Plant Design and Economics
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Lecture No-08
Plant Location

Welcome to lecture 8 of plant design and economics. Where will you locate your plant? That is a very important decision that you have to take, often times the success of your project heavily depends on your plant location. It is obvious that there will be various factors which will govern your choice, there cannot be a single factor which will be used to determine the location of a plant; usually there will be various factors.

So today's class will learn about the various factors that are used to determine the location of a plant. These factors are of very types, there will be technical factors, there are political issues as well as. So let us be familiar with various factors that are used to decide the plant location.

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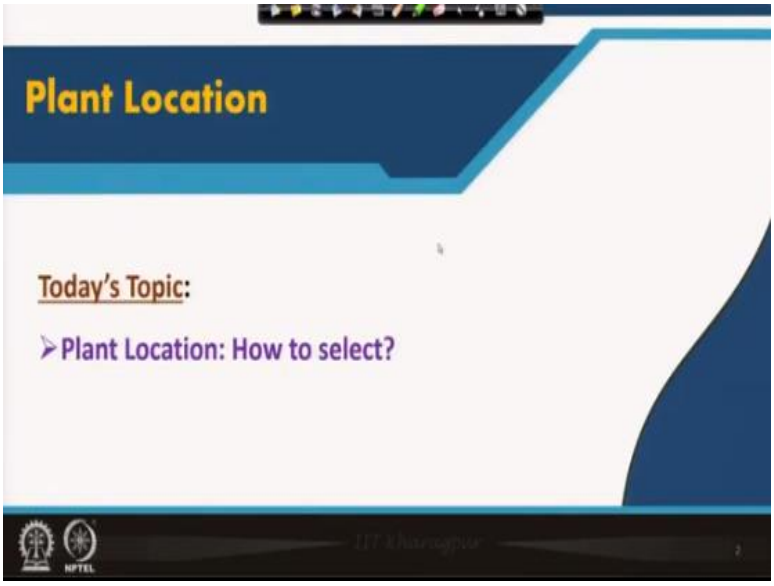

So, how to select a plant located, is today's topic.

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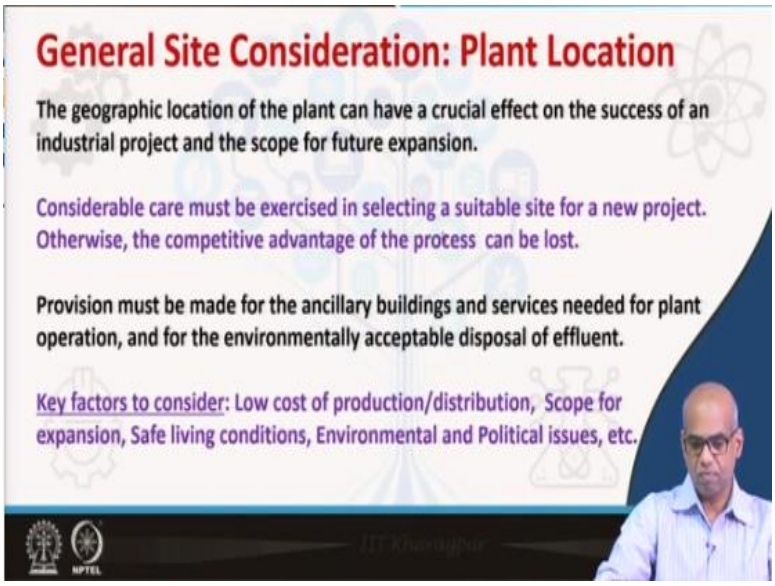

The geographic location of the plant can have a crucial effect on the success of an industrial project and the scope for future expansion. Considerable care must be exercised in selecting a suitable site for a new project. Otherwise, the competitive advantage of the process can be lost. Provision must be made for the ancillary buildings and services needed for the plant operation and for the environmentally acceptable disposal of effluent.

Obviously there will be several factors, but some of the key factors that are heavily used or heavily influence your choice are; low cost of production, low cost of distribution of products, scope for future expansion, safe living conditions for the personal in the industries, environmental issues and political issues. Note that no investors will be very happy to go and invest in a place where there is political unrest.

Also environmental issues are very important, and sometimes the cultural issues are also important, the industry must be acceptable by the local community.

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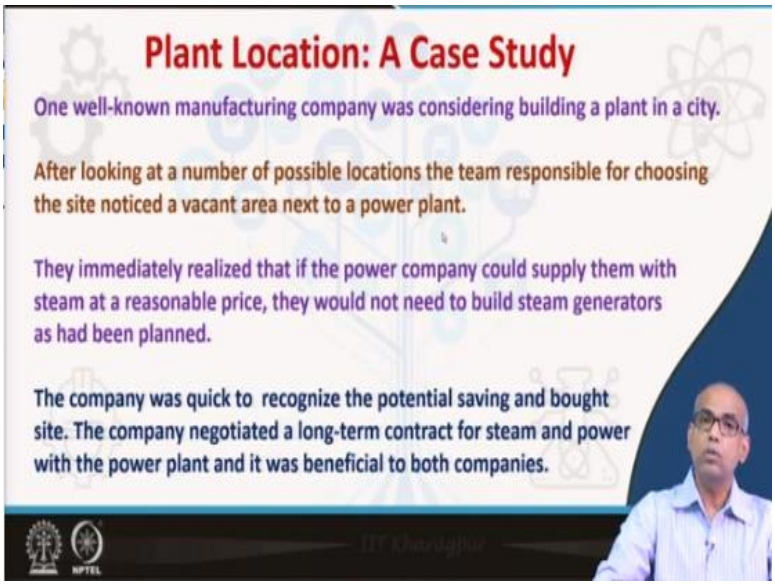

Now, let us consider a case study: one well known manufacturing company was considering building a plant in a city. After looking at a number of possible locations the team responsible for choosing the site noticed a vacant area next to a power plant. They immediately realized that if the power company could supply them with steam at a reasonable price, they would not need to build steam generators as they had originally planned.

