Modelling and Analytics for Supply Chain Management
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Lecture-20
Warehouse layout

Hello in the previous lecture. We had spoken about the total cost model for warehouse location. We took the fixed cost and variable cost and we showed you. How at 1 location also, we can have 2 or 3 warehouses. We have to set up an integer programming problem for that, problem formulation. Then we shifted to and we moved into how to convert a cost model into a revenue model? Because companies are not interested in minimizing cost only. They are also interested in maximizing profit.

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So in a warehouse location model it is not only necessary that your product will move from place a to place b. We also have to see that in at at a minimum cost. We will also have to see that this entire movement is at the maximizing profit level not at the minimizing cost level so what we did? Instead the demand constraints which were earlier equal to sign equal to sign means demand at a particular place has to be fully met. For example, demand in Delhi is equal to 20, equal to 20 means demand in Delhi has to be fully met with supply 20 quantities no matter where that comes from Madhya Pradesh, Himachal Pradesh or Uttar Pradesh.

So demand has to be made. Demand has to be satisfied. But in a revenue models since we are maximizing profits. What happens? In a revenue model the profit is a function of both the maximum retail price or the mrp as well as the cost. So profit is mrp or selling price - cost. So

where ever the selling price is fixed all over India, because the products are coming with a price tag printed right from the factory.

So the selling price is fixed. So the only way where which we can maximize profit is by reducing cost. Reducing cost means I will send more goods to that place where I have less transportation cost. And then I will increase my marketing activities and might be I will sell all the quantities in that market.

So I will send more goods to a particular location where the cost is less. So then the margin that is selling price - cost will increase. To do that if I set demand equal to sign then that can not be done. I have to put less than equal to sign. Because I am I have the option to send less, if I put equal to sign then I am not optimizing profit, so this is were we end it.

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Then I have the last question with modelling for warehouse location and that is GST goods and service tax. You all know that GST has been implemented in India just about few years back and the advantages you need not to pay the separate taxes, when your products are entering different states or region of the country.

So earlier what happend was warehouses were set up in almost every state of the country. Why? Just to take local tax advantage. So mathematical modelling was secondary local tax advantage was primary. Now with introduction of GST you are paying uniform tax where ever you are in the country. So that local tax advantage is gone.

So now the role of mathematical modelling comes, I will set up my warehouses only at that place where I will either minimize cost means c or I will maximize profit max z. Because tax is same every where. So my cost will be equal in terms of tax every where. So that that is the advantage that GST has given and a challenge also to supply chain.

The entire modelling is changing because of GST, all your warehouse locations are being redrawn. Some cases some places small warehouses are being clubbed to form larger warehouses, just to have efficiency increase the economies of scale, improve the economies of scale. So this thing they are happening. Now the point is how can we use GST? Or how can be model the GST into our mathematical framework?

In a very very easy manner, so that this decisions can be taken even at the mid management level where to have a warehouse? Where not to have a warehouses. Remember modeling, mathematical modelling always have to kept very simple. This is what I repeatedly tell because look not all our organizations can afford people, who can do very very advance modelling.

Because the financial charges for this experts will also be very high. So it is a bit difficult for the medium and small scale industries to have consultation with the supply chain planning and design people, number 1. Number 2 even after paying a high consultation charge, we have been presented with beautiful mathematical model.

But then who will run the model? Who will take care of the day to day issues with minor changes in the modelling? Because situation and things will vary from organization to organization. Who will take care of this? Say again you need somebody in the organization who can understand. Then again you can not afford because they are charging very high premium for it.

So modelling has to be very simply done for the msmes. Smaller medium scale enterprises. Because otherwise it is very difficult for the medium scale enterprises small and medium scale enterprises to use these techniques and reduce cost and increase profit and sustain. So be always be very careful about how you are modelling? It should be simple it should be understandable, so the issue now is GST, how to inbuilt GST in the same model that we had drawn.

