significance are VOCs (volatile organic compounds), CO, ammonia, HCl, and heavy metals. CO_2 as the main greenhouse gas is released in considerable quantities. NOx formation is an inevitable consequence of the high temperature combustion process, with a smaller contribution resulting from the chemical composition of the fuels and raw materials. Sulphur entering the kiln system via raw materials and fuels is largely captured in the kiln products. However, sulphur contained in raw materials as sulphides (or organic sulphur compounds) is easily volatilized at fairly low temperatures (i.e. 400- 600° C) and may lead to considerable SO_2 emissions in the stack. Other substances entering the kiln system which could give rise to undesirable emissions are either effectively destroyed in the high temperature combustion process or almost completely incorporated into the production. Thus, the inherent process conditions prevailing in cement kilns result in emissions being usually at insignificant levels for most of these substances such as VOCs, HCl, HF, NH_3 or heavy metals. Significant levels of organic compounds in natural raw materials may cause elevated hydrocarbon and CO emissions. The main contribution to the hydrocarbon emissions is from methane. Emissions of chlorinated hydrocarbons such as dioxins and furans are usually well below existing limit values. Input of other volatile components such as mercury is carefully controlled and limited to prevent undesired emissions. If kiln exhaust gas temperatures are low enough mercury will to a large extent be condensed onto collected dust in the filter system which is then returned to the process. Carbon dioxide emissions arise from the calcinations of the raw materials and from the combustion of fossil fuels. CO_2 resulting from calcinations can be influenced to a very limited extent only. Emissions of CO_2 resulting from fuel combustion have been progressively reduced due to the strong economic incentive for the cement industry to minimize fuel energy consumption. Potential is mainly left to the increased utilization of renewable alternative fuels or other waste derived fuels and to the production of blended cements with mineral additions substituting clinker. Heavy machinery and large fans used in the cement manufacture may give rise to emissions of noise and vibrations. Odour emissions are seldom a problem with a well operated plant, but may be mainly related to emissions from handling and storage of conventional or alternative fuels. In exceptional cases, nitrogen compounds in the raw materials may lead to ammonia emissions which even at low concentrations may give rise to odour. Process water in cement manufacturing will usually be completely evaporated or recycled in the process. Filtrate water from filter presses used in the semi-wet process is fairly alkaline and contains suspended solids requiring site-specific treatment and/or disposal options. Kiln dust collected from the gas cleaning devices is highly alkaline and may contain trace elements such as heavy metals corresponding to the contents in the source materials. Usually, kiln dust is completely returned to the process, but under certain circumstances, part of it has to be rejected and disposed of. Bypass dust extracted from the kiln system may be highly enriched in alkalis, sulphates and chlorides and similarly to filter dust in some cases cannot be completely recycled to the process. For both types of dust, conditioning and safe disposal avoiding contamination of groundwater or soil is a site-specific requirement. Cement manufacturing is a "high volume process" and correspondingly requires adequate quantities of resources, i.e. raw materials, thermal fuels and electrical power. The consumption of raw materials used on average for the production of cement. The consumption is calculated for a "medium-sized" plant with a clinker production of 3000 tons per day or 1 million tons per year. Cement manufacturing is also an energy intensive process. The specific thermal energy consumption of a cement kiln varies between 3,000 and 7,500 MJ per ton of clinker, depending on the basic process design of the plant. Major consumers of electrical energy in the cement manufacturing process are the mills (cement mills, raw mills, coal mills) and the large fans (predominantly in the kiln system and with the cement mills). The specific electrical energy consumption ranges typically between 90 and 130 kWh per ton of cement. Although there is little room for further improvement in up-to-date cement plants, efforts continue with regard to equipment design and process technology to further improve the overall energy efficiency. In addition, conservation of natural resources can be achieved through increased substitution of natural raw materials and fossil fuels by industrial by-products and residues in the manufacturing process [13].

2.6 Clinker manufacturing process

Historically, the development of the clinker manufacturing process was characterized by the change from "wet" to "dry" systems with the intermediate steps of the "semi-wet" and "semi-dry" process routes. "Wet" kilns allowed for an easier handling and homogenization of the raw materials, especially in cases when the raw materials are wet and sticky or exhibit large fluctuations in the chemical composition of the individual raw mix components. With more advanced modern technology however, it is possible to prepare a homogeneous raw meal using the "dry" process, i.e. without addition of water to prepare raw slurry. The main advantage of a modern dry process over a traditional wet system is the far lower fuel consumption and thus, lower fuel cost. Today, the Selection of the wet process is only feasible under very specific raw material and process conditions [14].

The four different basic processes can be briefly characterized as follows (i) Dry process.(ii) Semi-dry process: (iii) Semi-wet process: (iv) Wet process: The raw slurry is fed either directly to a long rotary kiln equipped with an internal drying or preheating system (conventional wet process) or to slurry drier prior to a pre-heater kiln (modern wet process).

For dry and semi-dry kiln systems, raw meal is prepared by drying and grinding of the raw material components in tube mills or vertical roller mills, making use of the hot kiln exhaust gases or cooler exhaust air for drying. Prior to being fed to the kiln, the raw meal is homogenized and blended either in batch type or in continuously operating homogenizing silo systems.

In suspension pre-heater kilns, the raw meal is fed to the top of a series of cyclones passing down in stepwise counter-current flow with hot exhaust gases from the rotary kiln thus providing intimate contact and efficient heat exchange between solid particles and hot gas. The cyclones thereby serve as separators between solids and gas. Prior to entering the rotary kiln, the raw meal is heated up to a temperature of approximately 810-830 °C where the calcination (i.e. the release of CO_2 from the carbonates) is already about 30 % complete. The exhaust gases leave the pre-heater at a temperature of 300-360 °C and are further utilized for raw material drying in the raw mill. 4-stage pre-heater kilns are susceptible to blockages and build-ups caused by excessive input of elements such as sulfur, chlorides or alkalis which are easily volatilized in the kiln system. This input has to be carefully controlled. Excessive input may require the installation of a system which allows part of the rotary kiln gases to bypass the pre-heater. Thereby part of the volatile compounds are extracted together with the gas. A bypass system extracts a portion (typically 5-15 %) of the kiln gases from the riser pipe between the kiln and pre-heater. This gas has a high dust burden. It is cooled with air, volatile compounds are condensed onto the particulates and the gas then passes through a dust filter. Modern suspension pre-heater kilns usually have 4 cyclone stages with a maximum capacity limited to approximately 4000 ton pr day (t/d). In some cases, 2- stage cyclone pre-heaters or 1-stage pre-heaters supported by internal chain heat exchangers are still in operation. A considerable capacity increase can be obtained with precalciner kilns with a second combustion device between the rotary kiln and the pre-heater section. In the precalciner, up to 60 % of the total fuel of the kiln system can be burnt. At an exit temperature of about 880 °C, the hot meal is calcined to a degree of around 90 % when entering the rotary kiln. Kiln systems with 5 to 6 stage cyclone pre-heater and precalciner are considered standard technology for new plants today, as the extra cyclone stages improve thermal efficiency. In some cases, the raw meal is fed directly to a long dry kiln without external pre-heater. A system of chains in the inlet part of the rotary kiln provides the heat exchange between the hot combustion gases from the hot zone of the kiln and the kiln feed. Long dry kilns have high heat consumption and high dust cycles requiring separate de-dusting cyclones as shown in Fig.2.1.

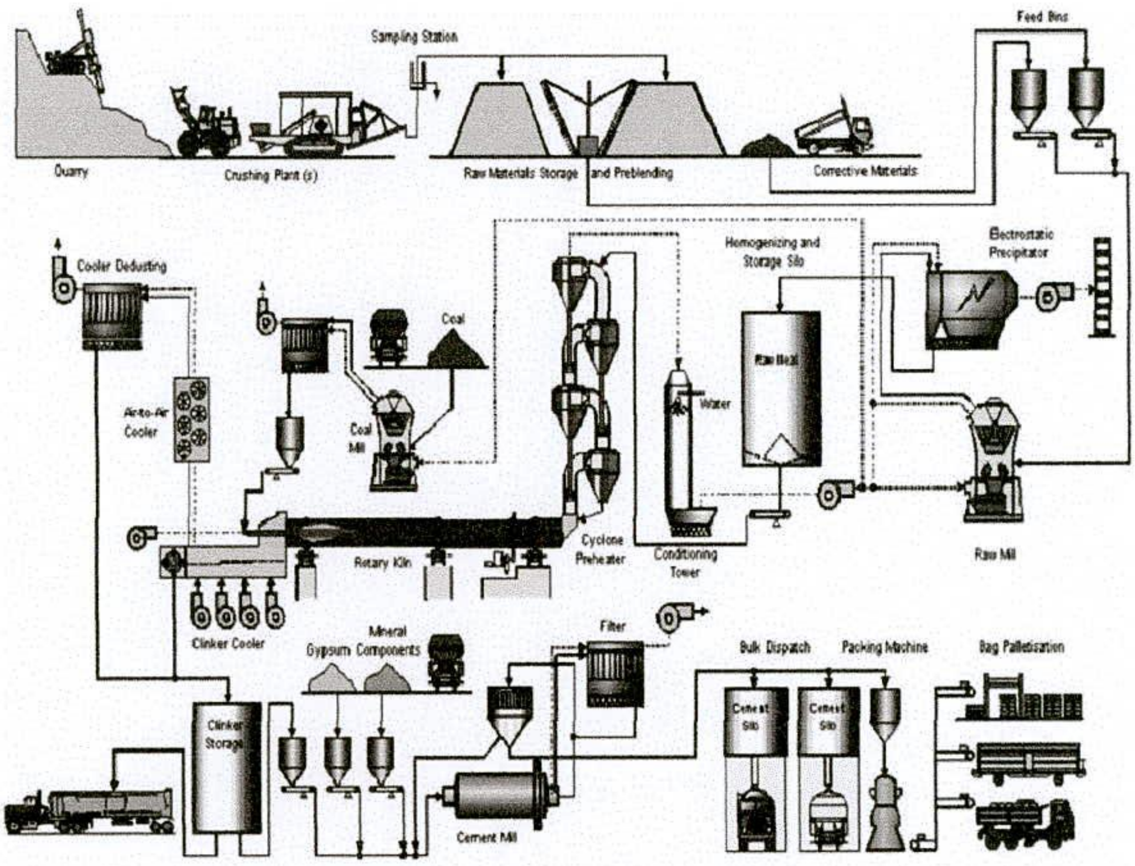


Fig. 2.1 Clinker manufacturing process under dry condition **[14]**

Conventional wet process kilns are the oldest type of rotary kilns to produce clinker. Wet kiln feed (raw slurry) typically contains 28 to 43 % of water which is added to the raw mill (slurry drums, wash mills and/or tube mills). Batch blending and homogenization is achieved in special slurry silos or slurry basins where compressed air is introduced and the slurry is continuously stirred. The slurry is pumped into the rotary kiln where the water has to be evaporated in the drying zone at the kiln inlet. The drying zone is designed with chains and crosses to facilitate the heat exchange between the kiln feed and the combustion gases. After having passed the drying zone, the raw material moves down the kiln to be calcined and burnt to clinker in the sintering zone. Conventional wet kiln technology has high heat consumption and produces large volumes of combustion gases and water vapour. Wet rotary kilns may reach a total length of up to 240 m compared to short dry kilns of 55 to 65 meter length (without the pre-heater section). In modern wet kiln systems, the raw slurry is fed to slurry drier where the water is evaporated prior to the dried raw meal entering a cyclone pre-heater or precalciner kiln. Modern wet kiln systems have a far lower specific heat consumption compared to conventional wet kilns as shown in Fig.2.2.