The company was quick to recognize the potential saving and bought the site. The company negotiated a long-term contract for steam and power with the power plant and of course, it was beneficial to both the companies.

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Let us consider another case on satellite plants. Satellite plants are plants that either use a by-product or a waste stream from another plant or are built mainly to supply a needed chemical to an adjacent plant. The nearby presence of another plant determines their location. In 1965, the Dow Chemical Company at Midland, Michigan, USA gave an adjoining site to American Salt Company, both got benefit from each other's presence, how?

Dow had excess salt after recovering bromine from brine. The Salt Company could buy this from Dow at a much lower transportation cost, because the brine was easily delivered to the Salt Company through pipeline. Dow was also able to sell the excess salt stream. Otherwise they would have pumped it back into the ground. So it was beneficial for both companies.

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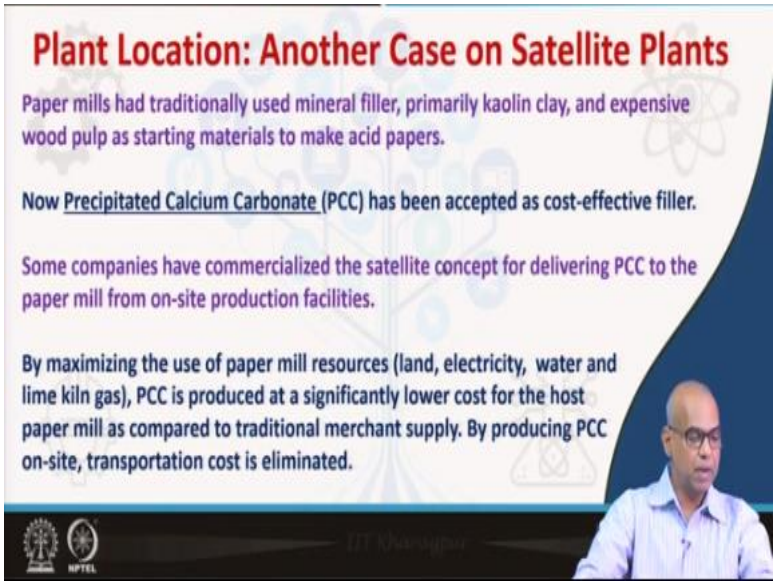

Another case on satellite plants, paper mills had traditionally used mineral fillers, primarily kaolin clay, and expansive wood pulp as starting materials to make acid papers. Now Precipitated Calcium Carbonate known as PCC has been accepted by the paper mill companies as a cost effective filler. Some companies have commercialized the satellite concept for delivering Precipitated Calcium Carbonate to the paper mill from on-site production facilities.

So some companies will set up the PCC production facility at the site of the paper mill, and these companies will use the resources from the host paper mill. The resources such as land, electricity, water and lime kiln gas will be used by the PCC production company from the host

paper mill. So the Precipitated Calcium Carbonate will be produced at a significantly lower cost for the host paper mill company as compared to the case when the paper mill company would buy from traditional companies.

By producing Precipitated Calcium Carbonate on-site, transportation costs for PCC will be eliminated. So the host pepper mill will let use resources for the PCC producing company and in return both will be benefited.

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Minerals Technologies Incorporated USA has recently signed an agreement with Century Pulp and Paper an Indian company to install a 45,000 metric tons per year satellite Precipitate Calcium Carbonate plant at its paper mill in Nainital, India. PCC will be used instead of costly wood-fiber as the paper filler to improve brightness, opacity, bulk and to reduce the cost. Minerals Technologies Incorporated also has a satellite plan for J K Paper at Odisha.

Precipitated Calcium Carbonate is produced in a satellite facility either onsite or very close to a paper mill and the resultant slurry is pumped directly to the mill, which almost eliminates the transportation cost.

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Now, let us look at another case where Industrial Waste and Environment decides plant location. Every year, millions of tonnes of fly ash is generated across India. In 2015, about 180 million tonnes of fly ash was produced across India and by 2025, it is estimated to reach 300 million tonnes a year. However, only 20 to 30% of fly ash is currently used in making Pozzolana Portland Cement PPC.

NTPC, the National Thermal Power Corporation occupies the premier position in the Indian energy sector. With a total installed capacity of more than 62,000 megawatt, it accounts for about 25% of India's total generation. NTPC has 24 coal based stations across India. In 2017, 15 companies in India have expressed interest to set up cement plants near NTPC power stations to help dispose of the power company of the 52 million tonnes of fly ash generated by its projects.

So the cement companies will be benefited by the fly ash and it will be an environmentally friendly project.

