

**Principles of Construction Management**  
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**Lecture - 05**  
**Resource management in construction projects**

[FL]. Welcome to this module on Principles of Construction Management, where we are talking of different facets of management of a large construction project and in this lecture we talk about resource management in construction projects. Before we get into the discussion of this topic I must share with you that resource management is a full course in itself and we must remember that whatever discussion we are doing in this not only this lecture, but in this module all together is only a tip of the iceberg as far as the management of construction projects is concerned. There is a lot more to it than what we are talking about here and that will become clear as we go along in this lecture.

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**INTRODUCTION**

A project can be taken to comprise individual activities, each of which,

- Has a definite objective to be achieved
- Has well defined specifications
- Has a well defined (predefined) start and end dates
- Consumes resources

**Resources**

- Materials
- Machinery and consumables
- Manpower
- (Money)

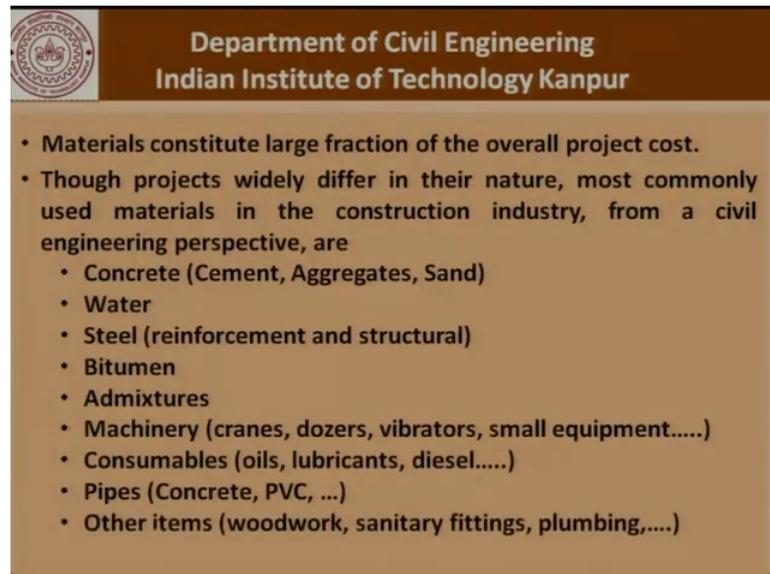
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Let us try to understand that a project can be taken to comprise individual activities each of which has a definite objective to be achieved and that is why we carry out that activity. It has well defined specifications, it has a well defined or a predefined start and end date and it consumes resources. Now as far as construction projects are concerned what is the kind of resources that are involved it could be materials, it could be machinery, and consumables it could be manpower and all of this can be converted or in

some way or form we looked upon as money. Let us look closely at the various aspects of the resources and their management.

So, coming to the first part of the discussion materials management.

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The slide features a brown header with the IIT Kanpur logo on the left and the text "Department of Civil Engineering Indian Institute of Technology Kanpur" on the right. Below the header, a list of materials is presented in white text on a brown background. The list includes: Materials constitute large fraction of the overall project cost; Commonly used materials in the construction industry from a civil engineering perspective; Concrete (Cement, Aggregates, Sand); Water; Steel (reinforcement and structural); Bitumen; Admixtures; Machinery (cranes, dozers, vibrators, small equipment....); Consumables (oils, lubricants, diesel....); Pipes (Concrete, PVC, ...); and Other items (woodwork, sanitary fittings, plumbing,....)

- Materials constitute large fraction of the overall project cost.
- Though projects widely differ in their nature, most commonly used materials in the construction industry, from a civil engineering perspective, are
  - Concrete (Cement, Aggregates, Sand)
  - Water
  - Steel (reinforcement and structural)
  - Bitumen
  - Admixtures
  - Machinery (cranes, dozers, vibrators, small equipment....)
  - Consumables (oils, lubricants, diesel....)
  - Pipes (Concrete, PVC, ...)
  - Other items (woodwork, sanitary fittings, plumbing,....)

Now, materials constitute a large fraction of the overall project cost and though projects widely differ in their nature most commonly used materials in the construction industry from a civil engineering perspective could be concrete which could be cement aggregates and water, it could be steel which is used as reinforcement or structural steel it could be bitumen which is very important from the point of view of road construction admixtures machinery consumables and so on.

The machinery could be cranes dozers vibrators small equipment and all that consumables would be oils lubricants diesel and what not then there could be pipes which could be concrete PVC steel and so on and so many other items would work sanitary fittings plumbing and all that depending on what kind of a construction project we are talking about.