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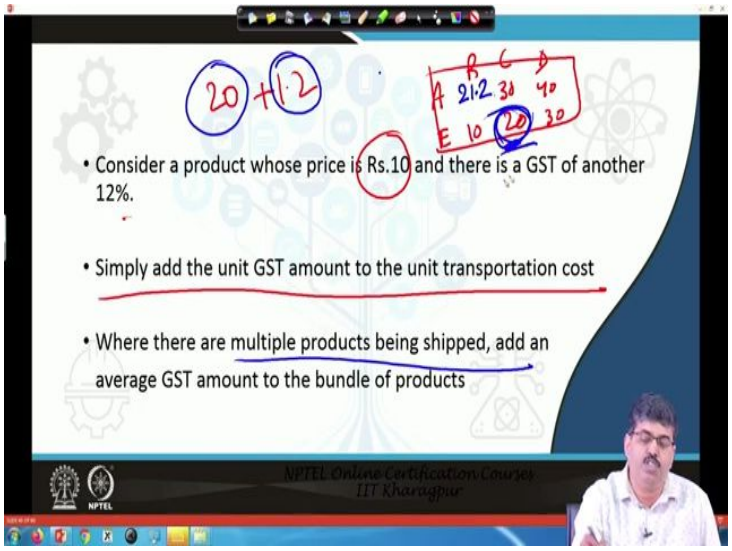

This is what we were speaking about. Consider a product whose price is rupees 10 and there is a GST of another 12 percent on the product. It is very simple yes you can you can find unit? You can according to situation but overall it is very simple. Simply add the unit GST to the unit transportation cost. Simply add the unit GST amount to the unit transportation cost. So if you remember this matrix from a to b, it was going and transportation cost was 20 rupees 20, 30, 40 then.

So this was my transportation metrics, 20 rupees is the per unit transportation cost, simply add GST. What was GST? 12 percent of rupees 10, so 1.2. So instead of writing 20 rupees here in this cost box instead of writing 20 rupees here, what you write 21.2. That is solves

your problem. Now it becomes a minimized cost problem or maximized cost problem, no issues.

Simply add GST to the unit transportation cost that is it. Where there are multiple products being shipped which is the rule for any organization, add an average GST amount to the bundle of products. This is the unit transportation cost, for the bundle. Whatever the GST is different products have different GST, add the average GST amount add to it finished your job is done.

So this is the simplest way by which you can incorporate GST into your mathematical models. GST is no rocket science nothing to fear. The simplest way to incorporate GST. Simply add this tax component to your transportation cost and where ever there are multiple products add GST average GST to all this to the average transportation cost of the products. Because then the transportation cost per unit is average, so just add the average. This is what we want to say about GST.

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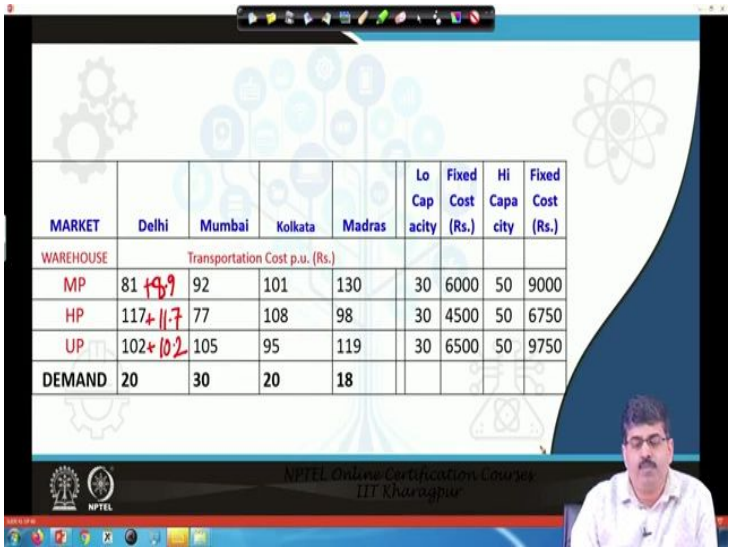

So as we said just keep on adding the GST quantity, just keep on adding the GST amount. So 81 + lets 12 percent, 8.9 rupees, 100 let us say 10 percent 117, so it will be 11.7 rupees. 102, 10.2 rupees. Just keep on adding and then it becomes same cost model no harm no issues. So this is how you can deal with GST. This is how you can deal with GST agreed.