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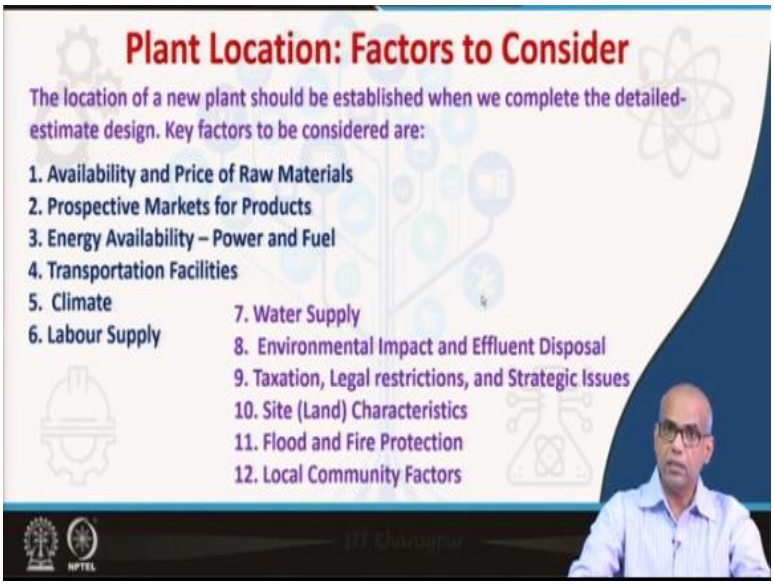

Now let us consider in detail the various factors that you must consider to decide the location of a plant. The location of a new plant should be established when we complete the detailed-estimate design. The key factors to be considered are: Availability and Price of Raw Materials, Prospective Markets for Products, Energy Availability- Power and Fuel, Transportation Facilities, Climate, Labour Supply, Water supply, Environmental Impact and Effluent Disposal.

Taxation, Legal restrictions and Strategic Issues. Site or Land Characteristics, Flood and Fire Protection, Local Community Factors. So you see there are various issues, not all are technical. Now let us start discussing these factors in some more detail.

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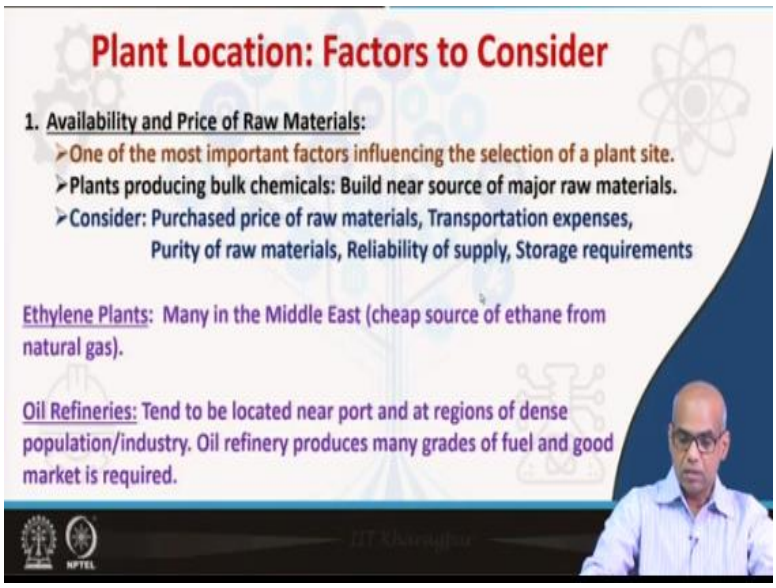

We start with availability and price of raw materials, this is one of the most important factors that influences the selection of a plant site. Plants producing bulk chemicals are generally built near the source of major raw materials. We have to consider, purchased price of raw materials, Transportation expenses, Purity of raw materials, Reliability of supply and Storage requirements. You will see that many Ethylene plants are located in the Middle East.

The reason being the cheap source of ethane from natural gas is available there. On the other hand oil refineries tend to be located near ports and in regions of dense population or where there are clusters of industries, oil refinery produces many grades of fuel and a good market is required in terms of dense population or several industrial presence.

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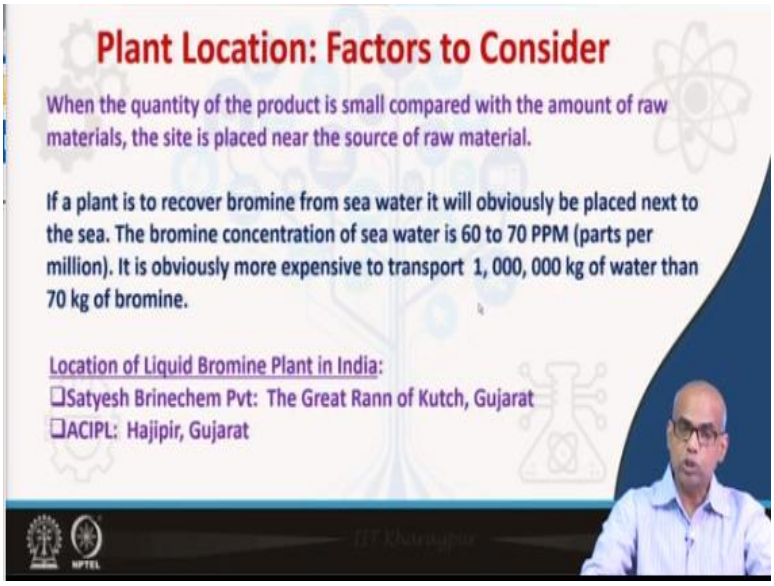

When the quantity of the product is small compared with the amount of raw materials, the site is placed near the source of raw material. Consider the following: if a plant is to recover bromine from sea water, it will obviously be placed next to the sea, the bromine concentration of seawater is about 60 to 70 parts per million. So it is obviously more expensive to transport one million kg of water than 60 to 70 kg or bromine.