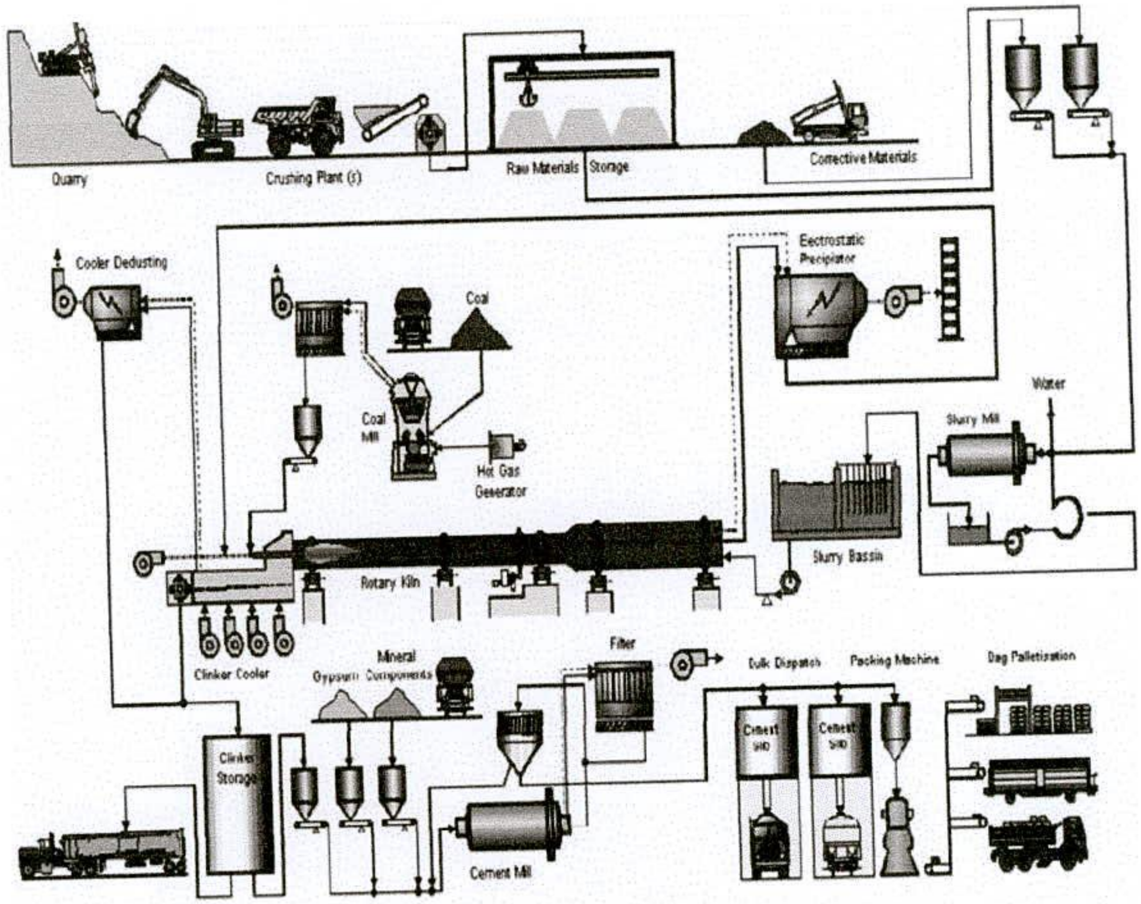


Fig. 2.2 Clinker manufacturing process under wet condition **[14]**

Clinker produced by burning a mixture of materials, mainly limestone ($CaCO_3$), silicon oxides (SiO_2), aluminum, and iron oxides, clinker is made by one of two production processes: wet or dry; these terms refer to the grinding processes although other configurations and mixed forms (semi-wet, semi-dry) exist for both types. In the wet process, the crushed and proportioned materials are ground with water, mixed, and fed into the kiln in the form of slurry. In the dry process, the raw materials are ground, mixed, and fed into the kiln in their dry state. The choice among different processes is dictated by the characteristics and availability of raw materials. For example, a wet process may be necessary for raw materials with high moisture content (greater than 15%) or for certain chalks and alloys that can best be processed as a slurry. However, the dry process is the more modern and energy-efficient configuration. During the burning or pyroprocessing, the water is first evaporated after which the chemical composition is changed, and a partial melt is produced. The solid material and the partial melt combine into small marble-sized pellets called clinker. The preparation of clinker also depends on clinker burning and clinker cooling. Clinker burning is the prepared raw material ("kiln feed") is fed to the kiln system where it is Subjected to a thermal treatment process consisting of the consecutive steps of drying/preheating, calcinations (e.g. release of CO_2 from limestone), and sintering (or "clinkerisation", e.g. formation of clinker minerals at temperatures up to 1450 °C). The burnt product "clinker" is cooled down with air to 100-200 °C and is transported to intermediate storage. The kiln systems commonly applied are rotary kilns with or without so-called "suspension preheaters" (and, in more advanced systems, "precalciners") depending on the main process design selected. The rotary kiln itself is an inclined steel tube with a length to diameter ratio between 10 and 40. Clinker coolers also the clinker leaving the rotary kiln at a temperature around 1200-1250 °C has to be cooled down rapidly to allow further transport and handling. This process also recovers heat from the clinker back to the kiln by preheating the air used for combustion in the main burner and in any secondary firing. In addition, rapid cooling prevents undesired chemical reactions in the clinker which may negatively affect the quality and the grind ability of the clinker [14, 20]. Three main types of clinker coolers are used namely (i) Rotary (tube) coolers (ii) Planetary (satellite) coolers, and (iii) Grate coolers.

2.7 Industrial Ecology

Industrial Ecology (IE) is a concept for improving the efficiency of industrial systems by imitating aspects of natural ecosystems. It provides an objective means for making progress toward sustainable development. IE considers a range of sustainability issues including energy and resource conservation; environmental, health, and safety improvement; climate change management and land use. As the term is defined in this sub study, the cement industry's exploration of IE began nearly 10 years ago. This history contains examples of both successes and failures based on a variety of drivers and barriers to implementation. In parallel with the industry trying to define and implement practices, governments and regulatory bodies have begun to set policies that have either facilitated or inhibited the industry from practicing IE. Experience has shown the need to consider a variety of issues, constraints, outcomes, and even the ability to maintain IE relationships. The following section provides a baseline assessment of the industry's current practices in relation to the proposed definition of IE. Economics and core areas of business drive the industrial ecology elements currently adopted by cement companies. Prior discussions also indicated that the cement industry clearly has the potential to be a significant player in the field of industrial ecology as it applies to sustainable development. To realize this opportunity, however, cement companies need to take a leadership role and strategically position themselves to take advantage of this emerging field. Many activities related to alternative fuels and raw materials exchanges are taking place within the cement industry. However, the industry has many more opportunities that could be realized. In most countries the percentages of substitution of materials and fuels could be doubled or tripled from current levels. A number of barriers and constraints will have to be addressed to improve the state of the practice. There are examples of the industry working collaboratively with other industrial partners, with governments, and with communities to achieve success. True success stories, where financial and strategic benefits were obtained, usually involve four considerations, including: [16].

- Financial benefits to the cement company and the supplying or receiving organization,
- Governmental support through regulatory, policy and technical guidance,
- Waste management system issues that create opportunities for business and society benefits,
- The community outreach and communication to build mutual understanding and trust.

Today's IE practices only rarely consider true sustainable practices. Currently, the cement Industry does not consider the full set of trade-offs and net benefits of IE decisions. In short, Considerations need to weigh various trade-offs that benefit both the industry and society. This Study has identified the following additional considerations when making IE decisions:

- Long-term efficiency and viability of operations.
- Impact on public image and also impact on the waste management infrastructure.
- Proprietary information sharing with partners.

Ultimately, the objective should be to move toward a sustainable industrial ecosystem. Characteristics specified in this research for such systems include:

- True partnerships with active collaboration among multiple industries with sustainability goals.
- All participants benefit with considerations for both partners and society at large.
- Waste management hierarchy principles apply with exceptions determined through application of systems analysis tools.
- Zero waste goals.

2.8 Pollution consideration

The cement industry caused four serious pollution incidents in 2004. None of these were major incidents. This is an increase on the previous three years when it caused no serious incidents. We made no prosecutions between 2000 and 2004 but we did take some enforcement action requiring improvements to be made in this period. We issued four enforcement notices and one caution, mostly associated with emissions to air. Environmental nuisances including noise, vibration, odour and visual impacts are generally not extreme enough to impact directly on the environment or human health. They are, though, important in the context of quality of life. Both cement and concrete production generate considerable quantities of air-pollutant emissions. Dust is usually the most visible of these pollutants. Another environmental issue with cement and concrete production is water pollution. The concern is the greatest at the concrete production phase. Water use varies greatly at different plants, while the cement and concrete industries can help reduce some of our solid waste problems (burning hazardous waste as cement kiln fuel and using fly ash in concrete mixtures, for example), one cannot overlook the fact that concrete is the largest and most visible component of construction and demolition waste [17].

2.9 Transportation consideration

Transport is an important part of the overall manufacturing process of cement industry, delivering raw materials to sites and distributing final products. It needs to be minimized to reduce congestion, fossil fuel use, and emissions to air, noise, vibration and accidents. Transport of raw materials and fuel to the cement plant, and cement to customers is largely by road. Most companies are taking steps either to reduce road transport by increasing the use of pipelines and rail, or to increase efficiency. Some cement industry use pipelines to deliver slurry feed from chalk quarries to the works. Most other works are connected to bulk raw materials by rail. The transport System', which allows road-going tankers and wagons to be carried by rail. For raw meal transport to storage silos pneumatic and mechanical systems are used. Mechanical conveyors normally have a higher investment cost but a much lower operating cost than pneumatic conveying. A combination of air-slide or screw or chain conveyors with a belt bucket elevator is nowadays the most commonly used conveying system [12].

2.10 Energy consumption in cement industry

Energy efficiency is an important concern for cement industry, because of high temperature requirements in the cement production process, limestone is calcined between 600^0C and 900^0C, and clinker production requires 1450^0C. Energy consumption is the biggest environmental concern with cement and cement gradient production. Cement production is one of the most energy intensive of all industrial manufacturing processes. The industry's heavy reliance on coal leads to especially high emission levels of CO_2, nitrous oxide, and sulphur, among other pollutants. A sizeable portion of the electricity used is also generated from coal. The vast majority of the energy consumed in cement production is used for operating the rotary cement kilns. Newer dry-process kilns are more energy efficient than older wet-process kilns, because energy is not required for driving off moisture. In a modern dry-process kiln, a pre-heater is often used to heat the ingredients using waste heat from the exhaust gases of the kiln burners. A dry-process kiln so adapted can use up to 50% less energy than a wet-process kiln, according to UBC researchers. Some other dry-process kilns use a separate combustion vessel in which the calcining process begins before the ingredients move into the rotary kiln--a technique that can have even higher overall efficiency than a kiln with pre-heater. Energy use for concrete production looks considerably better than it does for cement. That's because the other components of concrete--sand, crushed stone, and water--are much less energy intensive. While cement manufacturing is extremely energy intensive, the very high temperatures used in a cement kiln have at least one advantage: the potential for burning hazardous waste as a fuel. Waste fuels that can be used in cement kilns include used motor oil, spent solvents, printing inks, paint residues, cleaning fluids, and scrap tires. These can be burned relatively safely because the extremely high temperatures result in very complete combustion with very low pollution emissions. (Municipal solid waste incinerators operate at considerably lower temperatures.) Indeed, for some chemicals thermal destruction in a cement kiln is the safest method of disposal. A single cement kiln can burn more than a million tires a year, according to the Portland Cement Association. Pound for pound, these tires have higher fuel content than coal, and iron from the steel belts can be used as an ingredient in the cement manufacturing. Waste fuels comprise a significant (and growing) part of the energy mix for cement plants [**18**].

