



Construction Management (Short Course)

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TOPIC 1

Construction Industry

This course presents a brief introduction about the construction industry. Construction is indeed one of the most important Industries on earth dating back to the beginning of civilizations. The evidence is all around us, serving as witnesses to the ingenuity of man. Relics of the construction prowess of ancient civilizations are dotted all across the modern world in Asia, America, Europe, Africa, South America, and many other regions. Some famous examples of these include the Pyramids of Egypt, the Taj Mahal of India, Roman Amphitheatres of Italy, and the Great Wall of China.

Modern construction has evolved from simple manual techniques into a complex maze of highly mechanised and orchestrated symphony of activities, which requires billions of dollars in investment and serving as the second biggest source of employment in the world. Construction involves many field activities requiring the use of resources such as land, construction materials, labour, equipment, and energy, etc., to achieve a pre-defined object of putting up structures such as roads, buildings, dams, and just about any imaginable structure you find around you.

Due to limited and very costly resources, construction has to be managed productively and efficiently using innovation, creativity and sound organisational and economic principles. When construction projects are properly managed, the result is lower costs, completion of projects on time, and higher quality structures.

In order to construct a successful organisational model for a successful construction project, it is important to study and understand the various components that make up a successful model. Construction activities must be cost-effective using high quality material and performed within a limited time frame to achieve quality end products.

The face of the construction industry has been changing rapidly in recent times. These advancements in modern construction methodologies and techniques, as well as, the emergence of more productive equipment means that industry players must remain on their toes to keep up with the latest construction technology. In order to remain relevant, companies must adopt new approaches to managing and building projects. Growth in technology means that there are new and better materials to use, newer techniques of accomplishing tasks at lower costs and better time management skills, and newer equipment for more productive work, etc. Therefore, the human resource capacity must constantly update or upgrade their knowledge and skills.

Market Size and its Importance

The achievements within the construction industry spanning thousands of years and involving a diversity of civilization have been quite enormous. Construction has produced different types of infrastructure ranging from small residential building to the mega sports complexes and industrial buildings. It is no surprise that it remains one of the biggest businesses on the planet having market capitalization running into trillions of dollars.

Construction has contributed to most advanced economies of the world through provision of critical infrastructures of economic significance most especially in recent times. Investment in construction activities contribute a sizeable portion to a country's GDP, in terms of making available employment opportunities for workers to earn decent income and contribute to the economy.

Some established countries in Asia, such as Hong Kong and South Korea, rode on the benefits of construction to attain their present level of economic success. China and Malaysia are also following in the same footsteps by investing heavily in mega construction projects and having been doing so for the last 50 years or so. It is a very powerful tool for development and economic progress.

Features of Construction Industry

Some of the important features of the construction industry have been described below:

Complexity

The modern construction industry is highly mechanised and complex; it involves complex interactions between a vast array of resources, such as thousands, who are skilled in labour, equipment, such as, cranes, earth movers, logistics etc., all interconnected into thousands of activities. Activities may overlap simultaneously or in sequential discrete steps or even randomly – a phenomenon more complex than found in ordinary factory or manufacturing context.

Uniqueness

One way in which construction differs from other industries is that no two projects are ever the same. In other words each project is unique. This uniqueness of each project is defined by the nature of the site of construction and is also influenced by the weather, as well as, the ground conditions due to various site locations.

The construction supervisor and management team are critical to the success of every construction project. They are responsible for ensuring plans and specifications are adhered to and also, for managing the limited resources available within budget and deliver the complete project on time. Since there is little room for costly mistakes, it is incumbent on the supervisory team to be vigilant to ensure that mistakes are detected instantly and corrected immediately.

Mobility of Facilities

One major difference between the construction and mainstream manufacturing industries is that products resulting from construction are stationary, while those, which results from manufacturing, tend to be mobile during value addition. Construction industry requires moving resources such as labour, equipment etc., from one place to the other to create products under dynamic and hazardous working conditions. Manufacturing industries on the other hand require products at various stages of product lifecycle to move from one facility to the next for value to be added. Products are standardized and easy to control unlike

construction where new techniques or modifications to existing techniques have to be developed to deal with the constantly changing working environment.

Multiplicity of Agencies

Many agencies are involved in construction projects, from the conception of the product through to the completion of the project. Each agency is expected to play a specific role in the course to the project lifecycle. These agencies may include governmental agencies, land authorities, planning agencies, fire department, and Town and Country Planning Councils, etc. Their roles may differ but basically, they ensure that the project complies with the laws of the land. They carry out inspections and provide certifications for various activities on site.