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**Focus of material management**

<b>To procure materials</b> <ul style="list-style-type: none"><li>✓ In right quantity</li><li>✓ Of right quality</li><li>✓ At right cost</li><li>✓ At right time</li><li>✓ From right resources</li></ul>	<b>For each of the materials</b>  <b>Materials are not inter-changeable</b>
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**Proper material management helps in maintaining uninterrupted supply of materials to the site and also reduces storage costs by minimizing the wastage of materials**

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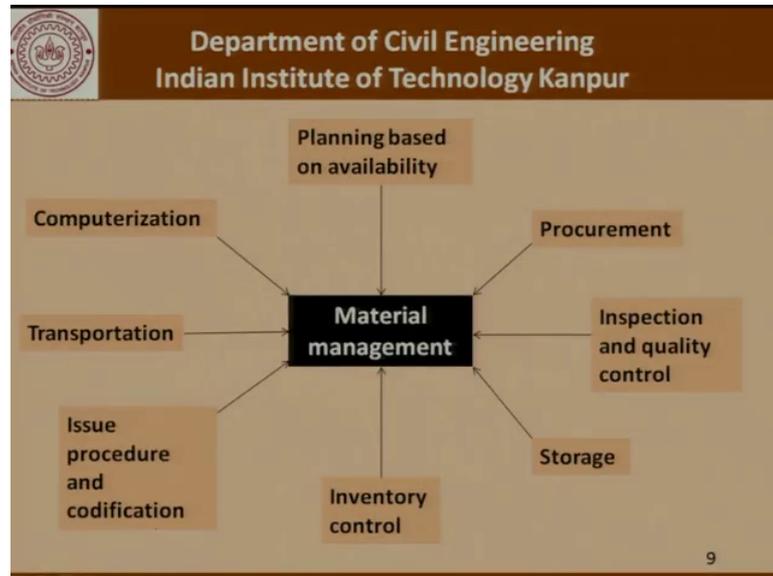
Now, having said that the focus of material management lies in procurement of materials in the right quantity we; obviously, need to have a very clear understanding of how much of what material is required of the right quality. There have to be specifications which tell us that we want an RC pipe of this diameter of this length and these numbers conforming to this standard at the right cost at the right time. Please also remember that material management involves procurement of these materials at the right time as well it makes no sense for us to buy all the material that is required in a project upfront when the material is going to be used at a later point in time.

So, we must know as to when a particular material is going to be used in the project and then try to plan for its procurement at the right time from the right sources. Now these issues have to be sorted out for each of the materials that is involved in a construction project and materials are not interchangeable, you cannot say that well I do not have a 16 mm steel bar can you use a 22 mm bar. In certain cases yes it can be done, but that puts a needless effort on the part of the site to these kind of changes if we want to introduce at the site that could cause delays.

Now, proper material management helps in maintaining an uninterrupted supply of materials to the site and also reduces the storage cost by minimizing the wastage of materials. So, we must understand that material management has a cost. The inventory if we buy a lot of cement for example, which is going to be used later. So, we have to store

the cement in a godown which is going to cost money. So, it is better to reduce the inventory cost better to a reduce the time that your inventory is there with you that is the way you can minimize the cost as well as wastage of the materials.

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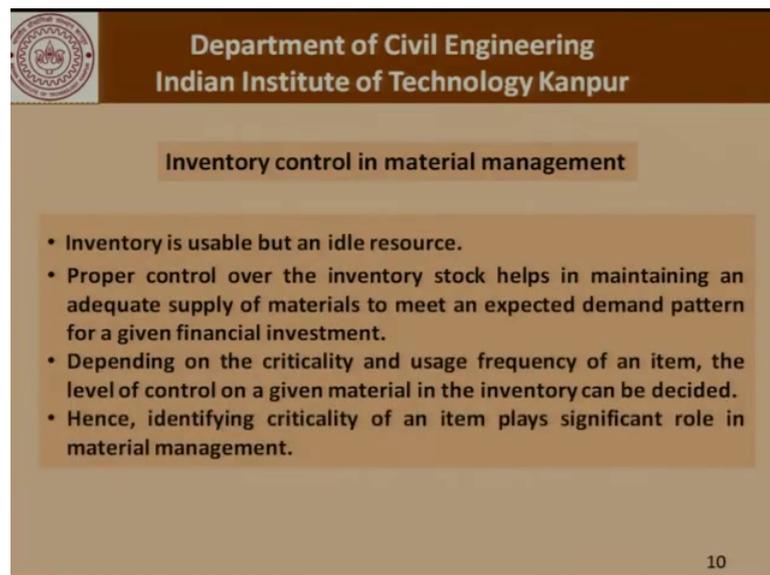
So, when it comes to material management there is a planning based on availability which is involved, there are procurement procedures involved, there is inspection and quality control involved, at times this quality control and inspection is done at the site where the material is being delivered or at times also at the site where the material or the equipment is being manufactured. There will be procedures which will allow an inspection to be carried out at the shop of the fabricator or the manufacturer to make sure that the equipment that is being delivered meets the requirements of quality then there are storage issues involved there is inventory control which is important there is an issue procedure and codification.