2.11 Cement constituents or other materials

Portland cement is produced by intergrinding clinker with a few percent of natural or industrial gypsum or anhydrite (calcium sulphate) acting as a set regulator. In the addition of up to 5 % of "minor constituents" such as raw meal, limestone or filter dust is allowed. In blended (or "composite") cements, part of the cement consists of mineral additions originating from natural or industrial sources. These mineral additions may have hydraulic (granulated blast furnace slag), pozzolanic (volcanic rocks, coal fly ash, micro silica, calcined clay) or filler properties (limestone). The composition of blended cements is specified in the national cement standards. The standards usually also includes quality specifications for the individual mineral additions used [**12**].

CAPTER 3

STEPS FOR DESIGNING A CEMENT INDUSTRY

3.1 Introduction

Cement industries typically produce Portland cement, although they also produce masonry cement (which is also manufactured at Portland cement plants). There are two types of Portland cement, Ordinary Portland Cement (OPC) - mainly clinker and gypsum are used and Prosononic Portland Cement (PPC) -clinker, gypsum and also fly ash are used for producing cement. Portland cement is important for making concrete and is an extremely versatile material, being used in the production of anything from nuclear radiation shields to playground structures and from bridges to yachts. It is able to be used in such a wide variety of applications because it can be poured into any shape, reinforced with steel or glass fibres, precast, colored, has a variety of finishes and can even set under water. Modern concrete is made by mixing aggregate (sand, stones and shingle) with Portland cement and water and allowing it to set. Of these ingredients, the most important is Portland cement. Cement is a fine grey powder which when reacted with water hardens to form a rigid chemical mineral structure which gives concrete its high strengths. Cement is in effect the glue that holds concrete together. Portland cement is a fine, typically gray powder comprised of dicalcium silicate, tricalcium silicate, tricalcium aluminate and tetracalcium aluminoferrite with the addition of forms of calcium sulfate. Different types of Portland cement are created based on the use and chemical and physical properties desired. Portland cement plants can operate continuously for long time periods with minimal shut down time for maintenance. The air pollution problems related to the production, handling and transportation of Portland cement are caused by the very fine particles of the product.

3.2 Machinery or equipment in cement industry

1. Jetty.
2. Hopper.
3. Conveyor (belt, bucket etc).
4. Silo (For clinker and cement).
5. Mill house (Ball Mill and vertical Roller Mill).
6. Control Room.
7. Workshop (Mechanical, Electrical).
8. Power Generation (Substation).
9. Weight meter.
10. Packing House, etc.

3.3 Site selection

To establish a new cement industry is a major, long-term investment. So site selection is a critical decision made by private and public owners that affects a wide range of activities ranging from land use planning to sitting of industrial facilities. Determination of facility location is critical for the success and failure of such investments. The selection of an industrial site involves a complex array of critical factors involving economic, social, transportation, technical, and environmental issues etc. Site selection is the process of finding locations that meet desired conditions set by the selection criteria. In such a process, manipulation of special data and satisfaction of multiple criteria are essential to the success of decision-making. Because of the complexity of the problems a number of tools must be deployed to arrive at the proper solution. A proposed approach is presented in which Expert systems, Geographic information systems and Multi-criteria decision making techniques are integrated systematically in solving industrial site selection problems. Site selection of a capital project is a critical decision made by owners or investors that significantly affects their profit and loss. Decisions regarding the locations of industrial facilities influence where people work live and determine the lifestyle of a community. Therefore for industry site location analysis is big business, whether measured in terms of amounts invested, decision-makers involved, employees affected or the economies of the area influenced. The goal in a site selection exercise is to find the best location with desired conditions that satisfy predetermined selection criteria. The selection process attempts to optimize a number of objectives in determining the suitability of a particular site for a defined facility. Such optimization often involves a multitude of factors, sometime contradicting. Some of the important factors that add to the difficulty of the proper site selection include the existence of numerous possible sites within a critical region, multiple objectives, intangible objectives, diversity of interest groups, lack of quantitative measures of the factors' impact, uncertainties regarding impact timing and magnitude, uncertainties regarding government influence on the selection process, uncertainties regarding possible delays of permitting and construction. A number of tools were used to determine the proper site for capital improvement facilities. These tools include Expert systems, Geographic information systems and Multi-criteria decision-making techniques. These tools have played an important role in solving site selection problems. However, each tool has its own limitations in addressing special data, which is necessary for special decision problems such as site selection. Sometimes site selection process has become increasingly complex because of environmental laws and regulations as well as the greater public awareness and involvement in the zoning and environmental issues. Site selection is one of the most important parts to design plant layout for a new cement industry because every position of the industry layout design is related to site selection which is including initial assumption of industry, transportation, climate feature, economic and cultural feature, season, energy consumption, emission, area projection, using industrial raw material, finished product supply, taxes, environmental issues and cost efficiency etc.

3.4 Stages of cement production

The stages of cement production at a Portland cement plant are illustrate as here under

1. Raw material preparation.
2. Fuel preparation.
3. Quarrying.
4. Cement grinding.
5. Finish Milling.
6. Packing and loading house.
7. Cement dispatch.

Raw material preparation

Raw materials preparation involves primary and secondary crushing of the quarried material, drying the material (for use in the dry process) or undertaking a further raw grinding through either wet or dry processes, and blending the materials. Most of the raw materials used are extracted from the earth through mining and quarrying and can be divided into the following groups: lime (calcareous), silica (siliceous), alumina (argillaceous), and iron (ferriferous), fly ash, slack etc. Since a form of calcium carbonate, usually limestone, is the predominant raw material, most plants are situated near a limestone quarry or receive this material from a source via inexpensive transportation. The plant must minimize the transportation cost since one third of the limestone is converted to CO_2 during the pyroprocessing and is subsequently lost. Quarry operations consist of drilling, blasting, excavating, handling, loading, hauling, crushing, screening, stockpiling, and storing. Limestone presents the major raw material input to cement production. High quality Limestone is accessible almost all over the country. For the production of OPC, clay and Gypsum serve as additives while the production of PPC requires additives that can be taken from industrial wastage such as fly ash and blast furnace slag respectively. Fly ash can be recovered as a waste product from electricity generation while slag residues from blast furnace of steel plants. After intermediate storage and pre-homogenisation, the raw materials are dried and ground together in defined and well-controlled proportions in a raw mill to produce a raw meal for the dry (and semi-dry) process. In the wet (and semi-wet) process, the raw materials are slurried and ground with addition of sufficient water to produce raw slurry. The resulting intermediate product i.e. raw meal or raw slurry (or their derivatives) is stored and further homogenised in raw meal silos, storage bins or slurry basins to achieve and maintain the required uniform chemical composition before entering the kiln system. As a rule of thumb, approximately 1.5 – 1.6 tons of (dry) raw materials are required to produce one ton of the burnt product clinker. Preparation of the raw material is of great importance to the subsequent kiln system both in getting the chemistry of the raw feed correct and also in ensuring that it is sufficiently fine. Therefore the following paragraphs cover the proportioning of the raw materials and methods of separating the ground product from the oversize particles as well as the grinding methods used **[20]**.

Fuel preparation

The physical nature of the fuels used in a cement plant solid, liquid or gaseous determines the design of the storage, preparation and firing systems both for conventional fossil fuels and for alternative fuels from industrial sources. The main fuel input has to be delivered in a form that allows uniform and reliable metering as well as easy and complete combustion. This is usually the case with all pulverized, liquid and gaseous fuels. A limited input may also be delivered by the addition of coarse materials at specific feed points. Fuels preparation is crushing, drying, grinding, and homogenizing usually takes place on site. Specific installations are required such as coal mills, silos and storage halls for solid fuels, tanks for liquid fuels, and the corresponding transport and feeding systems to the kilns. The thermal fuel consumption is largely dependent on the basic process design applied in the burning of clinker. Coal and petcoke are ground to fineness similar to raw meal in coal mills (tube mills, vertical roller mills or impact mills). For safety reasons, the whole coal preparation system is designed for protection from fire or explosion. The pulverized fuel may be fed directly to the burner (without intermediate storage and metering system) or which is common practice today may be stored in fine coal silos with adequate metering and feeding systems. Fuel oil is stored in large tanks on site. Handling is facilitated by heating up the oil to a temperature of about 80° C. Metering and combustion are facilitated by additional heating of the oil up to a temperature of 120-140° C, resulting in a reduction of the viscosity. Natural gas is delivered by national or international distribution systems without onsite storage. Prior to combustion in the kiln, the pressure of the gas has to be reduced to the plant's network pressure in gas transfer stations where also the fuel metering takes place. Alternative fuels originating from industrial sources may require specific treatment. Gaseous, liquid and pulverized or fine crushed solid fuels can be fed to the kiln system similarly to the fossil fuels mentioned above. Coarsely shredded or even bulky materials can be fed to the preheater section or, rarely, to the midkiln section only. For process reasons, the contribution of bulky fuels to the total heat consumption should be limited to about 15 to 30% depending on the kiln system. Alternative fuels are frequently prepared and blended outside the cement plant by specialized companies in facilities specifically designed for this purpose. The cement plant has to provide the storage and feeding systems only on site. Alternative fuel plants are often designed as "multi-purpose plants" in order to handle a variety of different wastage [**14, 21**].

Quarrying

Natural ("primary") raw materials such as limestone or chalk, marl, and clay oshale are extracted from quarries which, in most cases, are located close to the cement plant. Corrective materials such as bauxite, iron ore or sand may be required to adapt the chemical composition of the raw mix to the requirements of the process and product specifications. The quantities of these corrective materials are usually low compared to the huge mass flow of the main raw materials. To a limited extent, "secondary" (or "alternative") raw materials originating from industrial sources are used to substitute for natural raw materials and correctives. In the same way as traditional raw materials, they may be fed to the quarry crusher or more commonly directly to the cement plant's raw material preparation system [**12**].

Cement grinding

Portland cement is produced by intergrading cement clinker with a few percent of Natural or industrial gypsum (or anhydrite) in a cement mill. Blended cements (or "composite" cements) contain other constituents in addition such as granulated blast-furnace slag, natural or industrial pozzolana (for example, volcanic tuffs or fly ash from thermal power plants), or inert fillers such as limestone. Mineral additions in blended cements may either be underground with clinker or ground separately or mixed with Portland cement. Grinding plants may be located remotely from the clinker production facility. The different cement types have to be stored separately in cement silos prior to bagging and dispatch [**21**].

The selection of the grinding system should be specific to particular situations, to achieve optimum system performance. The factors that influence the grinding system performance are: i) Material characteristics ii) Moisture in feed materials iii) Energy costs iv) Maintenance v) Investment

Grinding is a highly energy intensive process in the cement industry. Approximately 60 – 70 % of the total electrical energy used in a cement plant is utilized for the grinding of raw materials, coal and clinker. Various technological improvements from the conventional ball mills in this area include: [**21, 22**]. i) High efficiency separators (HES) ii) Improved ball mill internals iii) Vertical roller mills (VRM) iv) High pressure grinding rolls (HPGR) v) Horizontal or Ring Roller Mill

Finish milling

During the final stage of Portland cement production known as finish milling, the clinker is ground with other materials (which impart special characteristics to the finished product) into a fine powder. Up to 5% gypsum and natural anhydrite is added to regulate the setting time of the cement. Other chemicals, such as those which regulate flow ability or air entrainment, may also be added. Cooled clinker is ground in tube or roller mills and blended by simultaneous grinding and mixing with additives (e.g., gypsum, anhydrite, pozzolana, fly-ash or blast furnace slugs) to produce the cement. Drying of the additives may be needed at this stage. Many plants use a roll crusher to achieve a preliminary size reduction of the clinker and gypsum. These materials are then sent through ball or tube mills (rotating, horizontal steel cylinders containing steel alloy balls) which perform the remaining grinding. The grinding process occurs in a closed system with an air separator that divides the cement particles according to size. Material that has not been completely ground is sent through the system again.