Organisation

The owner of the construction project normally advertises the project and invites tenders from prospective contractors to undertake the project. The contract is awarded to a successful bidder after a competitive bid process. The winning contractor then engages the services of sub-contractors on contracts to execute various planned activities within a specified time frame. Sub-contractors may also employ hundreds skilled workers to work on specialise aspects of the project. During the construction of larger - scale projects, it very common to have thousands of employees working on diverse aspects of the project site. The complexity of large scale projects means that there is the need of a great deal of organisation and management of a large group of people who interact with each other in many ways to produce the final product within a limited time period.

Three groups of people are normally involved in a typical construction project:

- The owner
- The engineering group which is made up of managers, architects, structural engineers, and civil engineers etc.
- The construction group consisting of a number of contractors and workers who perform the actual work.

These 3 groups interact in a well-organised way with no particular group having absolute control. Each group has a set of unique functions to perform at specific moments and their activities may overlap or occur sequentially. The owner is expected to exercise control of the finance and quality control, the engineering group ensures structural and aesthetic integrity while the contractor motivates the workforce to execute the work professionally and to a very high standard to meet the deadline.

The main categories of activities of a construction project include:

- i. Design and planning
- ii. Executing construction work
- iii. Supervision and inspection

Finance

Financial activities involved in construction can be classified into the following categories:

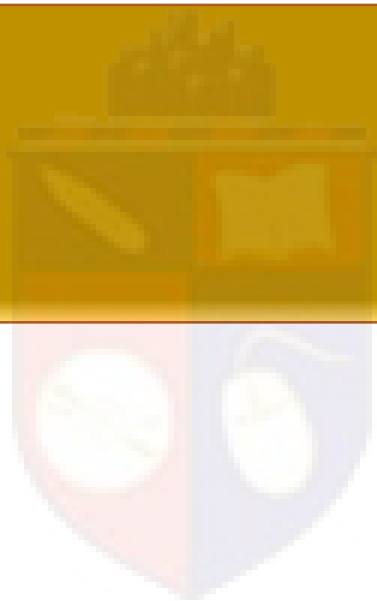
1. Investments in fixed assets, such as, tools, equipment, machinery, cantering, and shuttering, etc.
2. Short-term finances, such as, earnest money and security deposits to meet the cash flow requirements at construction sites
3. Investment in future through education, training, research, and development of human resource and technologies
4. Overheads in salaries and establishment other expenses relating to advertisement and public relations, legal expenses and other related expenses required for the project to run smoothly

Funding sources include credit facilities, loans, and securities. Most times, the construction industry experiences cash flow issues due to the blockage of security deposits, earnest money, and delayed payment of bills, among many other impediments.

Management

Since most companies HQs are far from the project site, it becomes difficult for the management to provide direct supervision and control of activities. This makes most projects workforce autonomous in tackling their responsibilities. This makes it imperative to have available well-trained personnel who would executive their mandated activities professionally and on time to achieve satisfactorily high quality products.

TOPIC 2



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Role of Construction Supervisor

The main duty of the construction supervisor is to motivate and coordinate activities of other workers to get the job done on time. Supervisors serve as the link between workers and top management levels of the organisation. They operate at the first line of management. There are three levels of management namely, the top - level, the mid – level, and the first-line level.

Top - Level Management

They formulate objective and policies of the company.

Mid - Level Management

They are mostly involved in the procurement of materials, labour and equipment management. They may also be responsible for highly specialised duties such as lift installation and HVAC.

First-Line Management

This level is usually comprised of the construction supervisors. It is the lowest level of management which takes instruction from the mid-level and report back to them during the course of construction.

Responsibilities of the Construction Supervisor

The responsibilities of the construction supervisor include making sure that all work meet the right quality, cost does not overrun budget due to mistakes and the work is completed on time.

Duties of Construction Supervisor

- The supervisor instructs workers on what to do
- Motivates workers to accomplish all objectives
- Encourages teamwork spirit
- Ensure workers are disciplined
- Deal with all manner of conflicts arising at the work site
- Promote a good relationship between the workers and the general public
- Ensure plans and schedules are adhered to by regular inspection and quality control
- Trains and develops the workforce to meet new challenge

Construction Supervisor and the Phases of Construction Project

The construction supervisor should be familiar with the various phases of the project. The following phases are normally devised for construction projects:

- Conception of the building based on requirements of the owner or user
- Determining the feasibility of the project and comparing alternatives

- Preparing detailed design, drawings, and resource cost estimates
- Translating construction ideas from paper into reality using resources.