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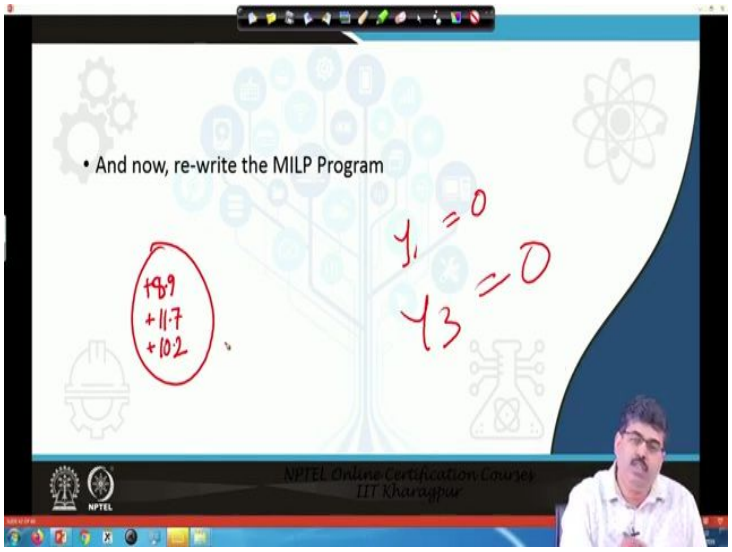

So with this a now definitely as you measure you can the re write the you can re write the mixed integer linear programming program. Just change the cost data just change the just keep on adding the cost.

And change the cost metrics the fixed cost remains same and then what will happen? your y 1, may be 0, that means even if you have warehouse there close the warehouse. Y 3 may be 0 if you having the warehouse close it, if you do not have it do not even open it. So GST just add the cost that is what we want to say.

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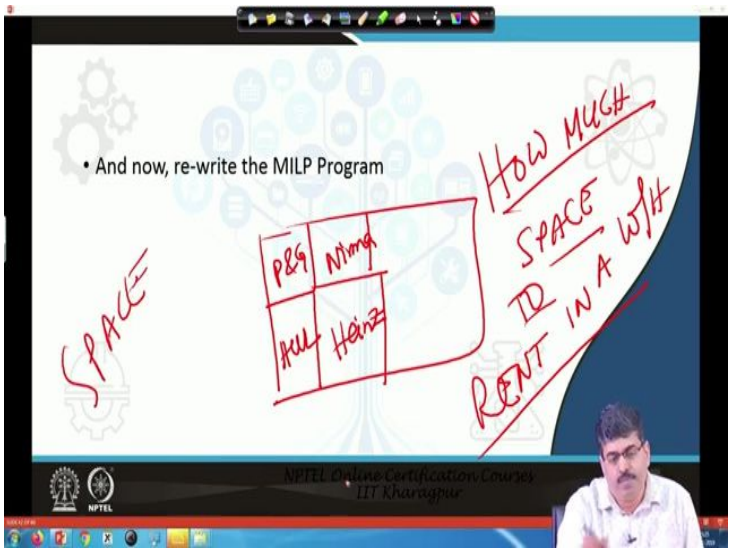

Now with this we basically finish off with the warehouse location problems. Now once you have finished off with location that means you have decided on, where to locate the warehouses. Then next comes is inside the warehouse, you decided I will locate my warehouse here, inside the warehouse. What do you mean by inside the warehouse?

Most important part inside the warehouse is how much space do it need? And space means cost, per square feet, per square meter cost. And most of the companies do not own there warehouses now a days. There are huge organizations owning huge amount of warehouse space that means they own warehouses and inside every warehouse there is huge number of square meter or square feet space.

And they rent portion of that space to different companies or organization. So basically you have such a big warehouse you have a very big warehouse. Who are you? You are not Procter & Gamble, you are not unilever Hindustan Unilever. Who are you? You are a warehouse leasing company, you are leasing out this much of space to PNG, these much of space to Hindustan Unilever.

This much of space to Nirma, the most popular brand name which is eclipse the name of the company. This much to Heinz etcetera. So the next question that comes which is most important is how much space to rent in a warehouse? More space you rent, more cost.

And particularly if your sales are down for some reasons or other in some quarter then you are incurring unnecessary cost. So how much space to rent in a warehouse? How much space? So Again space.