Packaging and loading

Once the production of Portland cement is complete, the finished product is transferred using bucket elevators and conveyors to large, storage silos in the shipping department. Most of the Portland cement is transported in bulk by railway, truck, or barge, or in 50 kg (In Bangladesh most of the industry) multiwall paper bags. There would be substantial difference old plant and new plant. Bags are used primarily to package masonry cement. Once the cement leaves the plant, distribution terminals are sometimes used as an intermediary holding location prior to customer distribution. The same types of conveyor systems used at the plant are used to load cement at distribution terminals.

Cement dispatch

Cement may be shipped as bulk cement or usually to a lesser extent packed into bags and palletized for dispatch. Transport methods used (i.e. road, railway, waterways) depend on local conditions and requirements.

3.5 Cement production process

There are two type of cement production in Bangladesh, ball mill house and vertical roller mills. For several decades the cement industry has successfully utilized Vertical Roller Mills (VRM) and ball mill house for grinding of raw materials and solid fuels. Most recently, this technology has been employed for the combination of Portland cement, blended cements and slag cements.

Ball Mill House

Ball mills have been conventionally an integral part of most cement plants for grinding raw materials, coal and clinker as shown in fig.3.1. The major technological advancements in conventional ball mills have been the improvement in phase, liners and grinding media. In this case use small diameter iron ball which is use grinding the clinker. The raw material pass into the mill house then mixing of raw material and ball are rotate, and fine Portland cement are produce from the ball mill house. The application and classifying liners and high volume grinding media have contributed to an increased rate of production and reduced specific power consumption in the grinding operation and wear rates. Traditionally, the closed circuit ball mill with high efficiency separator has been the most common system for cement grinding.

Fig 3.1 Ball Mill House

Vertical Roller Mill (VRM)

The vertical roller mill (VRM) is now successfully being used for many clinker grinding applications and is rapidly becoming the standard for new grinding installations. This is shown in fig.3.2. The first such vertical roller mill installation in the United States was part of a total plant expansion and began operation in August of 2002. The differences between raw and cement grinding have been well documented in numerous publications and presentations over the recent past. Specifically, as compared to limestone, clinker and cement raw materials are finer and harder to grind. This, coupled with the finer and more stringent product particle size distribution requirements, entails design considerations to allow for continuous and stable operation of the grinding system. The dual-lobed design is optimal for clinker grinding because it supplies two distinct grinding zones, a low pressure zone and a high pressure zone, at each roller. The low pressure area under the inner lobe de-aerates and consolidates the material to be ground. This ensures a compact well established grinding bed for maximum stability. The proper grinding then takes place in the high pressure zone under the outer lobe. The groove in the middle of the roller facilitates de-aeration of the material without fluidizing it.

Fig 3.2 Vertical Roller Mill

Quality control measure of VRM

In a cement vertical roller mill grinding is performed in closed circuit and with an integral high efficiency separator. Experience has shown that the overall product particle size distribution is consistent with that obtained from a ball mill grinding plant with a modern high efficiency separator. During the initial VRM optimization period the mill is fine-tuned to match its product to the existing ball mills. This is achieved by making adjustments to operational parameters such as:

- Separator rotor speed
- Air flow rate
- Grinding pressure
- Dam ring height

Because the VRM has significantly higher grinding efficiency than a ball mill there is much less heat input from the grinding process. This is evident in the almost 50% less installed power, but is further taken into account with a smaller percentage of the energy being absorbed by the material. Compared to ball mills where 75% of installed power may be absorbed a good VRM will take only 50% of the installed motor power as heat. The end result is that the product will not be heated up as much as in a ball mill. This means that a lower degree of gypsum dehydration could occur.

A lesser degree of gypsum dehydration is not problematic considering two conditions; the inability to adequately control temperatures in ball mills creates an environment where operation is at the extreme of the gypsum dehydration. Additionally, less dehydration is not an issue if the gypsum is sufficiently reactive to control the setting reactions with a lower degree of dehydration as is normally the case. If in special cases this is not the case different options are available to cope with the problem:

- Addition of more gypsum (within the SO3 limit)
- Increased dehydration of gypsum by adding more heat to the mill system
- Addition of a more reactive form of gypsum

Pre-hydration is not typically problematic in a VRM as it is in ball mill systems where higher temperatures and internal water-cooling systems are common. However, if cement is produced at a relatively high temperature and still has a lot of gypsum that is not dehydrated one must be aware of the potential problem of gypsum dehydration coupled with clinker pre-hydration that can take place during storage in the cement silos. If a problem of this kind is present it can be coped with it by one (or more) of the following options:

- Ensuring that the cement is cooled to a lower temperature before going into the silo
- Provoking a higher gypsum dehydration level in the mill
- Replacing part of the gypsum with natural anhydrite

3.6 Process analysis of two mill house

To compare the similarities or differences between cement mill products of the same composition but produced in a vertical roller mill or ball mills, samples from each of the plant's mill types were taken and tested. All samples were obtained while the mills were producing the same product.

- Mill offers a significant amount of power savings compared to conventional ball mill systems.
- Space saving design reduces civil costs which is most important for plant layout.
- Simple layout and operation with fewer machines in the circuit ensures a high run.
- Excellent drying capability well-suits the mill for grinding blast furnace slag and creating blended cement.
- Low vibrations are made possible by specially designed roller profile, ensuring operating reliability.
- The manufacturing Portland cement of vertical roller mills is so reliable for consumer.
- The initial installation cost is higher than ball mill machine.
- The adjustable Blaine and particle size distribution for required cement quality.
- Machining dust is negligible in vertical roller mill (VRM) so environment pollution is reduces.

3.7 Wastage analysis

Wastage is the one of the most important of a cement industry. The overflow from slurry concentrating equipment constitutes the main water pollution problem. For new plants that process slurry, closed-cycle water systems are used to return the overflow water to the process. Another source of waste is the stripped overburden. The combustion processes of cement kilns and rotary kilns have been used to dispose of hazardous waste material. For the cement kiln, waste material is burned with a primary fuel. For a wet process kiln, the raw materials are introduced into the top of the kiln and exit at the bottom as cement clinker. The burner is located at the lower end of the kiln where the fuel and waste are ignited. The hot gases move up the kiln and heat the raw materials, exit the kiln, and are then cleaned in a bag house prior to exiting through a stack. When waste is fired, any ash generated becomes a part of the cement product. While the cement and concrete industries can help reduce some of our solid waste problems (burning hazardous waste as cement kiln fuel and using fly ash in concrete mixtures, for example), one cannot overlook the fact that concrete is the largest and most visible component of construction and demolition wastage. In cement industry, there is a good potential for recovery of waste heat. It is possible to generate steam from this waste heat, which could be used in some other process like desalination of sea water for cement plant in coastal areas. Drying of materials such as slag, pozzolana, etc. is another possible application, which is already in practice in many cement plants. Normally, hot excess air from clinker cooler is used for this purpose. It is possible to generate electrical power from the waste heat. Normally, steam produced in waste heat boiler incorporated to recover heat from pre-heater gases cooler exhaust gases is used in a steam turbine to generate electrical energy. Actually Portland cement factory there is no manufacturing waste in this all the material is reused into their machining process [**18, 27**].

3.8 Cost analysis

Cost analysis is the main and one of the most important factors to plant layout design for any type of mass production cement industry because all of the owners or investors target their goals maximum profit according to their investment also consideration quantity and qualitative product. For years, the mass production industries have focused on some primary concerns in the creation of their buildings, instruments, labor, final production, area projection etc. The first, of most importance to architects, is the design of a building which is needed for the production or it's that the enjoyable to view and occupy. The client expects an architect to be able to design a building that satisfies their aesthetic and functional goals. Next concern, how much will be the total installation cost which satisfies the planning for the future demand. And next concern receiving more attention from plant owners is to investigate the economics of facility management which is the cost of production operations over the life of a building. The combination of economic theory and technological view allows for a more sophisticated approach to the design of a industry and facility than ever before. Instead of merely looking at the facility in terms of cost to design a plant and their perspective to include operations, maintenance, repair, replacement, and disposal costs. Sometimes some alternative industries by the same cost categories, over the same study period, using the same discount rate, replacement costs, and demolition costs are evaluated. The objective of modern cement factory is to produce high quality products with low cost. Through out, utilization and cycle time continue to be emphasized as key performance parameters for the planning of new assembly systems and they do have an effect on the cost efficiency of the system. Selection of the most appropriate design of industry can offer enormous benefits in terms of product quality, cost reduction and manufacturing productivity. However, selecting the right system for a product depends on a large number of factors and is not a simple problem. Sometimes some industries give main important to get high profit which destroys the life cycle of industry which is must be considered.

CHAPTER 4

DISCUSSION

4.1 Introduction

In this chapter the plant layout design has been developed at the various sections. Plant layout refers to the arrangement of physical facilities such as machinery, buildings, equipments, work places and other facilities of production in order to process the product in the most efficient manner. It is important for any type of cement industry where mass production system is utilized. Proper layout design of cement industry has met new market demands where existing plant has been modified and created new plant. Researcher continuously tries to improve the engineering design which is developed together with process planning and it includes the synthesis, analysis and assessment of the product against specifications. The layout performance has been found to tend to deteriorate significantly with fluctuation in design parameters such as product volumes, mix, routings or product life-cycles. Plant layout is applicable for cement industry or plant. This plant requires special arrangements which, when incorporated makes the layout look distinct from the types already discussed above. The installation of cement industry depends upon on the various machineries and equipments such as jetty, conveyor belt, clinker silo, cement silo, machining house, control room, workshop, and package house and cement dispatch etc which is related to the plant layout. The best site selection and reliable transportation system is considerable part of an optimum plant layout design of mass production system. Industrial safety is a considerable part for the cement industry, where an optimum plan must be maintained. A plant layout is applied besides the grouping of machinery, to an arrangement for other facilities as well. Such facilities include receiving and dispatching points, inspection facilities, employee facilities, storage etc. So all the plant layouts of cement industry propose their better design where the production rate is maximum to minimize the initial investment, manufacturing and operational cost.

4.2 Concept of cement industry layout

Plant layout is the most important for any cement industry because of their proper utilization of various machinery and equipments such as jetty, hopper, conveyor belt, silo, control room, workshop, and packing house etc. This imposes the requirement for the manufacturing facility to be designed for optimal economy, which infers the need for careful planning of cement industry. Sometimes plant layout of the cement industry faces some problems which are most important for manufacturing costs, dependent on whether the facility is planned on a product or process basis or the other types. If the cement industry layout is proper then huge amount of savings and the industry faces some loss in case of improper layout. Plant layout of cement industry is a long-term, costly proposition, and any modifications or rearrangement of an existing plant represents a large expense both in terms of relocation and lost processing time and can often not be accomplished easily. Cost reduction is provided better process control, elimination of waste and plant consolidations. A plant design should accomplish this goal in terms of material handling, personnel, and equipment utilization, reduced inventories, and increased quality. Today, existing layout configurations will not meet the expectations and needs of the multi-product organizations of cement industry. It is a necessary that there is a need for a new generation of factory layouts that are more flexible, modular and more easily reconfigurable. Flexibility, modularity and re configurability could save factories the need to redesign their layouts each time their production requirements change. Re layout of cement industry can be highly expensive and disruptive, especially when the entire factory has to be shut down and production stopped. Market analysis and customer survey is the important factor layout design of cement industry. At the installation of cement industry its must be consider the market analysis and customer survey which is also depends the existing layout design.