Satyesh Brinechem Private, ACIPL, these are the liquid bromine plants in India and both are located in Gujarat near sea.

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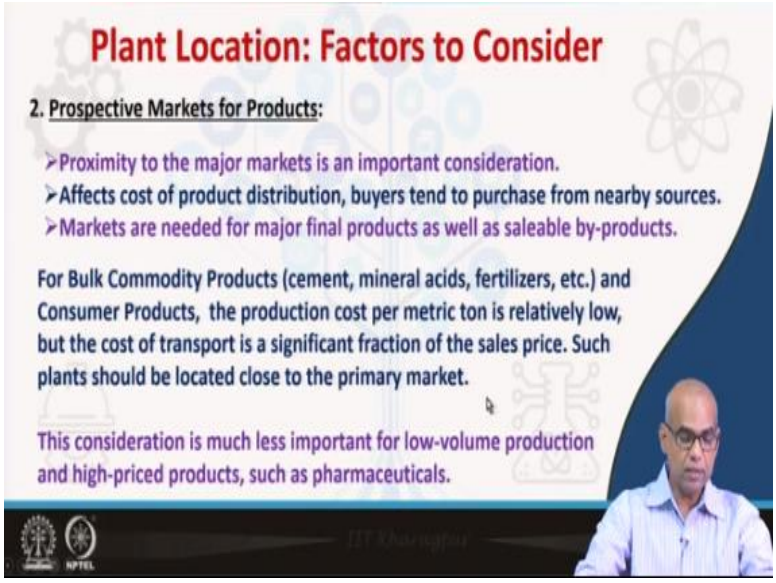

Let us talk about the next factor: Prospective Markets for Products. Proximity to the major market is an important consideration for selection of plant location. The proximity of the market will affect the cost of product distribution, buyers tend to purchase from the nearby sources. So if there is a market nearby, it will heavily influence the cost of product distribution. Markets are needed for major final products as well as saleable by-products that you may have in your industry.

For Bulk Commodity Products such as cement, mineral acids, fertilizers, etcetera and Consumer Products, the production cost per metric ton is relatively low, but the cost of transport is a significant fraction of the sales price. Such plants should be located close to the primary market. So that you minimize the transportation cost. However, this consideration is less important for low-volume production and high-priced products, such as pharmaceuticals, specific chemicals Specificity Chemicals etcetera.

Because these chemicals are produced in low volume, but their price is very high.

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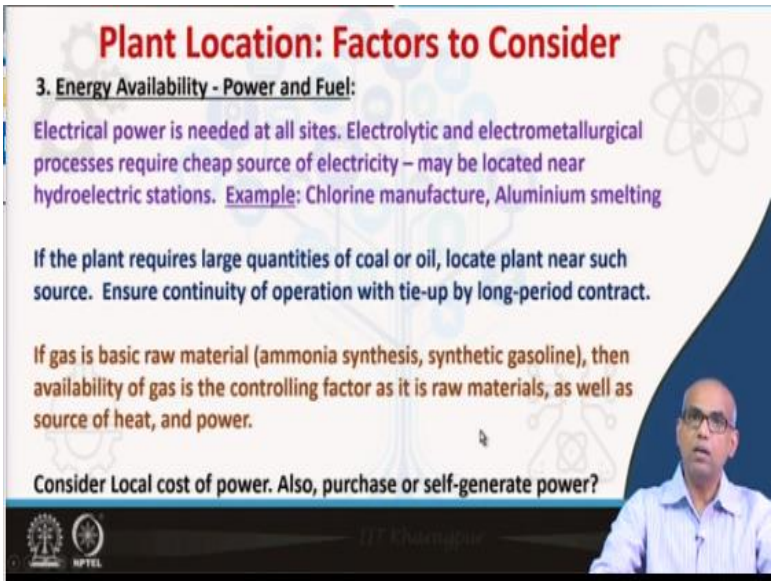

Next important factor that we consider is Energy Availability - Power and Fuel. Electrical power is needed at all sites, electrolytic and electrometallurgical processes require cheap sources of electricity, they may be located near hydroelectric stations. For example: Chlorine manufacture, Aluminium companies where Aluminium smelting is an energy intensive process, so they may be located near thermal power stations or hydroelectric stations.

If the plant requires large quantities of coal or oil, locate the plant near such a source. Ensure continuity of operation with tie-up by long-period contract. If gas is a basic raw material such as ammonia synthesis, synthetic gasoline, then availability of gas is the controlling factor as it is raw material, as well as source of heat and power. We have to consider the local cost of power. Then you can decide on whether to purchase power or you need to generate power on site.