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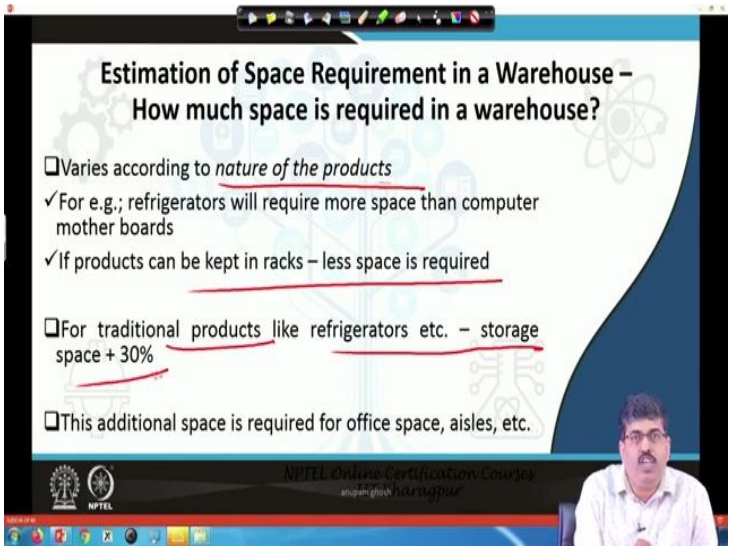

This is our next thing in now, Space requirement in a warehouse. Now see let us have some little bit of discussion, the space requirement varies according to the nature of the product. In your own house as you let us take your own residence. You are having a table on which you keep your books. You keep book 1, then book 2, then book 3, then book 4, then book 5 and you can keep on keeping 10 books, no problems keep on keeping 10 books.

But more than 10, 11, 12. What will happen? The slide tilt this side all the books will fall. Now assume you are having speakers for your computer, you have just received them from a shopping company, you have not even open the covers and you have kept them in the table so it is in a package.

It is in a packing or package, whatever you want to say, now how many books will keep over those speakers? How many? 1, 2, 10, 15 most probably you will not keep anything on the top of those speaker box. Why? Because it is a delicate product. If it falls it might stop functioning. So estimation of space required in a warehouse how much space do we require?

How much space is required for a warehouse? That depends on the nature of the product That depends on the nature of the product, if you are storing refrigerators in a warehouse, you will only keep 1 refrigerator, you will only keep 1 refrigerator then beside it another refrigerator beside it another refrigerator, not on 1 top of another, not possible.

But when you are keeping flat tvs, flat tvs in the warehouse the LCD, or the led tvs then you can keep 2, 3, 4, 5 stackings, stacking height. So space requirement in a warehouse estimation it varies according to the nature of the products. We were talk talking only about the fmcg and fmcd products. Think of the rice sack every day we require for our staple food. How many stackings?

Stacking means 1 over the other, if 1 book is kept on top of another book, then how many stackings? 2 stackings. 1 book then next 1, 2 stackings. Book 1, book 2, book 3, 3 stackings. Book 1, book 2, book 3, book 4, 4 stackings. So for a rise sack how many stackings? 1, 2, 3 and there is a simple way as we said your modelling is not always too much complex mathematical modelling.

It should be understandable, implementable always remember this all through out your life, it should be understandable it should be implementable. So modelling imagine I hope all of you seen rice sacks they are quite tall enough height wise. Now the question is how many rice sacks can you keep? How many stackings? How many rice sacks can you keep 1 over the other?

1 stacking means only 1 rice sack no nothing on top of it. 2 stackings means 2 rice sacks, 3 stackings how many? Question answer is very simple. 1 worker will stand there and most probably will take the rice sack on his shoulders and move and put it in some vehicle put it in the loading cart on the wheel cart. So he will take it on his shoulder and put it on the loading cart.

What is the height of the individual? 5 and a half feet, and he should be just he should be able to stand and put the edges of the sacks on his shoulder and move. So simple without even

applying mathematics. You can say that it is 2 stackings, 2 stackings of sacks of rice then you can easily put it on the shoulder and take it to the nearest trolley.

So see it as we said nature of the products the stackings the space required in the warehouse will vary. If products can be kept in the racks, less space is required, that is therule of thump. For traditional products like refrigerators, storage spaces 30 percent sorry storage space is whatever the area or volume of the that particular product + 30 percent.