4.3 Existing plant layout of cement industries

4.3.1 Meghna Cement Mill Ltd.

This is the large production rate cement industry of Bangladesh. It is one type of ball mill cement industry. The plant layout of this industry includes various machineries and equipments such as cement grinding mill house, conveyor belt joint, some factory roads, mechanical and electrical workshop, package house, inspection facilities, employee facilities, various raw materials storage positions etc but there is no bag plant here. In this cement industry there is no finished product storage house. There are three mill houses; every mill house has two units and two package houses in the industry. The main product of this industry is Portland cement. Clinkers are the main materials for manufacturing Portland cement. Also some additives such as gypsum, slack, limestone and fly ash etc are used. Almost (65~75) % clinkers and rest (25~35) % additives are used in this industry for manufacturing Portland cement. This cement industry is situated near the river and it is connected to highway road. So the site selection is proper and transportation system is also reliable. The production rate of this cement industry is (3800~4200) tons/day and the production time is continuous, i,e., (20~22) hours per day. The power consumption is 9 MW (connecting load) and the operating load is (6.5~7.5) MW. The used area is 9.83 acres. The brand of this industry is King Brand Cement. It is almost standard type of cement industry. This cement industry is an example of the proper application of optimum plant layout design of mass production system. Fig.4.1 shows the existing plant layout of Meghna Cement Mill Ltd.

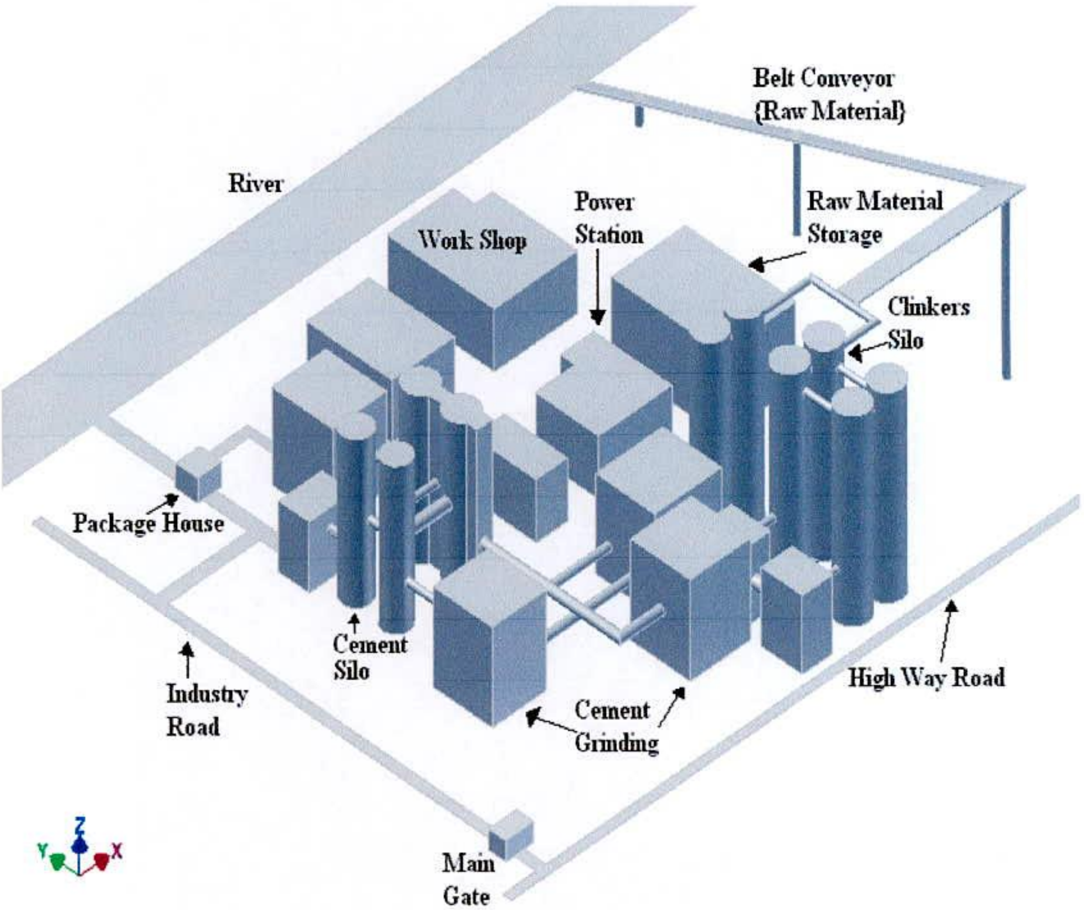


Fig.4.1 Meghna Cement Mill Ltd.

<u>Some limitations of this cement industry</u>

- There exists more number of silos than the requirements for production in satisfactory rate.
- Material handling conveyor is comparatively large and far distance between two sections. So energy losses are comparatively high.
- There is no finished product storage system.
- There is no bag plant.
- Energy consumption is comparatively high.

4.3.2 Mongla Cement Factory

It is one type of ball mill cement industry. The plant layout of this industry includes various machineries and equipments such as cement grinding mill house, conveyor belt joint, some factory road, mechanical and electrical workshop, package house, inspection facilities, employee facilities, various raw material and final product storage etc but there is no bag plant here. In this cement industry there is a finished product storage house which is used when market demand is comparatively low and to avoid any type of risk such as sometimes the unloading of packaging is not maintained in sequence. The main product of this industry is Portland cement. Clinkers are the main materials for manufacturing Portland cement. Also some additives such as gypsum, slack, limestone and fly ash etc are used. Almost (65~75) % clinkers and rest (25~35) % additives are used in this industry for manufacturing Portland cement. There are some unusable machineries and equipments which block the usable area and increase space requisition comparatively. This cement industry is situated near the river and it is connected to highway road. So the site selection is proper and transportation system is also reliable. The production rate of this cement industry is (2000~2300) tons/day and the production time is continuous, i,e (18~20) hours per day. The power consumption is 6.3 MW (connecting load) and the average operating load is 4.5 MW. The used area is 9.55 acres. The brand of this cement is Elephant Brand Cement and owner of this industry is Bangladesh Shena Kolyan Shongstha. This cement industry is a proper application of the optimum plant layout design of mass production system. This cement industry is the example of the proper application of optimum plant layout design of mass production system. Fig.4.2 shows the existing plant layout of Mongla Cement factory.

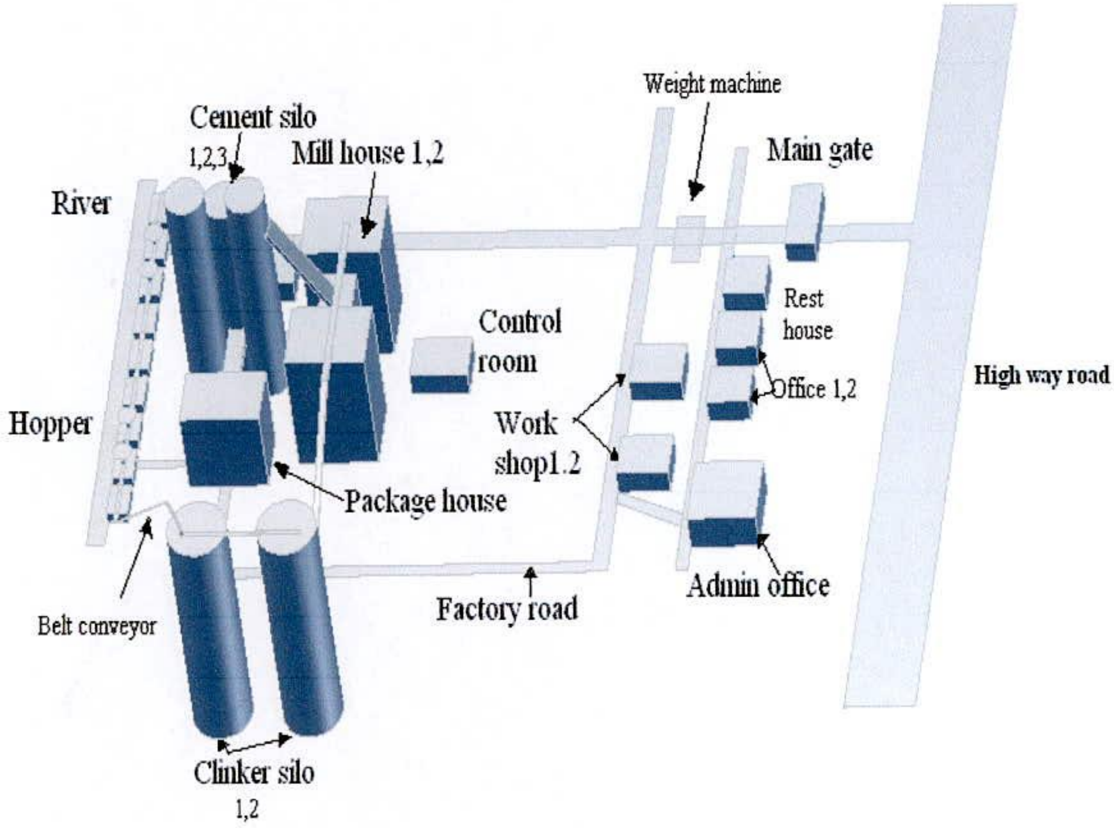


Fig 4.2 Mongla Cement Factory

Some limitations of this cement industry

- Space utilization is not proper.
- Distance between clinker silos and machining section is long So material handling is not continuously smooth resulting bad affects on production system.
- The distance between highway road and industry area is too long.
- Production rate is comparatively low.
- The operation is not smooth

4.3.3 Five Rings Cement

This is the small production rate cement industry. It is the one type of ball mill cement industry. The plant layout of this industry includes various machineries and equipments such as cement grinding mill house, conveyor belt joint, some factory roads, mechanical and electrical workshop, package house, various raw material storage systems etc. There is no finished product storage system. There are some unusable machineries and equipments which block the usable area and increase space requisition comparatively. This cement industry is situated near the river and it is connected to highway road. So the site selection is proper and transportation system also reliable. The main product of this industry is Portland cement. Clinkers are the main materials for manufacturing of Portland cement. Also use some additives such as gypsum, slack, limestone and fly ash etc. Almost (65~75) % clinkers and rest (25~35) % additives are used in this industry for manufacturing Portland cement. The production rate of this cement industry is (1300~1500) tons/day and the production time is continuous, i,e., (18~20) hours per day. Sometimes production rate may be changed which also depends on their market demand, supply and customer opinion. The power consumption varies as (3.0~3.2) MW. The used area is 7.0 acres. For designing optimum plant layout of the cement industry some information is essential from this industry. Fig.4.3 shows the existing plant layout of Five Rings Cement.