Project construction sites can be executed by the owner or by a contractor. Construction by the owner is termed departmental construction. It requires that the owner from his own company and engage the services of an engineer and contractor. The second method is to employ the services of contractors. The contractor-type construction involves both the owner and the contractor appointing their individual supervisor to oversee the project.

The owner's supervisor has to ensure that all specification and plans are being followed by undertaking regular planned or unplanned inspections of activities on the site. His responsibilities include the following:

- i) Ensure that construction is done according to the contract drawings, specifications
- ii) Make sure the contractor follows the agreed schedule
- iii) Ensure quality standards of materials, processes and workmanship are maintained

Supervision for the Owner/Consultant

Here is how the owner's supervisor can obtain success on the field -

- He must submit daily progress report to the owner's engineer
- Work with contractor's team frequently
- Clarify any aspects of work which the contractor does not understand or is unsure about
- Demand the highest quality standards from contractor
- Deal discretely and fairly but resolutely with contractor's staff on the field on all aspects of work to ensure high quality work
- Solve problems commensurate with his expertise and escalate to the site engineer when problems are beyond his ability or would require supervision of more senior personnel
- Taking timely actions to correct deviations from plans
- Report serious problems to the site engineer immediately
- He should use discretion and professionalism when implementing contract specifications, but, he should also receive occasional advice from the site's engineer and work within the limits of his responsibility and authority
- Must be tactful or diplomatic when dealing with field staff
- Maintaining proper documentation including registers, equipment documents, and labour documents, etc.
- Keeping work order book containing instructions from management to the contractor
- Requesting for early inspection and approval of completed portions of work to avoid delays
- Helping engineer to prepare account and issue payments to contractor
- Maintaining all contract documents such as drawings and specifications at each phase of the project

Supervision for the Construction Agency

If the owner decides to secure the services of a construction agency to undertake the project with the assistance of a construction supervisor, then the construction agency must ensure that the structure is completed on time, at the agreed cost and to the specified quality standard.

Before beginning construction activities, the supervisor for the construction agency should ensure that:

- All drawings are ready including detail working drawings
- Detail bill of quantities are available
- Information on all resources required are available and ready
- Suppliers and workers are ready for take off
- Execution plans for activities are developed, milestones and completion dates also finalised
- Project manager and his team of engineers have been selected to oversee technical aspects of the project

For a supervisor to really succeed in a project, he has to make sure he studies and understand all contracts requirements, designs, drawings and specifications and any other relevant document. He also needs to study the programme of construction prepared by the project engineer and his team and come up with realistic schedules for activities for each day of the week or a weekly schedule to keep up with overall project plan

Sample for a Supervisor's schedule for a typical day

Table 1

Supervisor's Schedule For A Typical Day

1. Brick masonry for the superstructure of Building 1 to be continued
2. Excavation for the foundation of Building 2 to be started today. Labour team to be organised, instructions to be given to them, necessary tools to be issued
3. Excavation work should be completed by tomorrow evening; make request to the field engineer to inspect the work tomorrow and approve the foundation so that laying the concrete bed for the foundation can be commenced in 2 days time
4. Send a requisition to the store to supply cement, to place an order for supply of sand and aggregates so that these materials will be delivered to site by tomorrow evening.
5. Request the project office to supply the working drawings of RCC slab to help estimate resource requirements
6. Send a note to the accounts department to arrange for the payment of wages to labour at the end of the week
7. Submit reports to the project office

The above list of activities is not exhaustive and should be considered in an indicative nature only.

Supervisor should see to it that the following facilities are available on the site:

- i.** Site offices, site stores, workshops, and canteens, etc. along with the necessary furniture, ventilation, and lighting, etc.
- ii.** Access to the site, as well as, various units such as site office, stores, and workshops, etc.
- iii.** Adequate parking facilities, unloading platforms for incoming materials
- iv.** Toilets suitably located - separate toilets for ladies
- v.** Adequate supply of water for drinking, washing and construction operations
- vi.** Arrangements for regular cleaning of office, stores, canteen etc
- vii.** Ensure adequate safety precautions on site by:
 - a)** Promoting safe stacking of material
 - b)** Encouraging safe handling of material
 - c)** Insisting on the use of protective wears like helmets, gloves, gum-boots, goggles where necessary
 - d)** Providing fencing around excavated trenches
 - e)** Ensuring good housekeeping on site
 - f)** Providing first-aid box
 - g)** Employing trained workers and operators
 - h)** Ensuring proper maintenance of equipment
 - i)** Providing training to workers and creating an awareness of safety amongst workers