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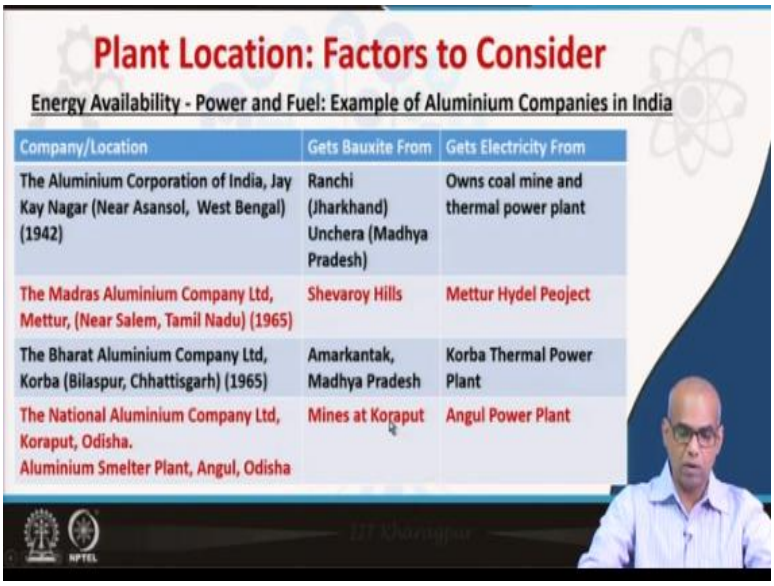

These are some of the Aluminium companies in India. These companies have either their own thermal power plant or they are located at the side of thermal power plants or hydel projects. For example: The Aluminium Corporation of India, they have a plant near Asansol, West Bengal and they own a coal mine and thermal power plant. The Madras Aluminium Company Limited is located in Mettur and Mettur has a hydel project.

The Bharat Aluminium Company Limited is located at Korba, which is in Chhattisgarh and Korba Thermal Power Plant is there. The National Aluminium Company has Aluminium Smelter Plant at Angul, Odisha and Angul has Angul Power plant. So aluminium being an energy intensive company, electricity intensive company, they are all located near the source of power, thermal power or Hydel power.

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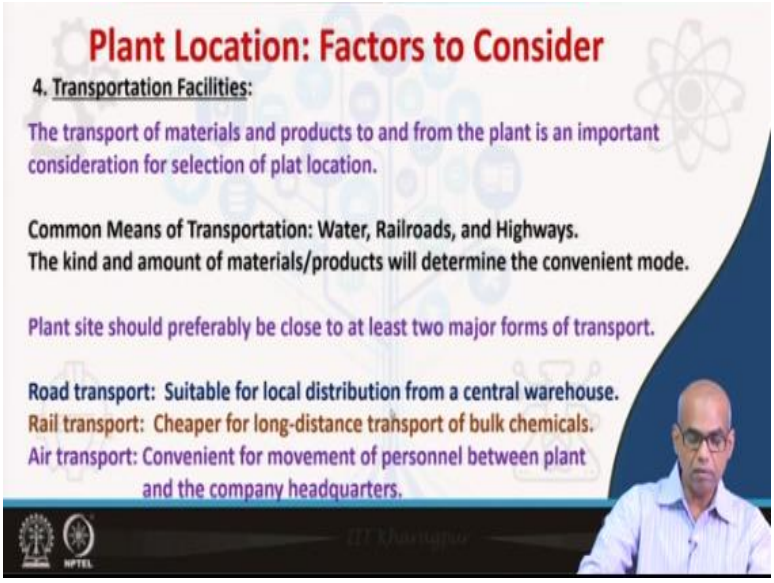

Next let us talk about Transportation Facilities. The transport of materials and products to and from the plant is an important consideration for selection of plant location. Common Means of Transportations are water, railroads and highways. The kind and amount of materials or products will determine the convenient mode. Plant sites should preferably be close to at least two major forms of transport.

Road transport is suitable for local distribution from a central warehouse, rail transport is cheaper for long-distance transport of bulk chemicals and air transport is convenient for movement of personnel between plant and the company headquarters.

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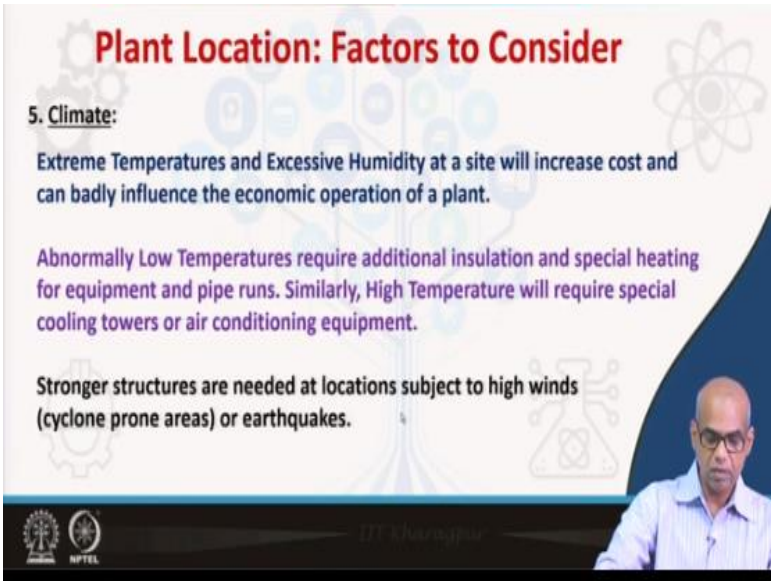

Next let us talk about Climate; Climate is another factor which must be considered for plant location. Extreme Temperatures and Excessive Humidity at a site will increase cost and can badly influence the economic operation of a plant. Abnormally Low Temperatures require additional insulation and special heating for equipment and pipe runs. Similarly, High Temperature will require special cooling towers or air conditioning equipment.