So, what we are talking about in this discussion today is material being procured by the client and then being supplied to the contractor or the material being procured by the contractor for the different activities that are involved in the construction of that project and be issue or being used by different agencies at the site. So, there has to be a process there has to be a procedure so that we know how much material was procured when it was procured to whom it was issued, where it was consumed, when it was consumed, whether it was properly inspected, when it came in whether the inspection has been

completed when it has gone out and so on to make sure that the material has not undergone any degradation while it is in storage.

Apart from that there are transportation issues and computerization has helped in a big way in ensuring a more sophisticated material management system for construction projects.

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**Inventory control in material management**

- Inventory is usable but an idle resource.
- Proper control over the inventory stock helps in maintaining an adequate supply of materials to meet an expected demand pattern for a given financial investment.
- Depending on the criticality and usage frequency of an item, the level of control on a given material in the inventory can be decided.
- Hence, identifying criticality of an item plays significant role in material management.

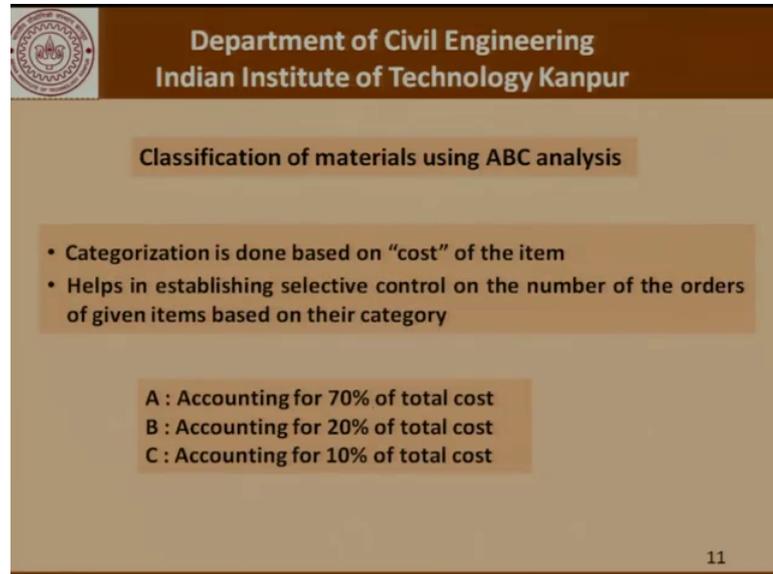
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So, inventory control and material management we are looking at inventory is usable, but an idle resource that is a reiteration of what we talked about earlier, proper control over the inventory stock helps in maintaining an adequate supply of materials to meet an expected demand pattern for a given financial investment and depending on the criticality and usage frequency of an item the level of control on a given item in the inventory can be decided. Please remember that not each item which is being procured or used in a construction project is equally critical, is equally costly is used to the same extent and so on.

So, as a contractor different levels of control we need to be exercised in its procurement different levels of caution will have to be exercised and that is something which we will talk about in the subsequent slides. Identifying the criticality of an item plays a significant role in material management. Now how do we identify the criticality of an item? One of the options available to us is what is called an ABC analysis and here what we do is we try to categorize them based on the cost of the item. Now how is the cost we

decided? This helps us in establishing selective control on the number of the orders of the given item based on that category.