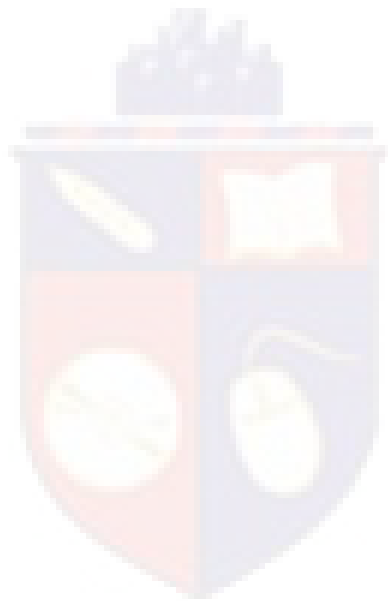
The supervisor should maintain documents containing the following:

- File containing list of contact details of all persons connected to the project including details of the owner(s), officials of local authorities, Government officials, suppliers, police department etc.
- Folder for approved drawings and specifications
- Contract documents
- Construction programme (e.g. in the form of bar chart)
- Files containing important letters
- Work order book
- Progress chart
- Registers for materials, use of equipment, labour employed
- Record of tests carried out on materials and works
- A general plan of work showing all work completed each day

Daily diary containing the following:

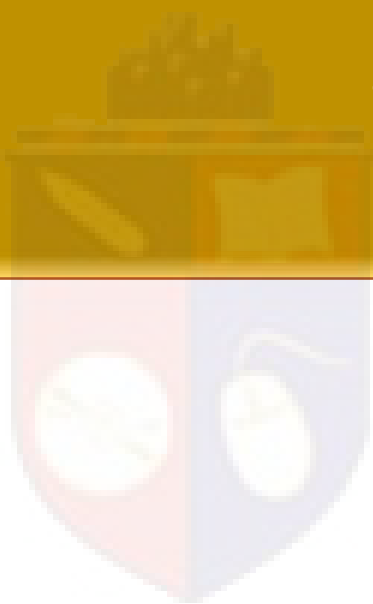
- Details of works in progress

- Notes on weather conditions
- Names of visitors
- Number of hours worked
- Details of work carried out by sub-contractors, labour contractors,
- Workers employed on work site
- Materials arrived; issued to sub-contractors, consumed on works
- Equipment details such as hours worked, fuel or power used, repairs and maintenance output etc.
- Any other relevant details.



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TOPIC 3



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Introduction to Estimation in Construction Work

Most construction projects require that you determine the approximate quantities of resources to accomplish project objectives. This preliminary determination of the quantities of resources required is known as the 'construction estimate'. Resources, which are needed, include labour, equipment, time, and construction materials. The process of estimating these resources is tied to money, so construction estimates usually require computing how much money is needed to execute the project from start to finish. All parties involved in the project are keen to learn about the estimates at various phases of the project. All estimates should be as close to the true value as possible.

In this unit, we will make presentation on the different components of estimating construction projects, including how to perform cost estimations at each phase of the construction project.

Estimate of a Construction Project

Purpose of an Estimate

Owner

- i) To provide necessary funds
- ii) To compare the offers given by tenders and select the best contractor at the lowest price

Contractor

- iii) Enable consultant earn a reasonable profit
- iv) Enable him to organise all necessary resources to complete the project

Consultant

- v) The estimates enable him to calculate the appropriate fees to charge the client
- vi) Assist the client in selecting contractors

Components of an Estimate

Construction projects involve numerous activities, which then consumes resources. These resources which cost money form the basis of estimating the cost of building a structure. There are other related costs incurred before the actual project takes off as well as after the project has been completed -these must also be considered. Estimates can be determined for each of the phases during the life time of the project. Below, we discuss how these can be done.

Estimation during Feasibility Studies

Feasibility studies include technical and financial dimensions. These have to be undertaken and approved before the actual project is executed. Technical feasibility studies involve detailed examination of factors such as building technology, design methods and materials that would make construction possible. Financial feasibility studies on the other hand are carried out to determine the profitability of the investment being made in the project.

Feasibility studies are important tools that help to obtain answers to the following crucial questions:

- Are the costs reasonable or too excessive?

- What economic alternatives are available to choose from?
- If alternatives exist, which one is more economical to pursue in terms of materials and layout, etc.?
- What is the overall cost of the project?

Construction cost estimates are useful for finding the answers to the question posed above and are also known as feasibility estimates. Feasibility estimates are usually performed at the early stage of the project within a short period. As a result, they are aptly referred to as approximate estimates because they are not useful during the actual execution of the project.