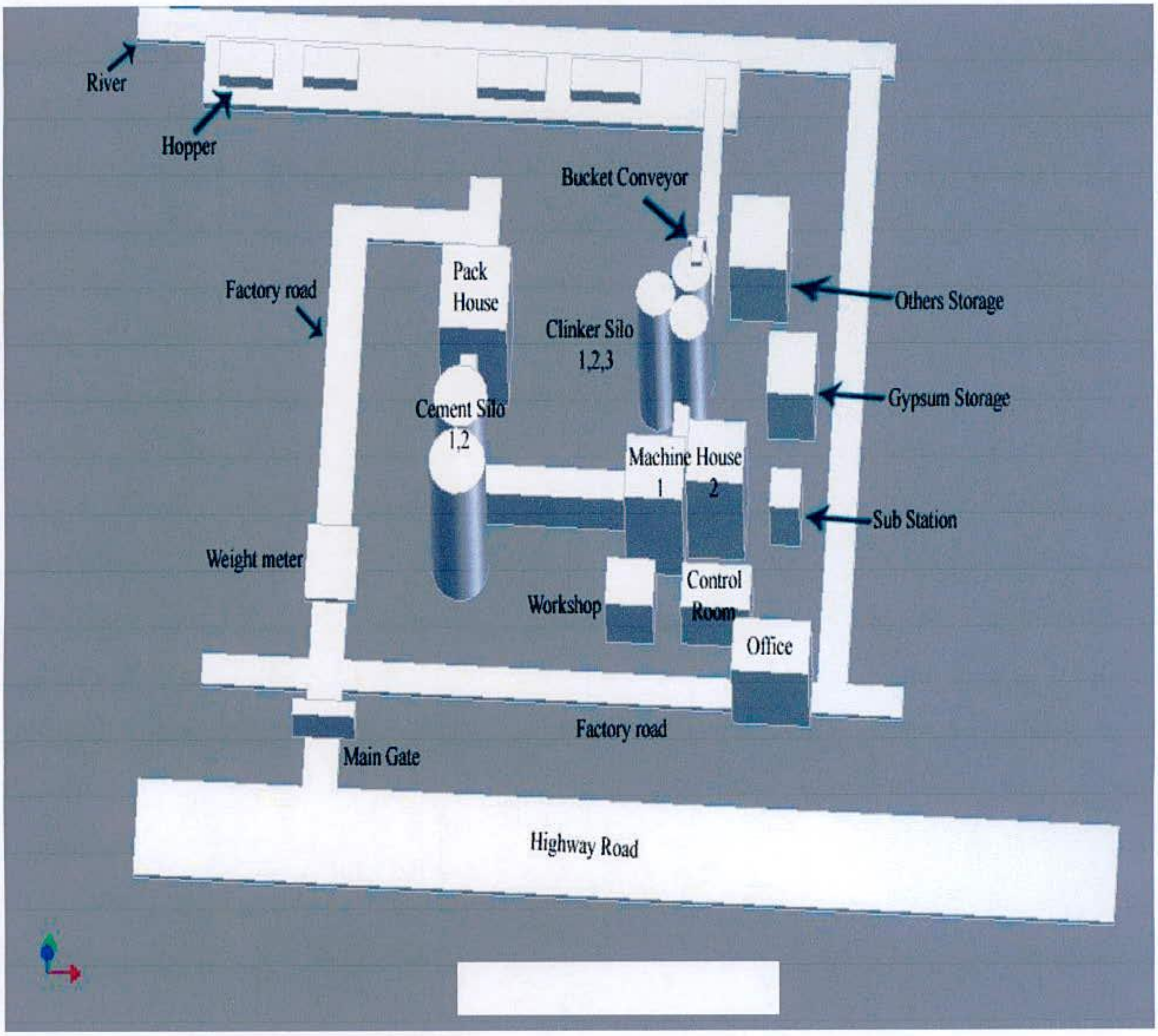


Fig 4.3 Five Rings Cement

Some limitations of this cement industry

- Raw material storage systems are not properly is their machining operation.
- There is no finished product storage system.
- The factory roads are not connected in the all positions of the industry.
- Low production rate.
- Belt conveyor and bucket elevator both are used for clinkers conveyance between jetty to clinker silos which is the slow machining process.
- The uses of area planning are very poor in the industry.

4.3.4 CEMEX Cement Ltd.

It is one type of ball mill cement industry. This is medium type of Portland cement production industry. The plant layout of this industry includes various machineries and equipments such as cement grinding mill house, conveyor belt joint, some factory roads, mechanical and electrical workshop, package house, inspection facilities, employee facilities, various raw material and final product storage etc but there is no bag plant here. In this cement industry there is no finished product storage house. There are no clinker silos in the industry. The dome shade is used here for clinkers and other raw materials storage and one cement silo is used for fine cement storage. The main product of this industry is Portland cement. Clinkers are the main materials for manufacturing Portland cement. Also some additives such as gypsum, slack, limestone and fly ash etc are used. Almost (65~75) % clinkers and rest (25~35) % additives are used in this industry. This cement industry is situated near the river and it is connected to main road. So site selection and transportation system of this industry is also reliable. The production rate of this cement industry is (1800~2400) tons/day and the production time is continuous i,e (20~22) hours per day. The production rate of this industry is changed with the respect to their market demand, supply and quality of the cement. The power consumption varies as (3.5~4.00) MW. The used area is 10.0 acres. For designing optimum plant layout of the cement industry also some information is needed from this industry. Fig.4.4 shows the existing plant layout of CEMEX Cement industry Ltd.

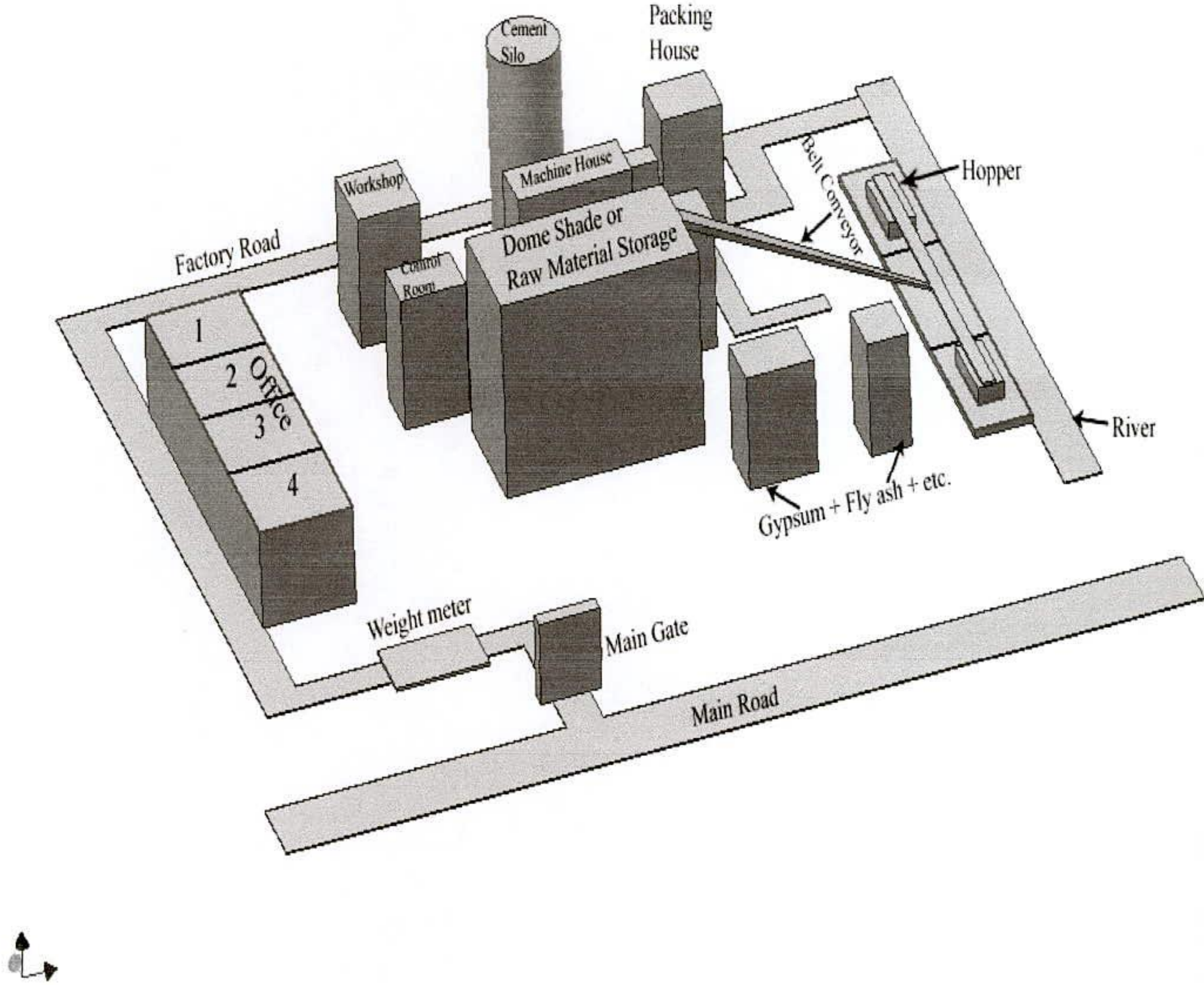


Fig 4.4: CEMEX Cement Ltd.

<u>Some limitations of this industry</u>

- In this cement industry a dome shade is used for raw material storage; there is no clinker silo used which affect continuous production.
- There is no truck parking place.
- Comparatively long distance between final product supplies to main road.
- Factory roads are not connected to all the positions in the industry.
- The site selection is not proper.
- The production rate is not reliable with respect to their area requisition.

4.3.5 Akij Cement Mill Ltd.

This is the Vertical Roller Mill (VRM) technology cement industry in Bangladesh. The small size ball mill plant is also used in the cement industry which is used only in emergency purpose and when market demand is so high. This is the medium type Portland cement production plant. The plant layout of this industry includes various machineries and equipments such as cement grinding mill house, conveyor belt joint, some factory roads, mechanical and electrical workshop, package house, bag plant, inspection facilities, employee facilities, various raw material storage systems etc. The main product of this industry is Portland cement. There are two type of Portland cement - Ordinary Portland Cement (OPC) and Prosononic Portland Cement (PPC). In this cement industry their are individual silos for PPC and OPC storage. Clinkers are the main materials for manufacturing Portland cement. Also use some additives such as gypsum, slack, limestone and fly ash etc. Almost (65-80) % clinkers and rest (20~35) % additives are used in this industry for manufacturing Portland cement. This cement industry is situated near the river and it is connected to main road. So site selection and transportation system of this industry is also reliable. The production rate of this cement industry is (2800~3200) tons/day and the production time is continuous, i,e (20~22) hours per day. The production rate is changed with respect to their market demand, supply and quality of the cement. The power consumption varies as (7.0-7.2) MW. The used area is 11.0 acres. This cement industry is the example of the proper application of optimum plant layout design of mass production system. Fig.4.5 shows the existing plant layout of Akij Cement Mill Ltd.