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**Classification of materials using ABC analysis**

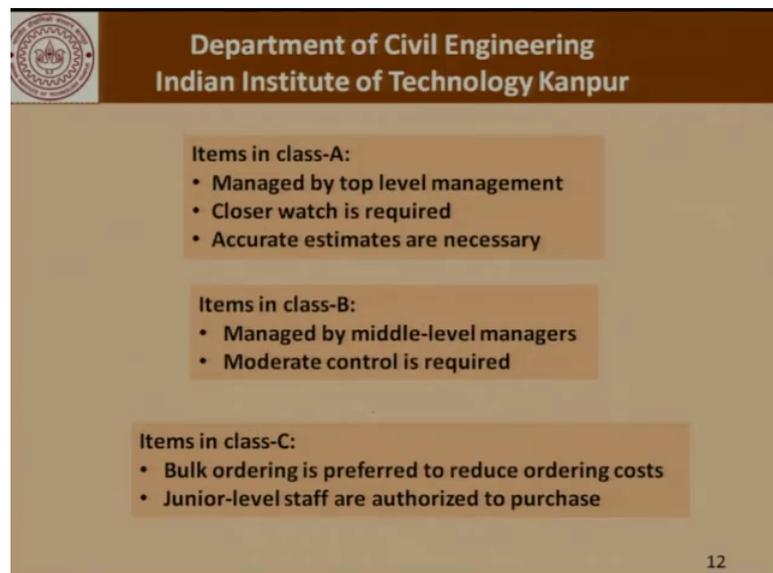
- Categorization is done based on “cost” of the item
- Helps in establishing selective control on the number of the orders of given items based on their category

A : Accounting for 70% of total cost  
B : Accounting for 20% of total cost  
C : Accounting for 10% of total cost

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We can classify items is A which account for let us say 70 percent of the cost, B which account for 20 percent of the cost and C which account for 10 percent of the cost. This will become clear as we go through an example now; obviously, from this slide it is clear that items which are classified as A need to be watched more carefully than items which are classified as C.

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**Items in class-A:**

- Managed by top level management
- Closer watch is required
- Accurate estimates are necessary

**Items in class-B:**

- Managed by middle-level managers
- Moderate control is required

**Items in class-C:**

- Bulk ordering is preferred to reduce ordering costs
- Junior-level staff are authorized to purchase

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Therefore as far as class A items are concerned they should be managed by the top level management of a company and a closer watch is required and accurate estimates are necessary. So, we do not want surplus of these items because they are simply too expensive. As against that when it comes to items in class B they could be managed by middle level managers and moderate control is required similarly for items in class C we could talk of bulk ordering is preferred to reduce the ordering cost and junior level staff are authorized to make the purchase.

So, this basically outlines a guideline for any company to come up with its own operating procedure or empowering the executives to make purchases of certain items.

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Item	Average annual consumption (No.)	Average cost per unit (in INR)	Average annual cost (in INR)	Annual cost (% of total cost)	Cumulative annual cost (%)	CLASS
c	3000	200	600000	47.75	47.75	A
a	5000	50	250000	19.89	67.64	A
b	2000	90	180000	14.32	81.97	B
d	3500	25	87500	6.96	88.93	B
f	1000	70	70000	5.57	94.50	C
h	650	45	29250	2.32	96.82	C
e	150	175	26250	2.08	98.90	C
g	450	30	13500	1.10	100	C
Total			1256500	100		

Arranging in the descending order of the avg annual cost

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Now, let us look at an illustrative example of classifying items using the ABC analysis now if we have these 8 items a to h with an average annual consumption in numbers given in this chart or the table and the average cost per unit in rupees how do we classify these items into A B or C the first thing we need to do is to find out what is the average annual cost involved in each of these items. So, if we take the average consumption and the unit cost we get these numbers here.

So, if we go beyond that and we rank the items in the order of the total cost from the highest to lowest if we do that this item here is the highest and there is this item here which is the lowest. So, if we do that kind of an exercise and rank them here so what we have done is that we have rank these items in this order or this figure here is the total

amount of money involved in procurement of all the items. So, if we take this as the base we find that item C uses 47.75 percent of the total allocation and this percentage varies to be extend that item g comprises only 1.1 percent.

So, if we take a cumulative cost here if we take these numbers. So, now, we can classify these items as A B and C, these two become class A because if we total these this number here crosses 70 at this point the number, here crosses 90 at this point and therefore, these two items that is C and A are classified as class A items b and d are classified as class B and these are class C items.

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**FOOD FOR THOUGHT**

A contractor is making a set of houses.  
Make the list of things that should be managed  
from the point of view of material management.

Repeat the exercise when you are at a railway  
platform.