Quick Method of Approximate Estimate

Two main steps are required to quickly estimate the approximate cost of new structures:

- The first step involves finding the total units for constructing the structure based on the physical dimensions such as the area, volume or length
- Next, multiply the figure obtained in step 1 by the cost of structure per unit

Cost Data

Site supervisors need to keep records on total cost of materials and other resources used for executing a project to enable the cost estimator to produce accurate and reliable unit rate for computing the approximate estimate. The benefit of such records is that they could be used in the future to produce approximate estimate of the cost of similar projects. In order to do so, the estimator must, however, take note of the following when estimating new project cost using previous data:

- Take note of any price variation since the project was completed and include this in the new calculation
- Take note of differences in new product due to site location, design methods, construction methods, type of materials, labour, equipment etc.

How reliable an approximate estimate turns out depends on the following factors:

- Accuracy of recorded cost data
- Price adjustment based on new information on the new structure

Estimation during Project Report Stage and for Project Approval

Execution Strategy

When a project is found to be feasible for execution, the next step taken is the writing of a project report detailing important details which will be useful in the execution of the project. These include:

- i) Layout of the project
- ii) Design and drawings
- iii) Technical specifications
- iv) Estimates of cost

The project report and the cost estimates may also be used to solicit the approval of qualified authorities who have an interest in the project. The layout of works, design, drawings and technical specifications should have been completed prior to carrying out the estimation for the project report. The owner of the facility must also decide on the execution method at the project report stage as this helps in the correct preparation of estimates. The owner has two choices to make in terms of mode of execution:

- Decide whether the project will be by contract or departmental construction
- If it will be a contract arrangement, then, what type of contract would be the best option to choose?

For jobs, which cannot be easily measured or estimated, provision is made for using lump sum contract.

Estimating Procedure

i) Items and Units

The estimator creates a list of activities that need to be performed with the aid to the drawings and specifications. The list can subsequently be used for the bill of quantities and for tendering and making payment to contractors. Activities that can be undertaken include:

- Lineout
- Excavation

The units of measurement are determined based on length, width, height, area or volume of various components of structures.

ii) Taking off the Dimensions

The items listed above will require a suitable dimension being taken off materials and the drawings done in appropriate units for each item, and allowances made for portions of the items which are not required to be removed before construction starts. For example, allowance may be made for doors and windows and these must be factored in appropriately.

The two procedures described above (the Lineout and Excavation Procedures) should result in a list consisting of items, their quantities and matching units. All items are priced per unit, taking into consideration all resource input cost associated with each item.

Each construction item requires materials, labour, and equipment. This means that it is imperative to create applicable rates for each item.

iii) Materials Rate

The material quality for each item should be known by the estimator based on the exact specifications given. Suppliers usually provide price quotations for the materials. The material rate should also include the following costs in addition to the supplier's quoted price:

- Transport of the material
- Loading and unloading
- Handling on site
- Storing, watch and ward
- Wastage to cover breakage, losses, theft which may vary from 2%-10%

iv) Labour Rate

The labour rate is the most unpredictable plan due to several factors. Factors such as the expertise of the worker and weather effects are difficult to control. The labour rate depends upon the skill and size of labour. The size of labour is influenced by the quantity of items and the output of labour. Since it has been established that labour outputs are uncertain, the best solution requires keeping records of skilled, unskilled and semi-skilled worker time for a period of time. This comprehensive record can help to determine the labour components for each item (i.e. this should be in terms of the number of labour days taken to perform a task).

Calculation can subsequently be made for the cost of labour per head for each day. This includes:

- a) Basic wage primarily governed by the prescribed minimum wages or fair wages
- b) Payment for inclement weather when the labour reports to work but cannot be assigned any work or can do work only for a part of the day due to unfavourable weather or heavy rains
- c) Paid holidays
- d) Expenditure incurred on travel, labour camps
- e) Overtime payment
- f) Sickness benefits
- g) Insurance
- h) Any other payment as per statutory requirement
- i) Conveyance of labour
- j) Items (b) to (i) form a percentage of the basic wage

v) Equipment Rate

The equipment's rate can be calculated using the quantity of item and the output of the equipment. It is performed based on the total hours the equipment can be put to work (equipment hours) or the required unit output expected of each item. The following lists are considered when determining the equipment rate:

- Cost of capital investment
- Depreciation
- Cost of fuel and lubricants
- Repairs and maintenance
- Salaries of operators and helpers
- Allowance for potential idle time
- Insurance
- Any other related expenses

The material rate, labour rate and the equipment rate are used to calculate the unit rate for each of the items and then subsequently, the overall cost of each item. Lump sums are quoted in cases

where the cost of the item cannot be determined by measurement. This is usually obtained using past experience or based on the work content of the item.