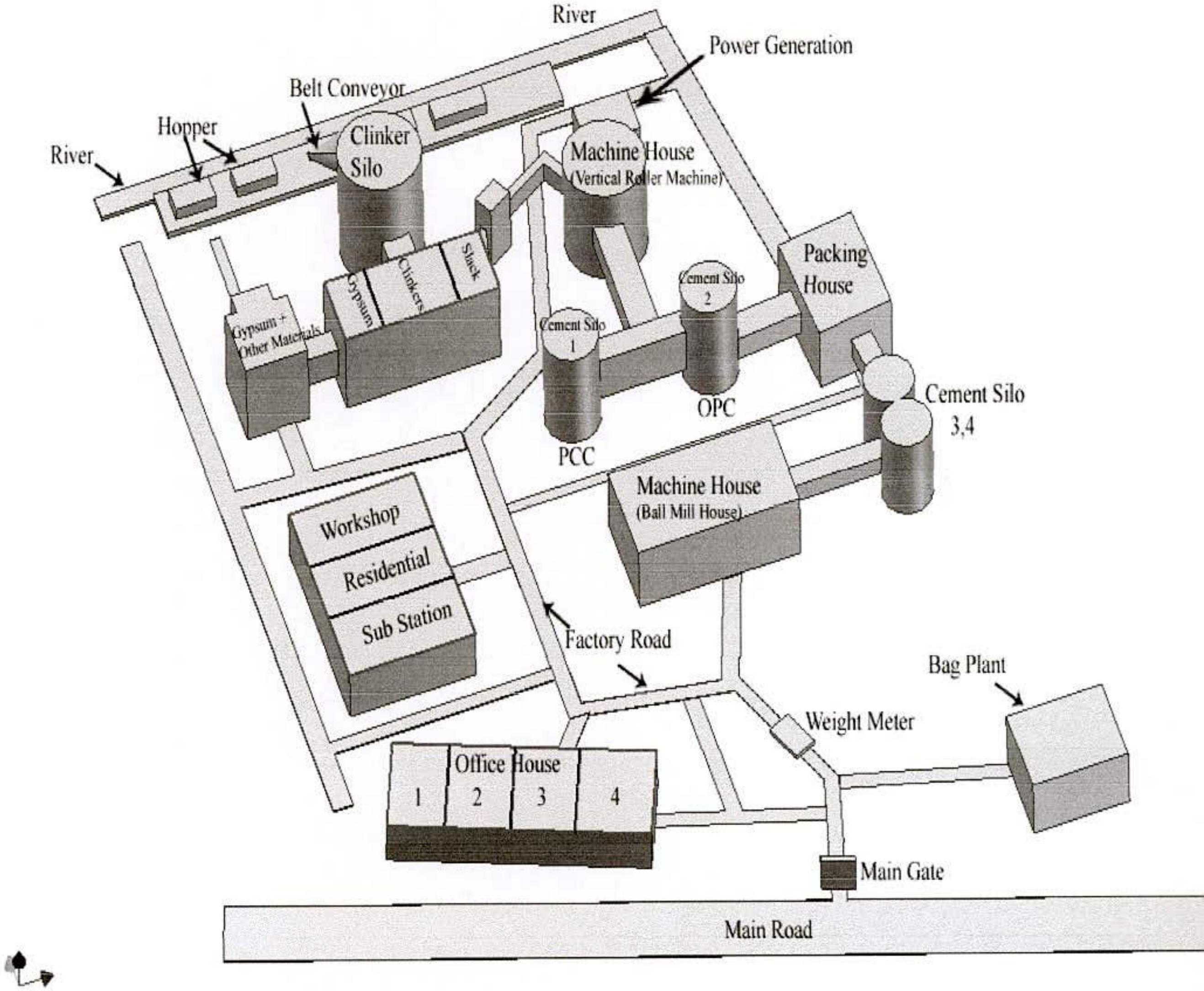
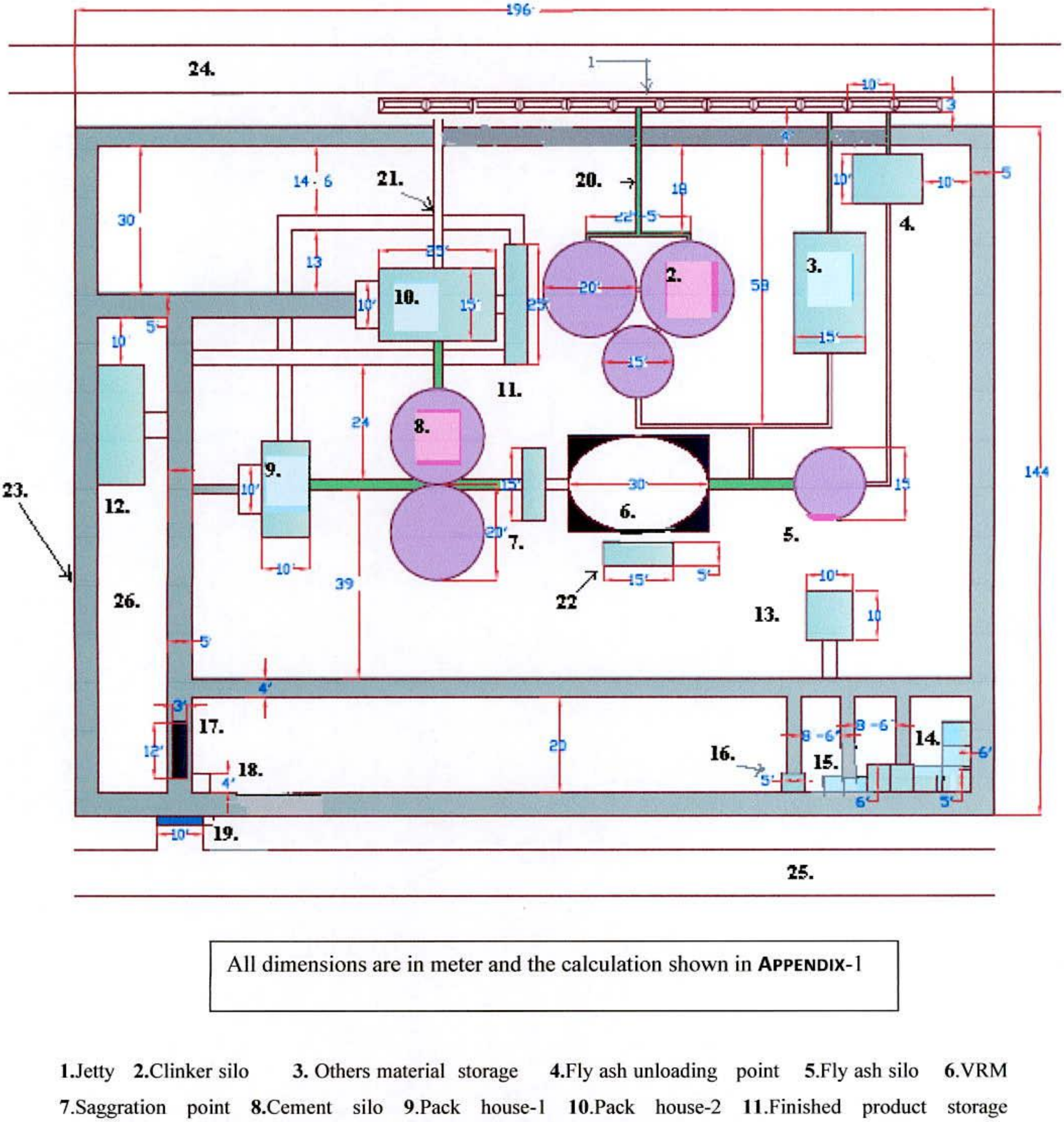


Fig 4.5 Akij Cement Mill Ltd.

<u>Some limitations of this cement industry</u>

- Unnecessary machinery, equipments and silos are placed in the cement industry.
- Unplanned factory road.
- Space utilization is not proper.
- Two type of mill house(VRM and Ball Mill) which flactuates final production rate and power consumption become high.
- The placement of the office area and residential house is not reliable.
- The production rate is comparatively low with respect to space utilization.

4.4 Proposed layout of cement industry



All dimensions are in meter and the calculation shown in **APPENDIX**-1

1.Jetty **2.**Clinker silo **3.** Others material storage **4.**Fly ash unloading point **5.**Fly ash silo **6.**VRM **7.**Saggration point **8.**Cement silo **9.**Pack house-1 **10.**Pack house-2 **11.**Finished product storage **12.**Bag plant **13.**Substation **14.**Office **15.**Work shop **16.**Hydrent pump **17.**Weight meter **18.**Gaurd room **19.**Main gate **20.**Belt conveyor **21.**Bypass road **22.**Control room **23.**Factory road **24.**River **25.**High way road **26.**Truck parking

Fig 4.6 Proposed layout of cement industry

4.5 Layout analysis of proposed cement industry

For designing plant layout of cement industry, the production rate is assumed 3000 tons/day and continuous for (20~22) hours per day. The production rate may be changed with respect to market demand, smooth supply and quality of the cement. The plant layout design of proposed cement industry should be optimum. In this cement industry Vertical Roller Mill (VRM) technology is used. This is the standard type Portland cement production plant. The plant layout of this industry includes various machineries and equipments. Some important parts of industry are as cement grinding mill house, conveyor belt joint, some factory roads, mechanical and electrical workshop, package house, bag plant, inspection facilities, employee facilities, various raw material storage systems, finished product storage systems and truck parking etc. The bag plant and truck parking facility is considered here which is rare for cement industry. Every dimension of every machinery and equipments is considered. In this cement industry the distance required for industrial safety between every machinery and equipment is also considered. The main product of this industry is Portland cement. There are two types of Portland cement - Ordinary Portland Cement (OPC) and Prosononic Portland Cement (PPC). Clinkers are the main materials for manufacturing Portland cement and some additives are used such as gypsum, slack, limestone and fly ash etc. Almost (70~80) % clinkers and rest (20~30) % additives are used in this industry for manufacturing Portland cement. To establish a new cement industry is a major, long-term investment. So site selection is a critical and important decision made by private and public owners that affects a wide range of activities ranging from land use planning to sitting of industrial facilities. This cement industry is considered near the river and it is connected to highway road. The optimum layout is more important for any type of cement industry of mass production system. The main target of optimum plant layout is cost minimization of their production system, increase production rate, quality maintain and properly manpower uses of manpower where various environmental issues is considered which also depends on their manufacturing system. The power consumption of this industry is 6.40 MW and power consumption per ton is 2.13 kW. The area is 9.02 acres. The power consumption and space utilization is comparatively very low according to the production rate. Environmental issues are considered also. So it is an optimum plant layout design of a cement industry where the proper placement of all the machineries, equipments, various houses is maintained and the maintenance cost is minimized.

Comparison of various cement industries with proposed industry

	Meghna Cement Mill Ltd. (Exclude bag plant)	Mongla Cement Factory (Exclude bag plant)	Five Rings Cement (Exclude bag plant)	CEMEX Cement Ltd. (Exclude bag plant)	Akij Cement Mill Ltd. (Include bag plant)	Proposed Cement Industry (Include bag plant)
Production rate (tons/day)	*3800~4200*	*2000~2300*	*1300~1500*	*1800~2400*	2800~3200	**3000**
Power consumption(MW)	6.5~7.5	4.4~4.6	3.0~3.2	3.5~4.0	7.0~7.2	**6.40**
Power consumption per ton(KW/tons)	1.75	2.09	2.21	1.78	2.36	**2.13**
Area(acres)	9.83	9.55	7.0	10.0	11.0	**9.02**
Environmental issues	Good	Average	Average	Average	Average	**Excellent**

4.6 Results

The optimum plant layout of cement industry proposes better consideration of site selection, raw material storage system, machining process, physical setup of machinery, office, package house, bag plant, factory road and transportation etc. The space is properly utilized. The proposed industry area utilization is 9.02 acres. Site selection consideration of cement industry is that its position must be nearest the river and connected the high way road. The proposed industry is near by the river and connected with high way road. By using river, the transportation of raw material and finished product is so easy. Raw material storage is the important factor of cement industry. Storage capacity is needed at least (10~20) times more capacity than the per day production rate to avoid risk. The raw material (clinkers) must be situated at the air free area, so that air cannot react with clinkers and maintain proper composition of properties. So the various types of silo are used for clinker storage. The proposed cement industry uses 3 clinker silos, 2 cement silos, 1 fly ash silo which is optimum for smooth production. In this case also used others material storage house for continuous production. There are two types of cement grinding machine in Bangladesh- Vertical Roller Mill (VRM) and Ball Mill. Both mills produce the same product but their production rate, initial investment, cost and energy saving rate is different. The proposed layout of cement industry uses, Vertical Roller Mill (VRM) technology by considering Bangladesh power situation. The proposed design of industry the power consumption is 6.40 MW and per tons power consumptions is 2.13 (kW/tons) which is comparatively low according to the production rate and bag plant. Control room is an important part of machining section and its position should be near the machine house. There are many types of conveyor (belt, bucket etc) used in cement industry. The use of belt conveyor is better than bucket elevators. Office room is important for cement industry and it should be positioned at side of the factory. The proposed cement industry has a packaging section. The position of packaging section is connected to both factory road into the main road and river. Therefore, the transportation of the finished product transportation is easy and maximum. Factory road is an important part of cement industry. The road should be such that every position of the industry is connected to the road and this road is also connected to main road. By considering concept of this idea, the plant layout design of this cement industry is optimum and cost is minimum.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Conclusions are drawn on the results of theoretical and survey analysis. The present study includes the collection of data, documents and the physical survey of the cement factory which will be carried out for all the machineries, the input raw material processed, their storage position, the working procedure of machine, the position and distance of one machineries to machineries in the industry. The main features of the present work is concerned with the survey and data collection from various cement industries. Some theoretical analysis in generalized form applicable to all situations are discussed.