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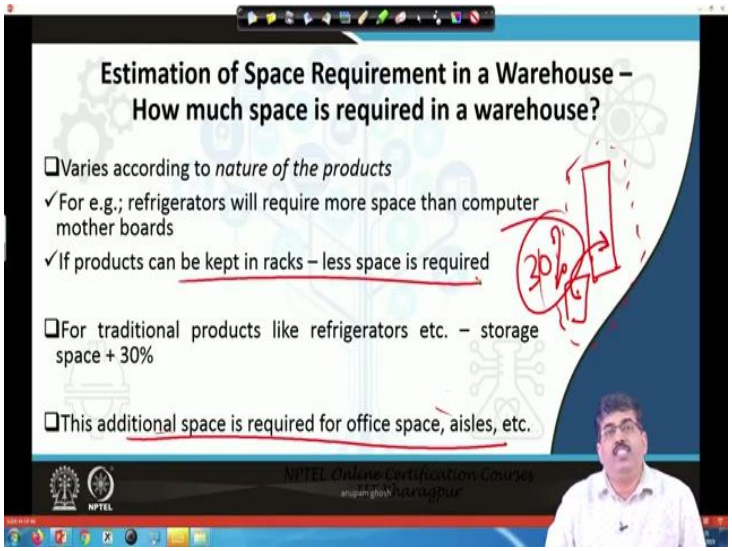

Why this 30 percent? Because you know I will show you know this is a refrigerator in the warehouse, a trolley comes and picks it up. Somebody has to put the refrigerator in the trolley because not all warehouses are fully automatized. Somebody has to put it from the trolley in it is space. So you need some space around this to move it. to place it. That is what is your 30 percent

As we said this additional space is for aisles, movement, office space etcetera some cases are another additional 30 percent, we will see we will learn this. So if products are kept in racks less space is required. So see varies from product to product. I hope all of you have seen these is aerated drinks, the cold drinks.

The Coke and Pepsi and Thumbs Up they have a plastic wrapping, very thick plastic wrapping all along and there will be 10 bottles or 12 bottles in 1 plastic wrap, they are very hard plastic wraps. So you can pick up the entire thing and take it and put it in the vehicle. So question is that is kept on the floor those 10 bottles, 10, 2 liters bottles. How many stackings?

Were it be the shoulder height no. What height? It will be your waist height because you have to take it by your hand and your hand level is this your hand level is your shoulder sorry your waist. So it should be your waist height. That should be stacking height of a coke, Pepsi bottles stacking heights, so it varies.

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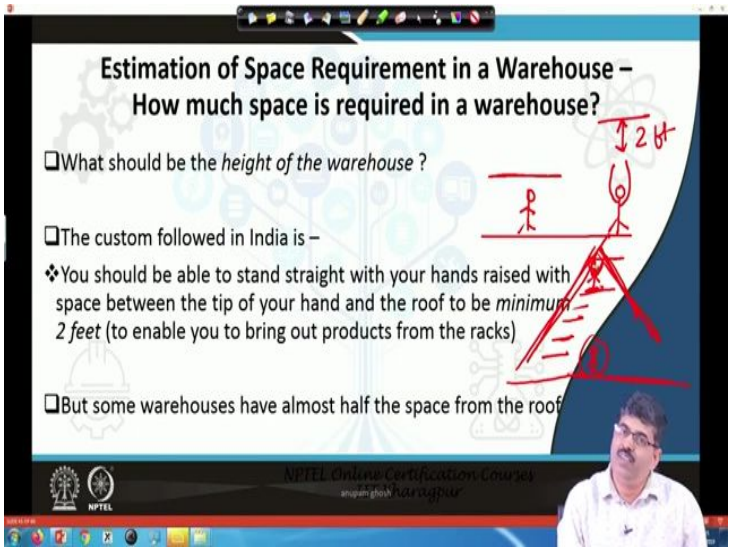

Now next question these are snapshots next question. What should be height of the warehouse? Now the custom that is followed in India, height of the warehouse Custom that is followed in not stacking height, height of the entire warehouse. Roof till floor the custom followed in India is you should be able to stand straight with your hand raised with space between the tip of your hand and the roof to be minimum to 2 feet.

To enable you bring out the products from the racks that is point number 2. You should be able to stand straight with your hands raised space between the tip of your hand and the roof to be minimum 2 feet. That means that is explain this this is the floor of the house here is a human being standing. So this roof of the warehouse should not be like this.