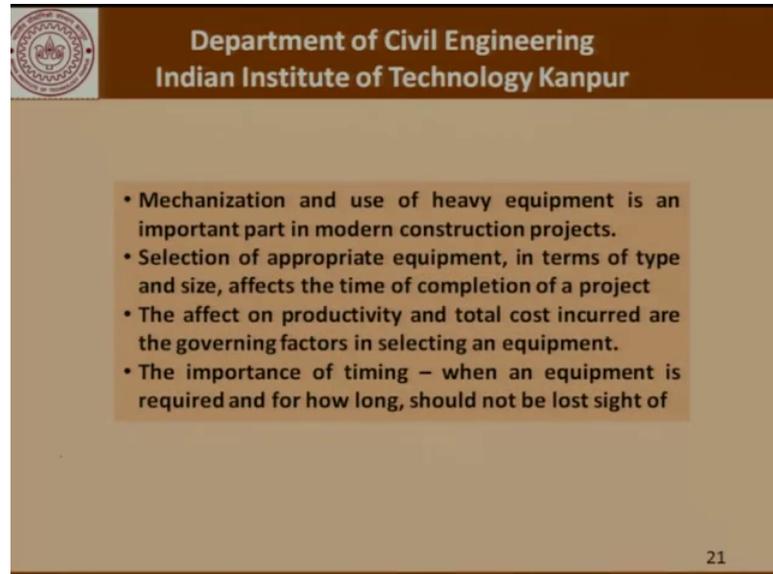
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Now, having done the simple exercise I would like to leave a few questions for you to think about. A contractor is making a set of houses just make a list of things that should be managed from the point of view of materials management. You just have to look around the house and see what are the different items that need to be procured from a contractors point of view, that must include all the items that you see in the house not counting furniture perhaps unless you are talking of furnished accommodation, but even if you are looking at bare walls it should include all items related to electricity, all items related to plumbing, the woodwork and so on.

So, once you make that list you will realize how complicated a job it is or will be to manage the inventory of all those items. Repeat this exercise when you are at a railway platform the situation will be vastly more complicated perhaps the kind of items the scale

of the items and so on is quite different. So, with this food for thought let us move on to the second resource that we talked about that is equipment.

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- Mechanization and use of heavy equipment is an important part in modern construction projects.
- Selection of appropriate equipment, in terms of type and size, affects the time of completion of a project
- The affect on productivity and total cost incurred are the governing factors in selecting an equipment.
- The importance of timing – when an equipment is required and for how long, should not be lost sight of

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Mechanizing the equipment is an important part of modern construction projects. Selection of appropriate equipment in terms of type and size affects the time of completion of the project.

The effect on productivity and the total cost incurred are governing factors in selecting an equipment and the importance of timing when an equipment is required and for how long should not be lost sight of. These are the things that we will keep at the back of our mind when we try to talk about equipment selection, equipment procurement and so on it will become very difficult for example, to make changes in a mechanical equipment once it has been delivered to the construction site or the site where it is going to be installed.

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Common equipment used during construction		
S. No.	Job / activity	Typical equipments used at site
1	Excavation / loading	Crane, clamshell, dragline, back-hoe, pile-driver, shovel
2	Compaction / grading	Sheep foot roller, grid roller, vibratory roller, steel wheel roller
3	Drilling	Percussion drills, rotary drills, Tunnel Boring Machine
4	Lifting / erecting	Derricks, boom type tower cranes
5	Concreting	Batching and mixing plant machinery, mixers, transit mixers, pumps

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The common equipment used during construction vary depending upon the job or the activity which is involved. If your talk of excavation or loading it could be cranes, clamshells, draglines, back hoes, pile drivers, shovels, and so on. If you are talking of drilling it could be percussion drills, rotary drills, the tunnel boring machine. If you are talking of concreting then your batching and mixing plant machinery, mixers, transit mixers, pumps, vibrators and so on and so forth.