In cement industry some external views are considered such as height restriction, proper manpower scheduling, optimization of material flow, their loading and unloading system etc. The information of environmental issues including waste and dust management may also be considered. Further investigations may be carried out for various cement industries especially regarding layout design. The layout design of cement industry may be compared and analyzed. Finally an optimum plant layout for the production system has been developed and recommended for the cement industries in general.

The plant layout may also be modified to improve the production rate and machining efficiency. That will also maintain proper management and scheduling. Also waste disposal can be performed at the right place .It will help to utilize skilled manpower, reducing unnecessary workers. The operating cost will be reduced and the initial investment will be minimized. The existing production system of different cement factories have been studied and analyzed for the improvement of the system. The plant layout is designed and compared to other cement industries. The placement of machineries and equipments in a right place has been found to be optimum. Finally the product handling cost and the manufacturing cost are minimized.

5.2 Limitations of the present study

- It's so difficult to improve the machining performance for existing production system and plant design of cement production industry.

- Sometimes the placement of machineries and equipments at the right places is not possible for their shortage of space and irregular shape of area.

- Product handling cost sometimes becomes high due to shortage of their materials and high investment cost.

- The comparison between vertical roller mill and ball mills is so difficult because of some limitation and advantage.

- Various factors need to be considered for the selection of plant location from area to the specific site.

- The production system for best plant layout of a cement industry, the product handling cost and labor movement are considered.

- Due to the lack of knowledge of plant location and plant layout the design of cement industry may not be optimum.

- As the cement industry is a long time investment, it's various factors influencing the choice of an initial layout and its subsequent modification is quite impossible.

5.3 Recommendations

The present work deals with the survey of data collections and some theoretical analysis for plant layout of machineries, equipments and raw materials etc. The Portland cement manufacturing process also has been discussed but more experimental studies are required to improve machining efficiency. The knowledge from this work will be applicable in any mass production industry for better production and profit.

This project may be used as a useful tool for any better plant layout for a cement industry and thus product handling cost and manufacturing cost could be optimized.

REFERENCES

[1]. http;//www.du.ac.in/coursematerial/ba/esb/lesson-7.pdf.10.03.10.

[2]. Vilarinho, P.M. and R.C Guimar~aes(2003) / Investiga_c~ao Operacional, " A Facility Layout Design Support System" p. 3-23, 145-161.

[3]. Zeydan, M. and A. Golec. 2004. "Plant Layout and design through the simulation and increasing the capacity of cement factory". p-3 .

[4]. Kumar A., "Plant Location and Layout" p.1-5, Available from; http: //www.du.ac.in/coursematerial/ba/esb/lesson-7.pdf.20.03.10.

[5]. Shan, H.S, P. Kumar and P.K Jain, "Production Planning and Control" P. 3 Available from ;http: //nptel. iitm.ac.in/courses/ Webcourse -contents/ IIT-Roorkee/ industrial engineering /index.htm.

[6]. Khurmi, R.S. and J.K.Gupta, 2005. 7th ed. S.Chad, Eerasia Publishing House, Mechanical Engineering, P. 734.

[7]. Wang, N. and Lars-André Tokheim, 2008. "Environmental production: Use of waste materials in cement kilns in China" Telemark University College, Faculty of Technology, M.Sc. Programme, p.11-12,.

[8]. Wang, Y.M. (2005). Histories of China cement industry development. Beijing: China Building Material Industry Publishing House.

[9]. Zeydan, M. and Adem Golec, 2004. "Plant Layout and design through the simulation and the capacity of metal workshop of a factory" Erciyes University, Industrial Engineering Department, 38039, Kayseri, p. 1-2.

[10]. Drive, W. and AztecWest, November 2005. "Measuring environmental performance for the cement industry" Waterside Drive, AztecWest Almondsbury, Bristol BS32 4UD, version1, p. 4-6.

[11]. Sauar, G. July 1998. "Analysis for cement and concrete industries" Engineering Foundation Conference on Advances Cement and Concrete, P. 1-5.

[12]. European Cement Industry to the exchange of information and preparation of the IPPC BAT. December 1999. "Document for the cement industry "Best available technique for the cement industry" p. 68.

[13]. Bryan Michael Landry B.A, May 2006. Louisiana State University, "Site selection analysis for potential biomass" p. 33.

[14]. World business council for sustainable development, January2006. "Formation and realize of pops in cement industry" p. 22-40.

[15]. Waterside drive, Aztec, "Environmental performance for the cement industry" p. 14-18, November 2005.

[16]. Bruce Vigon, Tiffany Brunetti, Vinay Gadkari, Scott Butner, and Jill Engel-Cox, march-2002. "Industrial Ecology in the Cement Industry" p. 15-45.

[17]. The Manufacture of Portland Cement, 1989. The Cement and Concrete Association of New Zealand.

[18]. Ministry of Energy and Mineral Resources, Bangladesh and Ministry of Powerand Energy, Sri Lanka, 1994. "Output of a Seminar on Energy Conservation in Cement Industry" p. 5-7,32.

[19]. "Cement industry process description" p.1-9, Available from; http; //www. inece. org./mm coarse/ chap 6.pdf. 05.04.10.

[20]. Schumacher, K. and Jayant Sathaye, July 1999. "India's Cement Industry: Productivity, Energy Efficiency and Carbon Emissions" p. 13-17

[21]. Batra, V.K. P.K. Mittal, Kamal Kumar and P N Chhangani Holtec , 2005. "Modern Processing Techniques to minimize cost in Cement Industry"p. 1-3,

[22]. Dr Jankovic, A. and Dr Walter Valery, 2003. "Cement grinding optimization" p. 3-6.

[23]. Bapat, J.D. J.P. Sexana and H.S.Chauan, 1984. "Appropriate system for bulk packaging in cement industry"v-4, p .2-3.

[24]. Simmons, M. Lee Gorby and John Terembula, 2002. "Operational experiance from vertical roller mill for cement grinding" p. 1-9.

[25]. Best Available Techniques in the Cement, May 2009. Lime an Magnesium Oxide Manufacturing Industries, European Commission, Institute for Prospective Technological studies, Seville.

[26]. Robert Mccaffrey, editor, *gcl magazin*, 2002. "Climate change and the cement industry" p-2.

[27]. Homebuilder Categories, March/April 1993. "Cement and Concrete: Environmental Considerations" From EBN Volume 2, No. 2, p. 9.

APPENDIX-1

Calculation of Proposed Layout

Assuming, production rate to be 3000 Tons/day

01. Power Consumption :

For Vertical roller mill, The total power consumption = (3.5~4.0) MW . Per day production 3000 Tons.

Pack House 1 = 500 kW=0.5 MW

Pack Hose 2 = 500 kW=0.5 MW

Clinker unloading = 300 kW= 0.3 MW

Fly ash + Other raw material unloading = 200 kW= 0.2 MW

Bag Plant = 650 kW= 0.65 MW

Office+Residential+ Lighting + So on = 500 kW =0.5 MW

Total power consumption =(3.5-4.0)/2 +0.5+0.5+0.3+0.2+0.65+0.5

= **6.40 MW**

Power consumption per ton = (6.4×1000)kW/3000 tons [as 1 MW=1000kW]

=2.1333 ≈ **2.13 kW/ ton**

02. Area :

From fig. 4.6, Width = 196.2 m

Total width= (196.2+D_1+D_2) m [Where D_1 & D_2 is the both side extra distance of industry= 10m]

=(196.2+10+10)m

= 216.2m

From fig. 4.6, Length = 144 m

Total length=(144+D_3+D_4) m [Where D_3= river side extra distance= 15m

D_4= road side extra distance=10m]

=(144+15+10)m

=169m

Total area = (216.2×169)= 36,537.8 m^2 = **9.02acres**

03. Number and dimension of silo:

For clinkers

The production rate of portland cement is 3000ton/day and clinker use (70~80)% of total production rate .

so clinker use =3000× 75%

=2250 tons/day

At least (10~15) =12.5 times clinker storage should be considered for smoothly production.

Therefore, total clinker storage need = 2250×12.5=28,125 tons

Let, silo diameter, d = 20m and height, h = 40m.

Therefore, silo capacity = $\Pi r^2 h \times 1.28$ [Bulk density=1.28 for clinker]

$=\Pi/4 \times d^2 h \times 1.28$

$=(3.14 \times 20^2 \times 40 \times 1.28)/4$

=16076.8 ton

If 85% fillup then the capacity of silo=16076.8×0.85

=13665.28 ton

So, no. of silo needed =(28,125)/13665.28

= 2.05 ≈ 2 piece (20m×40m) and safety silo= 1 piece(15m×30m)

Total no. of clinker silo = 2+1= **3 piece**

For fly ash

The total production rate of cement is 3000tons/day and fly ash is use avarage (3-5)% of per day production rate.

So fly ash storage need = $3000\times(3\sim5)\%$

$=120$ tons

At least 20 times capacity of perday production rate is needed.

Therefore, total fly ash storage need $= 120\times20$

$= 2400$ tons

Let, silo diameter, d = 15m and height, h = 30m

Silo capacity = $\Pi/4\times d^2h\times0.94$ [For fly ash, bulk density = 0.94]

$=(3.14\times15^2\times30\times0.94)$

$=3320.55$ tons

Therefore, fly silo needed = 2400/3320.55

$= 0.7227 \approx$ **1 piece (15m×30m)**

For cement

As the production rate is 3000 tons/day and cement silo is used for continous production, approximately 5 times finished cement is needed for per day production rate.

So, total finished cement storage needed = $3000\times5 = 15000$ tons.

Let, silo diameter, d = 20m and height, h = 40m.

Silo capacity = $\Pi/4\times d^2h\times1.12$ [For OPC, bulk density = 1.3 and for PPC, bulk density = 0.94
Avarage bulk density = (1.3+0.94)/2 = 1.12]

$=(3.14\times20^2\times 40\times1.12)/4$

$=14067.2$

So, no. of silo needed = 15000/14067.2=1.066 ≈ 1 piece(20m×40m) and safety silo = 1 piece(20m×40m)

Total no. of cement silo needed = 1+1 = **2 pieces(20m×40m)**

04. For other materials (gypsum, slack & so on)

From fig. 4.6, Let, width = 15m, length = 30m, height = 25 m.

Volume = (15×30×25) m^3

= 11,250 m^3

Here (15-25)% other material is used for continous cement production.

So, other materials used = 3000×(17-25)%

= 630 tons/day

Approximately (15-20) times other material storage is needed for per day usage.

So, total other material storage capacity needed = 630×(15-20)

=11,025 tons; here the volume of other material storage house is 11,250 m^3, which may be acceptable for other material storage.

In this case, for storing other materials, storage house and various free space of the industry may be used.

Per day production V_S material used:

Per day production rate = 3000 tons

Per day clinker used = 2250 tons

Per day other materials used = (630+ 120) tons

Therefore, total materials used per day = (2250 + 630 +120) tons

= 3000 tons = Production rate (3000 tons per day).

So, production and manufacturing process should go on smooth.