The human being means hands raised in space like this why? Because again you have to pull something on your shoulders or something. So hands raised and 2 feet between the hand and the roof that is the normal stacking rule for height of the warehouse. But you will ask me but sir warehouse is unlike huge height is huge huge height of warehouses.

So it is not only 1 human with hand up up there it is it is it is about a 20 humans standing 1 above the other that will be the roof of the warehouse. You are correct, but you know something this is the warehouse. There are multiple layers this are rackings racks. So height

is the worker is not at the ground the worker is on the top most rack and then he is raising his hand, there after 2 feet.

Worker not at the bottom worker is at the top of most rack and then raising his hand. That is what we call as the height. But yes some warehouses have almost half the space from roof, may be they are using machines so they do not need that space. Things are changing a bit over time and it will change further.

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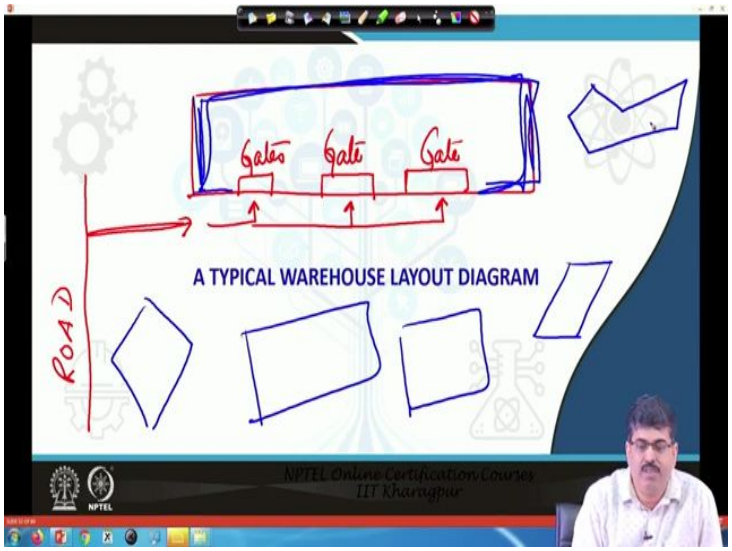

Now let us quickly look at a typical warehouse layout diagram, typical warehouse layout. What do you understand? What do you mean by warehouse layout diagram? Warehouse layout diagram is this is my gate outside is the main road. And vehicle enters and here is my warehouse.

There will be gates here. So vehicle enter some vehicle go at this gate some vehicle go at this gate and some vehicle go at this gate. These are... Our job what do you mean by this heading typical warehouse layout diagram? We want to know what is there inside this warehouse? Why are we doing all these? What is the role of these diagrams in modelling and analytics?

Unless you know how the warehouse diagram looks like from inside? Not all warehouses are square. Not all warehouses are rectangle. Not all warehouses are diagonals, so diamonds. Not all warehouses are parallelogram. So each some warehouse may look like this. This is the layout diagram of warehouse, very few but then this might be the layout of diagonal of warehouses. So unless you know how the warehouse looks like you cannot calculate spaces. Space calculation requires you to know the layout diagram or vice versa also.