The costs that have been determined above collectively make up the cost associated with the actual work. The following costs should also be added:

- a) Expenditure on surveys, data collection, design, drawings, and estimating
- b) Land acquisition
- c) Establishment required during the execution of work
- d) Allowance for unforeseen works that may be found necessary in the course of execution
- e) Overhead expenses, which are meant to be incurred on site, as well as, in the head quarters

The cost of work plus the additional associated cost summed up to give the total cost of the project.

vi) Project Approval

Two types of approval have to be secured for construction projects; the administrative and technical approvals.

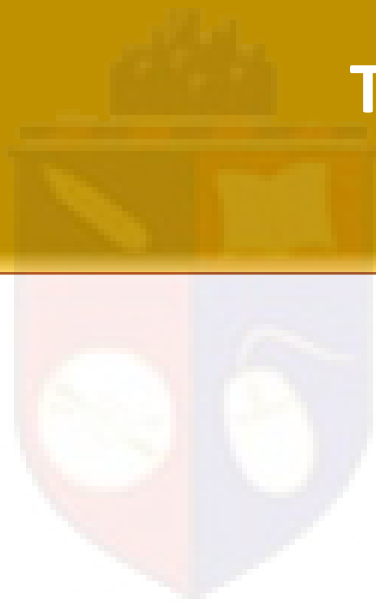
a) Administrative Approvals

The administrative approval must be acquired first. The approval is given by a competent authority at the user department. If for example, the health department wants to construct a hospital, it may contact the Public Works Department to carry out feasibility studies, provide layout drawings and specification to enable initial cost estimates to be determined as explained in the previous paragraph. The owner of the project (user department) is provided with the drawings and cost estimates for him/her to give the go ahead when the proposals from the Public Works Department are deemed acceptable. The above process is known as the administrative approval.

b) Technical Sanction

When the user department (owner) gives his approval for the initial drawings and cost estimates, the Public Works Department goes ahead to provide detailed design, drawing and cost estimates. Detailed reports must be approved by a competent person(s) at the Public Works Department.

TOPIC 4



Planning for Equipment

During the planning stage, we may run across a situation where two different equipments can perform the same function but have to decide which one to choose. The equipment planner has to determine which one is most suitable for the task. The planner will have to calculate the production rates of the 2 equipments in order to select the lowest cost option. This unit will show you how to go about planning, selecting and matching the most suitable equipment to specific functions using some effective procedures to accomplish this feat.

Equipment Selection

The following factors should be considered when selecting equipment to perform a function:

- Equipment productivity
- Product features and attachments
- Supplier support
- Cost

Equipment Productivity

Determining the ideal size of equipment required to undertake task of known quantity and at a competitively low cost can be quite tricky. The best way to tackle such problem of ideal equipment size is to use past experience from suppliers of the equipment and the owner's own experience. Most suppliers are able to provide information of equipment performance under different operating conditions. It is important to determine what is the primary use of equipment and also, identify other potential secondary functions. The primary usage is what determines the size of equipment and the extra features or attachments that would be suitable for the equipment to perform productively.

The productivity of equipment is usually influenced by the conditions of operation. In order to define equipment productivity, it is essential to understand all likely condition of operation because some equipments work best under certain condition than others. Experience and judgement would be required to understand local conditions such as the climate, topography and soil conditions.

When transporting large equipments, it is advisable to find out any legal restriction or laws governing these movements on local road networks. Permits for transporting equipment should be sought before proceeding. Alternatively, the equipment could be partially disassembled before transporting and reassembled again on the work site.

The operator's wage should also be considered when determining the size of equipment to use. Large equipment size coupled with high productivity will cause an increase in the wage bill of the operator. Also,

obtaining equipment which is too large may not be economical. In contrast, when the equipment is too small for a particular work, it may have to undergo frequent maintenance and repair works.

Product Features and Attachments

When contemplating features and attachments for equipments, it is important to evaluate the impact of these extra gadgets on the overall performance of the equipment you are thinking of enhancing. Generally, these attachments or extra features are intended to increase the productivity of machinery and improve the safety of workers. Careful analysis should determine all advantages and disadvantages of procuring attachments before actually renting or purchasing them.