Stronger structures are needed at locations subject to high winds such as cyclone prone areas or areas which are history with earthquakes or prone to earthquakes.

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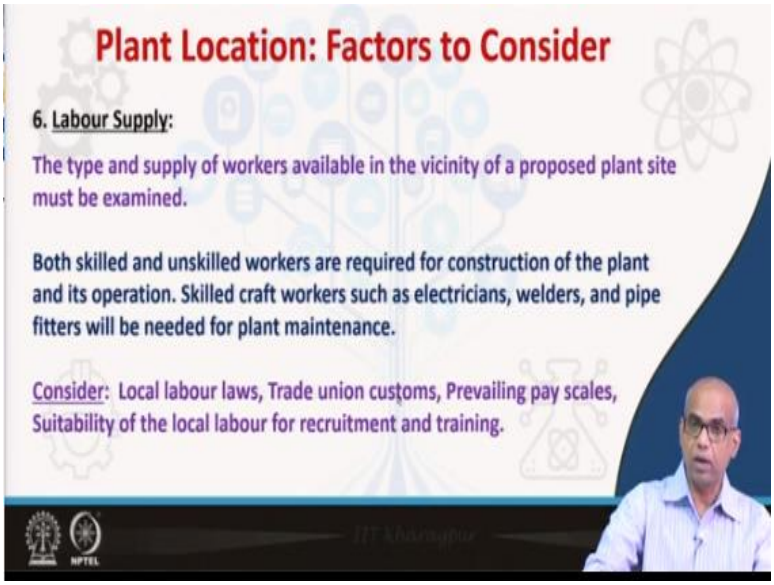

Labour Supply is another very important factor that must be considered for plant location. The type and supply of workers available in the vicinity of a proposed plant site must be examined. Both skilled and unskilled workers are required for construction of the plant and its operation. Skilled craft workers such as electricians, welders and pipefitters will be needed for plant maintenance.

You must consider local labour laws, Trade union customs, Prevailing pay scales, Suitability of the local labour for recruitment and training.

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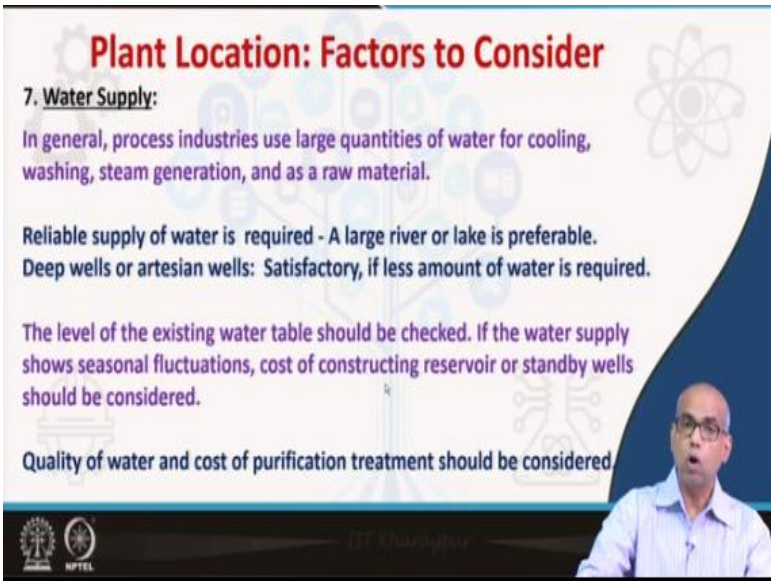

Next let us consider another factor, which is Water Supply. In general, process industries use large quantities of water for cooling, washing, steam generation and also as raw material. Reliable supply of water is required, a large river or lake is preferable. Deep wells or artesian wells will be satisfactory, if less amount of water is required in your plant. The level of the existing water table should be checked.

If the water supply shows seasonal fluctuations, cost of constructing reservoir or standby wells should be considered. Quality of water and cost of purification treatment should also be considered.

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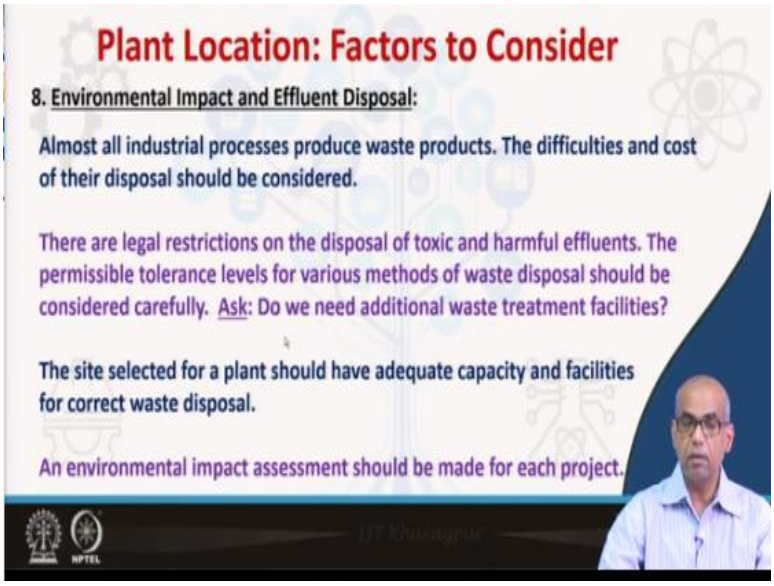

Next factor; Environmental Impact and Effluent Disposal. Almost all industrial processes produce waste products. The difficulties and cost of their disposal should be considered. There are legal restrictions on the disposal of toxic and harmful effluents. The permissible tolerance levels for various methods of waste disposal should be considered very carefully. We have to see whether we need additional waste treatment facilities for the plant or not.