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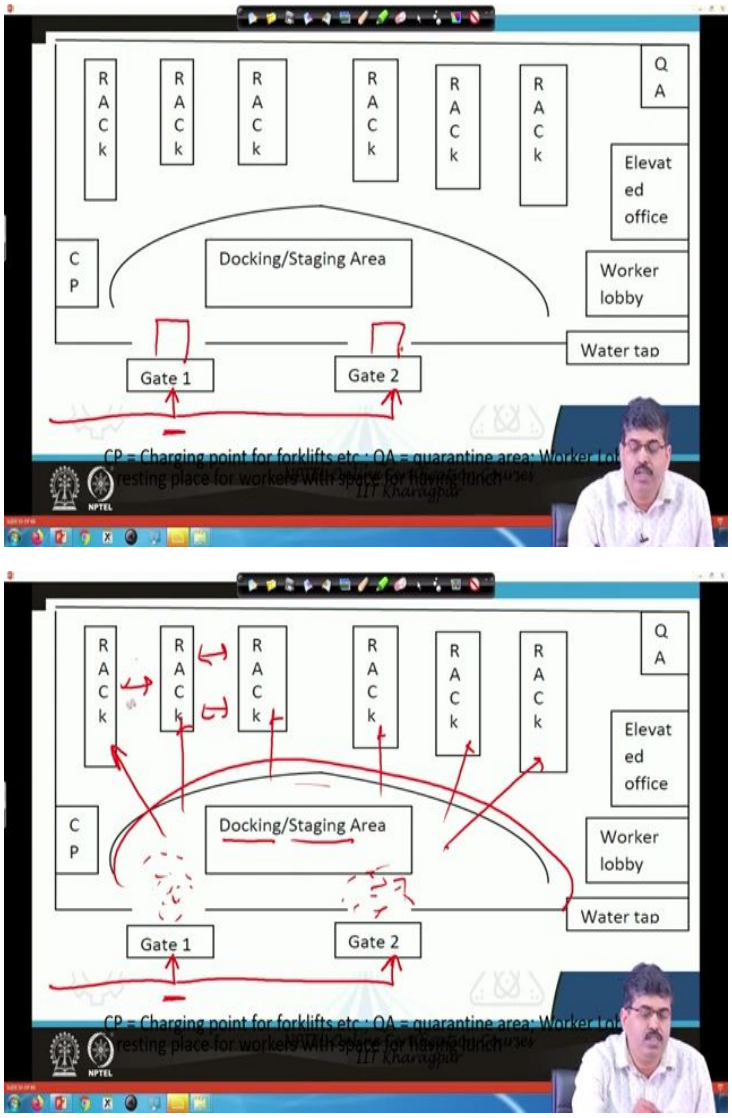

So a typical warehouse layout diagram will look like this, just look at it for a second. As we mentioned the vehicle enters either goes to gate number 1 or goes to gate number 2. Now once it goes into this gates this are the openings. This is where the trucks will enter, the trucks will enter facing in front. Back is facing the warehouse why? Then the back dalla of the truck the back door of the truck will open and they will dumbs the goods inside. Now once your open sorry once you were once your truck is here at gate number 1 or gate number 2.

Then you start dumbing the products in this area. That is why this is called as a docking area or staging area. So whenever a loading un loading is happening the products are kept here for sometimes, then either loaded or after unloading there counted and all and then they are send

to the racks. As you can see this are the aisles or the space between the racks. What is the purpose of this spaces?

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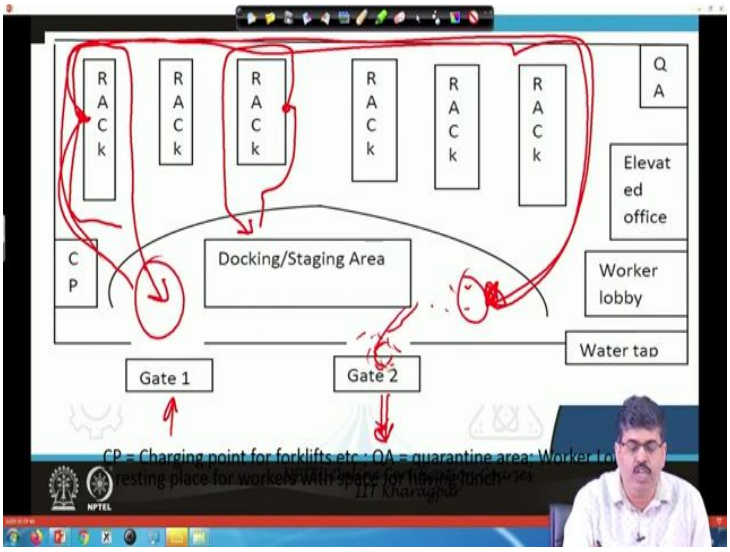

What is the purpose of these spaces? The purpose of these spaces is a forklift will go pick up the products do not come back that way go there and come back this way and dumb it here.

Another forklift will go you may go this way no problem but then different organization has different rules pick up the products go up till the end come back and dock here, so this is the way. In some cases where the warehouse space is less then it goes picks up travels the entire distance and then drops it here. If suppose gate 1 is for receiving goods.

And gate 2 is for dispatch then this model may be followed it picks up goes till this end comes down here and drops the product here. Then they are picked up for this gate for dispatch. So this is this space is the unloading and this place is the loading gate. So this is this is what the racks are for they kept in the racks after counting and this is c p. What c p means? C p means charging point. Most of the warehouses now have forklifts which are operated by battery and this is the charging point.