Examples of how to increase productivity of equipment include:

- Using the right equipment with suitable attachment would increase productivity. You may increase a wheel loader's productivity by using extra features such as an automatic bucket control and other special purpose buckets depending on the nature of the task at hand
- Proactive diagnosis and adequate maintenance will help prevent equipment downtime and make it available for more work

The project's owner is directly responsible for the workers' safety. He must always take the safety of his workers seriously. The safety of workers must always be guaranteed by ensuring that warning signs and lights are properly displayed to ward of hazards, fire extinguishers are available, and all vehicles are fitted with working windshield wiper and seatbelts.

The correct type of tyres and tracks should be used, depending on prevailing conditions. Owners should work with suppliers to find the best and most economical equipment solution to problems with the help of previous records, experiences and regulations.

Supplier Support

The equipment supplier is expected to play a pivotal role during the lifetime of the equipment on the work site. Replacement spare parts, servicing and guidelines of how to use the equipment optimally should be sought from the supplier. Support may involve regular inspection of equipments, serving and pre-negotiated price of purchasing the equipments from the owner. Alternatively, the arrangement could entail getting and using the equipment on short or long term lease.

Cost

Besides all of the above points, one last factor to consider when obtaining equipments is the cost. This should be considered along with costs of servicing, maintenance and repairs and reselling. The decision to

buy equipment should not only be based on the cost, but also the associated cost of operating the equipment should be considered.

Equipment Planning

Equipment Planning refers to the steps that are taken to procure equipment and any strategy of implementation, which will put the equipment to good use in an economical way when the project takes off. This includes making detailed plans of different work cycles ahead of time and then getting the right equipment to carry activities to meet project objectives. In order to schedule projects, it is important to design an operational plan of activities as part of the overall project plan. Projects plans should highlight the objectives, which need to be satisfied, as well as, the procedures and methods required to meet these objectives.

After finalising all activities that need to be executed during the project lifespan, the next step requires specifying the equipments to be used to carry out the activities. It is also important to specify in the plan how the equipments will be used and the sequence in which they must be used. Next, the category or class and the number of equipments are also determined based on the production rates specified for the time-bound activities.

To arrive at reliable and realistic plan for equipments, the planning team has to have the required knowledge and experience of a similar sort of work. The team must be highly competent to make good decisions during the equipment planning phase. The planning team should also be highly skilled in analytical techniques such as the critical path method (CPM) to enable them carryout this important task of assigning equipment to each activity.

A time grid network of histograms shows how much equipment will need to be used and the duration of utilization is then developed. Equipments can only be used for duration of about 75% of its economic life on a project. Also, do not procure the maximum number of equipment at the start of the project. Instead, it is best to increase the number as the number of activities increase with progress of work. When a particular activity is completed as the tempo of work declines, the equipment should be transferred to another project in accordance with the project plan.

Matching of Construction Equipment and Plant

Construction jobs require several plants and equipments to execute scheduled activities to meet all objectives of the project. These plants and equipments are deployed in a manner so that they work in a particular combination to produce the final outcome. For instance, the construction of a concrete dam requires several activities which are carried out using different types of equipment and plants at the same rate in such a manner that there will be no stoppage until the final product is achieved. This entails continuous availability of functioning equipment and raw materials by matching or synchronising the equipments and plants.

Still, when constructing a dam, we expect uninterrupted synchronisation of all activities between the aggregated crushing processes, conveyor system, the concrete mixer, the concrete transporting vehicles such as the agitator trucks, dump truck or cranes and the concrete vibrator. Each of these equipments should work at the same rate as the previous one and should be capable of handling all materials assigned to it; otherwise the entire production may be stalled or interrupted leading to additional cost being incurred.

Construction Plant and Job Layout

The project overseer is tasked with preparation of the job site layout. The layout consists of scaled drawings of all items to be used on the construction site. Items include space for offices, material storage, warehouses, steel members and section, construction forms, assembly point etc. The rule for an excellent layout is to ensure the area are properly arranged to reduce the time it takes to transport materials from storage area to the project area. The time taken to move equipment to the work site should also be minimal.

Equipments and materials for similar purposes should be stored together. Cement bags should be stacked in such a way that the older bags, which were delivered for storage, will be used first before the newer ones are. For example, the layout at a dam's construction site should be designed to accommodate multi-functionality of equipments and provide adequate room for manoeuvring during the execution of activities such as hoisting, shifting, frameworks, positioning reinforced bars and blasting, which are all undertaken in the construction of a dam.