If needed then this will add to your cost the sites selected for a plan should have adequate capacity and facilities for correct waste disposal and environmental impact assessment should be made for each project.

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Next Taxation, Legal restrictions and Strategic issues. Tax rates on income, local building codes, law and order situation should be considered. Capital grants, tax concessions and other incentives are often given by the government to direct new investment to preferred locations such as the government may want that investment made in areas of high unemployment. See if there is an area of high unemployment, then the government can give incentives, if investment is made in those areas.

For example, in India, we have a Special Economic Zone where if you invest you can enjoy Duty free export, Tax incentive, etc. Government also gives Seed Funding Support. So in the Startup India project, one time grant will be given by the Government to start your industry. In today's

globalized economy, the determination of the plant location is even a more difficult problem. Because, now you not only consider the regions around you but you are free to choose areas from all over the world.

Of course, there will be several factors, laws, restrictions, several issues etcetera. But in today's globalized economy, the problem is much more than it used to be a few years back.

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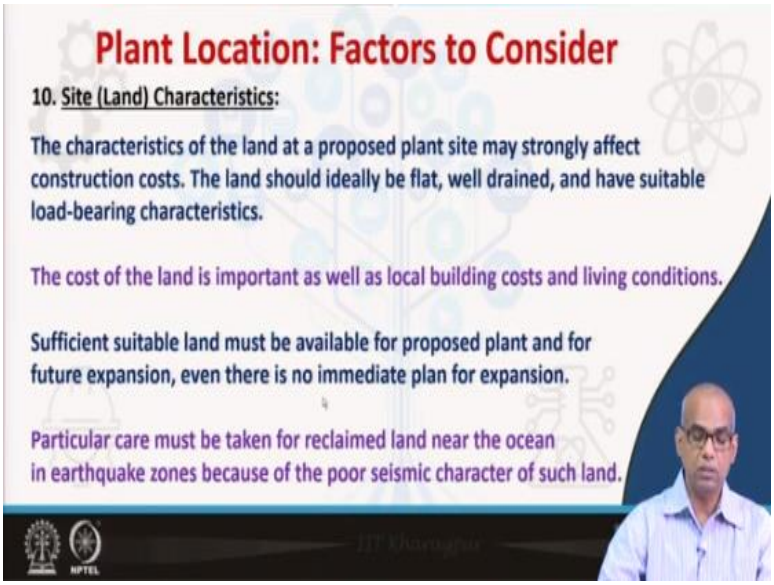

Next factor we consider is Site or Land characteristics. The characteristics of the land at a proposed plant site may strongly affect construction cost. The land should ideally be flat, well drained and have suitable load-bearing characteristics. The cost of the land is important as well as local building costs and living conditions. Sufficient suitable land must be available for the proposed plant and also for future expansion.

Even if there is no immediate plan for expansion, particular care must be taken for reclaimed land near the ocean in earthquake zones because of the poor seismic character of such land.

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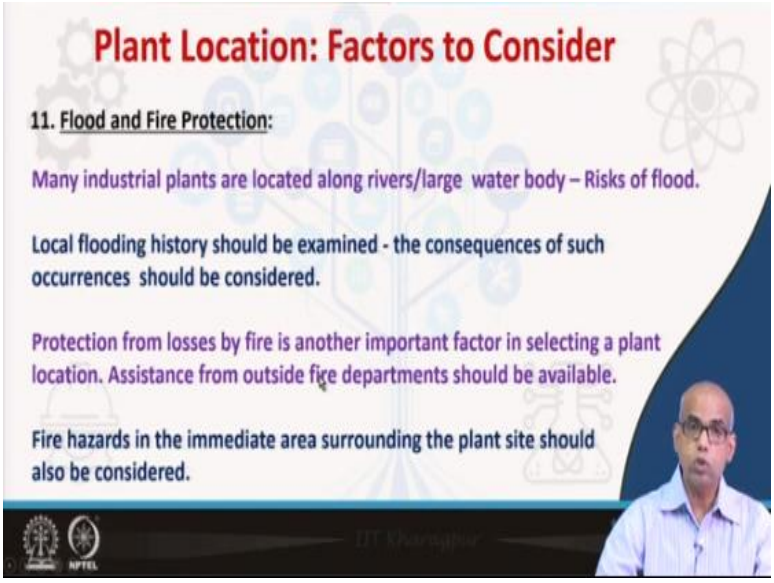

Next, we consider Flood and Fire production. Many industrial plants are located along rivers or large water bodies. So there is a risk of flood, local flooding history should be examined and the consequences of such occurrences should be considered. Protection from losses by fire is another important factor in selecting a plant location. Assistance from the outside fire department should be available. Fire hazards in the immediate area surrounding the plant side should also be considered.