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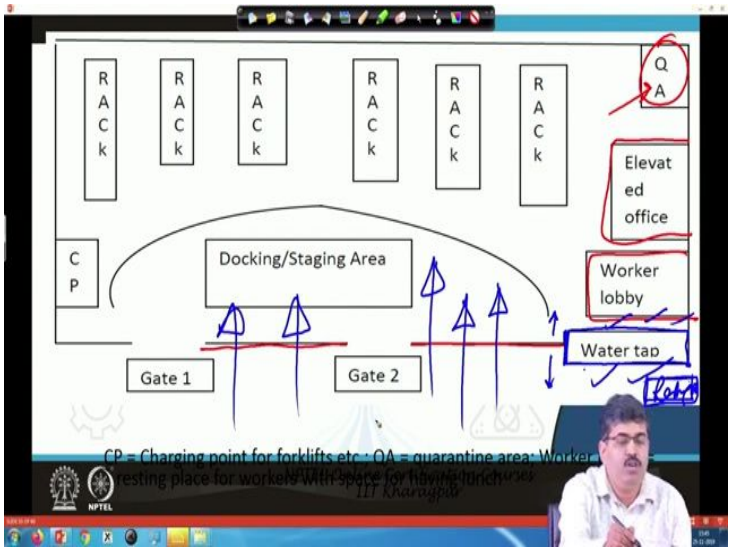

Now if you see at this end this is something called q a. Q a is quarantine area certain product which are broken may be it is hair oil or shampoo, they may be broken containers some leakage something something so they will be taken here quarantine area. And it is a caged enclosure so that nobody can and always locked the key is under the warehouse managers supervision. So nobody can actually open the cage and again lift up the products which have been kept there, and after sometime regular interval some body basically takes care that this products are destroyed. Somebody takes care that the products are destroyed.

Now there is an elevated office. What do you mean by an elevated office? Elevated office means the office is not in the ground office is not in the ground. It is always on props iron

bims are there office will be on top, why? This is office since the warehouse is very very long in height it means roofs are very much above.

As you were just mentioning, so if you if you at the height it is very easy to supervise down. What is happening? Where things might go wrong? So that is why warehouse is also on top always on top 1. 2nd reason why warehouses are on top is, then you can use the space below. Though the rule is we should not store anything below that space.

But again some people rest worker rest may have their tiffin etcetera . So as we mention this is the worker lobby. Where they can take some rests they can have their food etcetera. Now if you notice very carefully this is something that you need to be very careful just. This is the wall of the warehouse of the storing area and this openings are the gates were the trucks are loading unloading goods.

If you see here the water tap. If you see this water tap half of it half of the wall of the water tap is outside the gate and another half is inside. This is the water tap. Half of the water tap portion is inside and half of it is outside. What it means is? There central water pipe 3 or 4 or 5 taps will be outside the warehouse wall this side. And 3 or 4 taps will be inside the warehouse here.

Central water pipe carring the water on 4 outlets inside and 4 outlets outside, why? So that the workers were working is inside need not come out for water every time, it safe time, it safe energy and every time they have to come out there is some security check every time they have to go in there is a security check. So unnecessarily waste a lots of energy, lots of dissatisfaction also said in.

Why is the water tap outside? The truck drivers are coming there are other people who are coming to the warehouse, so if they want water they also need not go inside. Ideally you should not allow a 3rd person to enter the warehouse other than your own staff members and somebody who is coming for work. So the truck drivers whose only whose job is to take the goods and deliver.

Or to keeps the goods or to dumb the goods inside to, so they have no reasons no business to be inside the warehouse. So they will drink water from here. And outside at this side there may be a rest room or were they can take rest for some time. This is a rest room rest room does not mean wash room, rest room means were they can take rest for sometime.

There will be small room with the fan etcetera . So basically the idea is no 3rd party will enter the warehouse for a reason which is non-describable. So this is pretty much the diagram of a warehouse. Now next lecture onwards we will tell you how to calculate warehouse space? And like how to decide on how much space we required? How to reduced warehouse space? How to decide on warehouse? How much space you require and how to reduce the warehouse space? So thank you for today. We will carry on with the discussion in the next class.