The layout should be designed so that it can regulate and systematize itself and be able to teach a large number of works in such a manner that they can learn how things should function on the job within a short time. Thus, the whole project becomes fixed when the equipments are selected and the layout subsequently developed, making the job a done deal, provided the right equipments have been procured and the layout are reliably functional. When done right, costly mistakes which slow down progress could be avoided altogether.

It is instructive to build a small model of the layout to check the validity of actual layout and equipments. The model also helps to bring out any hidden aspects which were previously overlooked during the layout design phase. Models of some equipment can serve as a guide in obtaining critical information and provide guarantees before embarking on large scale procurement and operations which require substantial capital.

Financing

It is best if a contractor obtains equipment for construction work through financial arrangements with third parties such as banks. This way, he will conserve his own capital to take care of other aspects of his business.

Ways to finance equipments includes:

- i) Entering into financial contract with suppliers. This arrangement usually requires a down payment of between 10-15% of the cost of equipment and the remainder paid via monthly instalments. This arrangement usually results in the issuance of a note and conditional sales contract showing records of credit, debt and monthly payments of the principal and interest rate to be made. The supplier retains ownership of the equipments until the contractor make the last payment. However, with this type of arrangement, the interest rate is usually astronomical and may even reach more than 50% of what the supplier obtains from the bank or the interest may even be based on the full value of the equipment until full payment is made. This type of arrangement should be avoided due to double interest rate charges. A buyer (contractor) with good credit rating may negotiate for interest payment to be made on declining balance at each stage of repayment and not based on the full cost of equipment.
- ii) Another way to secure financing is through commercial corporations purposely created to finance purchase of construction equipments. But this method is also expensive as these companies tend to charge high interest rates on the full cost of equipment, even though this interest rate may be considered as income tax deduction.
- iii) Equipment leasing companies buy equipment and rent them out to customers. These companies may consist of banks or other groups of companies who decided to come together to undertake such ventures.
- iv) The contractor or buyer may approach the bank directly if he has a good credit rating and sufficient cash at hand. He will be required to furnish the bank with equipment note which lists equipment items and their cost prices. A cash discount of 10-15% of the cost's price can be secured to pay the supplier. Banks tend to finance approximately 75% of the cost of equipment and the remaining 25% is financed by the contractor. Loan terms are more favourable with regards to repayment date and interest rates. Light duty equipment, heavy duty equipment and ultra heavy duty equipment require 2, 3 and 4 years respectively for repayment of loans. Payment is usually on monthly or quarterly basis. The banks must be informed and duly paid any difference due before the equipments are sold or transferred outside the country.

Hire-Purchase Options

To acquire additional equipment, the contractor may:

- Purchase
- Rent with option to purchase the equipment
- Lease the equipment

It is usually more economical to purchase the equipment if it is for long term use, while it is better to rent when short term use is being considered. To help in making the right decision with regards to which approach to choose, cost analysis should be carried out.

Advantages of Purchasing Equipment

- Regular availability of equipment
- Frequency of use is higher
- Equipment is likely to be well-maintained

Disadvantages of Purchasing

- It is more expensive
- There are opportunity costs of using personal finance to purchase equipment. It could be used for other investments
- Equipment may become obsolete with time as newer ones arrive on the scene
- Purchasing specialize equipment may close the door to other profitable opportunities somewhere else which would require the use of different equipment
- There is temptation to use the equipment beyond its expected lifetime resulting in lower productivity

Renting is usually ideal when the equipment is for short term use only. But the cost of rent can be quite high, as well. A second option for renting with the option to buy can also be considered. This is ideal when the contractor believes he can use the equipment to perform sufficient work but is unsure of how much equipment time is involved. This arrangement can result in high rental rates than normal.

Owning and Operating Cost

Different methods of determining the cost of owning and operating equipment exist but, the best method is only capable of providing just an estimate of the true cost. One way of determining operating costs is to glean information from previously used equipment records but, this is subject to conditions under which it was used. Factors such as cost of equipment, conditions of operating equipment, duration of use per year (i.e., the total amount of hours used), age of equipment, maintenance and repair conditions, and the demand for the equipment on the used equipment market should help determine the cost of owning and operating the equipment.

To estimate the cost of owning and operating equipments without any past records, the buyer should consider calculating costs associated with the following: capital investment and depreciation, repairs and maintenance, and fuel and lubricant costs.

Assessment**Total Marks: 20**

1. Discuss key features of the modern construction industry. 5
2. Outline the duties of a construction supervisor. 5
3. What is the quick method of approximate estimate? Discuss the estimating procedure in detail. 5
4. Discuss the factors involved in equipment selection? Write the advantages and disadvantages of purchasing equipment? 5