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S. No	Name	Image	Used in	Manufacturer	Cost in lakhs (INR)
1	Back hoe	 <p>Source: <a href="http://www.pinterest.com">www.pinterest.com</a></p>	Excavation works	JCB	20
2	Derrick crane	 <p><a href="http://timberlandequipment.com">http://timberlandequipment.com</a></p>	Lifting and erection	Timberland equipment limited	24

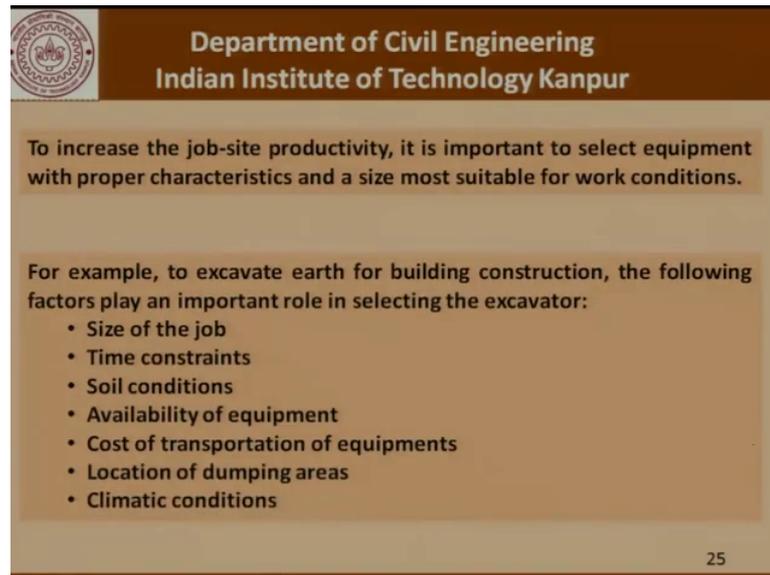
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Here is an example of two of the equipment the back hoe and the derrick crane which are used for excavation works manufactured by different people including let us say JCB and there is a cost which is given here as a illustrative number. Of course, in this discussion of this brief discussion that we are having today on equipment management there is no way that we can make a list of all the construction equipment that is used in a construction project and therefore, the simplest thing for me to do is to leave it to you, please try to make a comprehensive list of equipment and complete the table as suggested.

What I am really looking for? As far as you are concerned to be able to do this job is to understand the capacity of the equipment and try to look at the costs involved, you will realize that these costs are not trivial. You should also remember that an equipment which is procured is not necessarily consumed at that site that equipment is not like concrete or it is not like electric wires which are consumed at that site.

That is something which is carried over from one side to another and to that extent that equipment becomes an asset for the construction company. So, there is a whole lot of different thought process that goes on when the company tries to procure an equipment or use an equipment for construction at a particular site and in order to be able to do that exercise this kind of a list will come in very handy. So, once you do that exercise you will realize the complexity of the job and also get introduced to the different manufacturers who manufacture different equipment.

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To increase the job-site productivity, it is important to select equipment with proper characteristics and a size most suitable for work conditions.

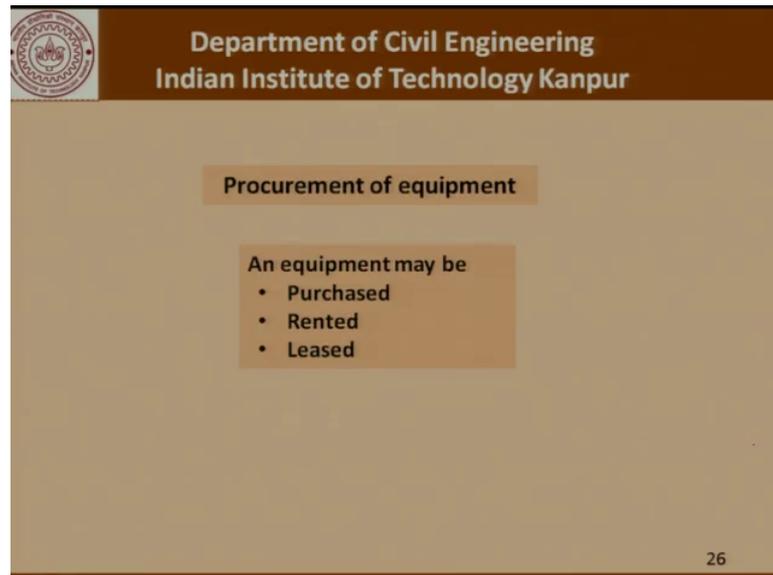
For example, to excavate earth for building construction, the following factors play an important role in selecting the excavator:

- Size of the job
- Time constraints
- Soil conditions
- Availability of equipment
- Cost of transportation of equipments
- Location of dumping areas
- Climatic conditions

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Now, continuing with the discussion to increase the job site productivity is important to select the equipment with proper characteristics and a size most suitable for work conditions. For example, to excavate earth for a building construction the following factors could play an important role in selecting the excavator, the size of the job whether you are trying to do an isolated footing or you are trying to do a raft foundation the time constraints soil conditions availability of the equipment, cost of transportation of equipment, location of dumping areas, climatic conditions and so on the engineer at site needs to keep all these conditions in mind before deciding which particular excavator will be used for that particular project.

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**Procurement of equipment**

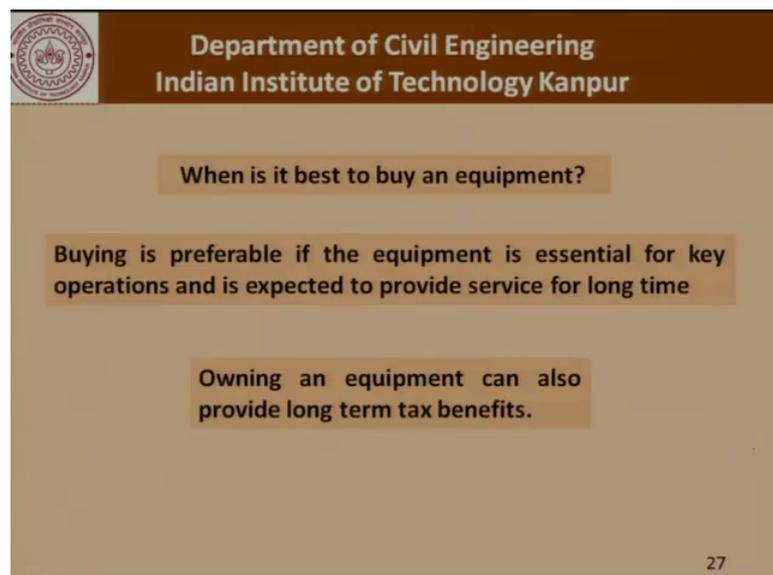
An equipment may be

- Purchased
- Rented
- Leased

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Now, let us talk about procurement of equipment basically what we are talking about is the following. We need to use a certain equipment at a certain site what are our options. The equipment can be purchased apart from purchase it could be rented or it could be leased. What is the difference between rented and leased? That is something which will clarify in a slide or two, but purchase we understand what it means.

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**When is it best to buy an equipment?**

Buying is preferable if the equipment is essential for key operations and is expected to provide service for long time

Owning an equipment can also provide long term tax benefits.

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When is it best to buy an equipment? So, let us try to just cursorily understand what are the conditions which will prompt us to buy an equipment that is the outright purchase of

an equipment. Buying is preferred if the equipment is essential for the key operations and is expected to provide service for a long time.

So, the contractor makes a decision that well in this project this screen or this excavator is going to be used and it is going to be useful to are company even in the long run in other projects that we are going to do. Owning an equipment can also provide long term tax benefits as we will probably see it some other point in this course, if we decide to buy an equipment then what are the considerations that should operate on our mind in making that I choice.

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Considerations in equipment purchase

- Technology
- Post warranty repair and associated cost
- Availability of maintenance and repair facility with minimum downtime
- Low operating costs
- Availability of consumables
- Ease of installation and operation

A B

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What is the technology involved? What is the post warranty repair and associated cost? What is the availability of maintenance and repair facility with minimum downtime? What are the operating costs? Is there a proper availability of consumables and spares and what is the ease of installation and operations? So, these are some of the things that must be considered when we are trying to evaluate one equipment versus another from the point of view purchasing it.

So, once we have a list of these items we can almost compare to equipments A and B in terms of technology in terms of the post warranty repair and associated cost the operating costs and so on and so forth and then decide whether we will buy A or we will buy B.

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**When is it best to rent an equipment?**

Acquiring an equipment on rent is preferred when :

- Trying an equipment before buying it
- If the requirement is limited for short duration
- Operating only in case of special projects
- If the owned equipment is out-of-service

**When is it best to lease an equipment?**

Leasing an equipment is preferred if the equipment is expected to be used frequently and sufficient resources are not available to purchase

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Now apart from buying there is the option of renting an equipment. Acquiring an equipment on rent is preferred when trying an equipment is an option before buying it. If the requirement is limited for a short duration and we do not want to make an investment into buying that equipment the equipment is required only in certain special projects and if the old equipment is out of service.

So, a basically saying if you already have the equipment we do not need another equipment of the same nature, but for some reason the equipment that we have is not working and therefore, as a short term is stop gap arrangement we need to rent an equipment. Now apart from renting there is the option of leasing the equipment and leasing an equipment is preferred if the equipment is expected to be used frequently, but sufficient resources are not available to purchase. So, it is because we cannot buy it we lease it on the long term basis which is different from renting it which is for a short term.

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The slide is titled "Department of Civil Engineering Indian Institute of Technology Kanpur". Below the title, it states "Workforce in a construction company consists of". It lists two columns of roles:

- Architects
- Engineers (Design and Site)
- Managers (Divisional and sectional)
- Human resources
- Tendering team
- Accounting personnel
- Drafting personnel
- Labor
- Drivers and security staff

- Welder
- Carpenter
- Bar benders
- Mason
- Mixer operators
- Crane operators
- Workers performing blasting operations at quarries
- .....

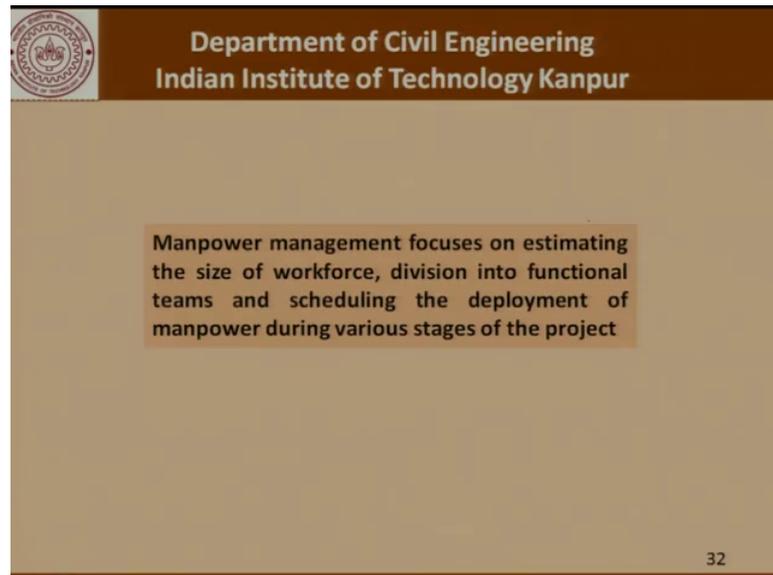
Each has its own qualifications, certifications, licenses, etc.

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Now, coming to the third part of our discussion which is manpower management - the workforce in the construction industry comprises of architects, engineers which could be from the design office, or at site managers divisional and sectional managers, human resource team, the tendering team, accounting personnel, drafting personnel, labor, drivers the security staff and the list goes on welders to carpenters to bar vendors, masons, mixer operators, crane operators, depending on the kind of job if you are doing plastic in quarries it could be people are involved in the blasting operations.

Now, we must remember that each of these cranes has its own qualification, certifications, licenses. So, a person who is operating a crane has to have a proper license has to be fit there are fitness criteria associated with that. A person is operating as a welder that person needs to have the right kind of certificates; he has to have the right kind of qualifications. So, managing a site involves managing a vast diversity of personnel who are qualified differently and have different responsibilities.

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So, basically manpower management focuses on estimating the size of the workforce, division into functional teams and scheduling the deployment of manpower during various stages of the project. Much like as in the case of equipments different kinds of people are required at different stages of the construction work. Civil engineers are required in the beginning when certain kinds of construction is going on, mechanical engineers are required when the certain erections of equipment and so on is going on.

So, for example, civil engineers are required at the outset when we are trying to do the construction activity. If we consider a industrial construction mechanical and electrical engineers would come in later welders would come in slightly later when there is erection of pipelines or erection of equipment going on. So, the task of a project manager is to carry out this exercise in a very effective and a optimal manner.

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**Project manager**

- Plays a very crucial role
- Should have a proper balance of technical skills and behavioral skills

**Traits/skills of a project manager**

- Team building
- Leadership
- Conflict resolution
- Technical expertise
- Planning
- Organization
- Entrepreneurship
- Administration
- Management support
- Resource allocation

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Now, with this discussion let me close by talking about the project managers role as such it is a very crucial role and it is expected that he will have a proper balance of technical skills and behavioral skills and what are the kind of traits or skills that are expected in a project manager could include team building, leadership, conflict resolution, technical expertise, planning, organization, entrepreneurship, administration, management support, and resource management. So, only if you have all these skills you can be a successful project manager at a construction site.

So, with this we come to an end of the first module of this course on construction management where we talked about largely the project management or construction management in a generic sense. What we will do from now on is to try to get estimates of quantities from drawings move on to cost and other aspects related to management of construction projects.

Thank you.