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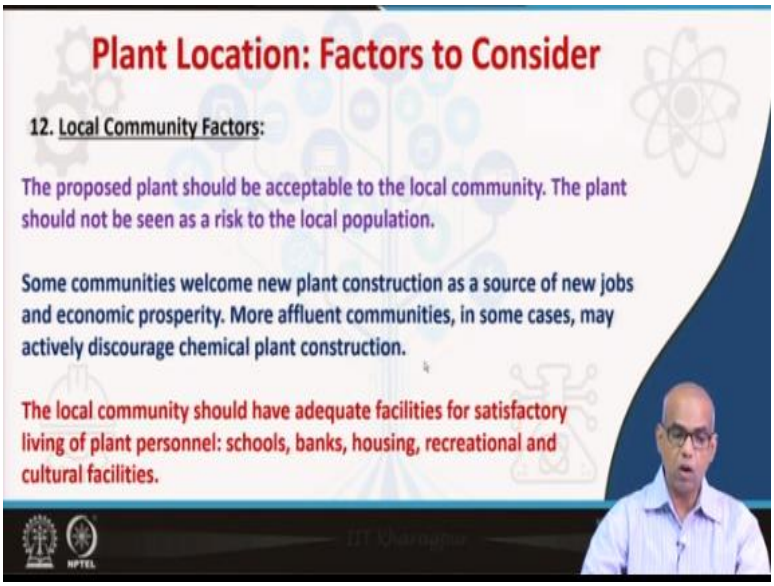

Finally we consider Local Community Factors. The proposed plant should be acceptable to the local community. The plant should not be seen as a risk to the local population. Some communities welcome new plant construction as a source of new job opportunity and economic

prosperity. However, sometimes more affluent communities may actively discourage chemical plant construction because they can see it as a hazard to the community.

Local communities should have adequate facilities for satisfactorily living of plant personnel: schools, banks, housing, recreational and cultural facilities should be available. So these are all the 12 factors that you can consider for deciding plant location.

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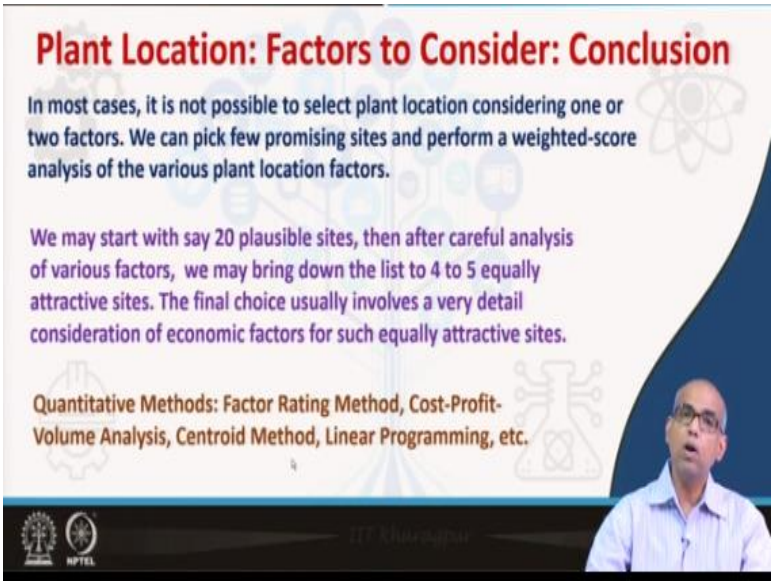

So we conclude these factors as follows. In most cases, it is not possible to select plant location considering one or two factors. We can pick few promising sites and perform a weighted-score analysis of the various plant location factors. We may start with say 20 possible sites, then after careful analysis of various factors, we may bring down the list to 4 to 5 equally attractive sites. The final choice usually involves a very detailed consideration of economic factors for such equally attractive sites.

Quantitative methods are used for consideration at the final stage such methods are: Factor Rating Method, Cost-Profit-Volume Analysis, Centroid Method, Linear Programming method, etcetera.

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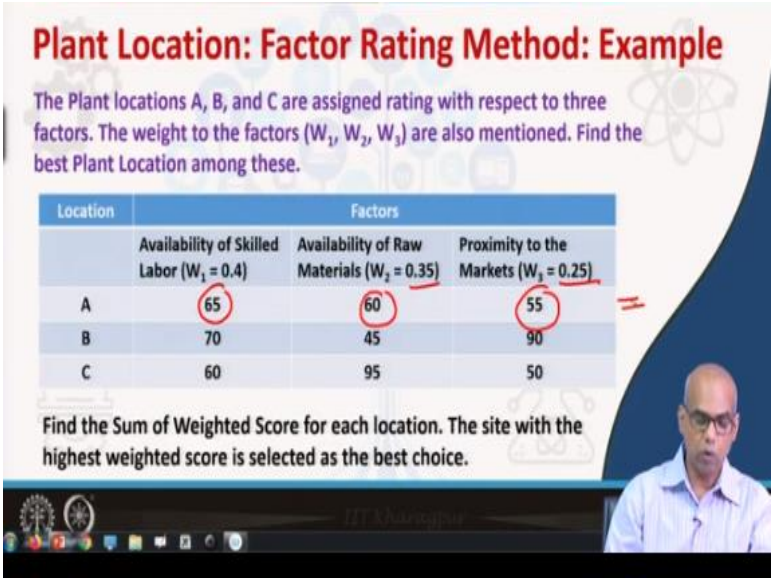

Now, let us take one simple example from the factor rating method. The plant locations A, B and C are assigned ratings with respect to three factors availability of skilled labor, availability of raw materials and proximity to the markets. The weight to the factors, W1, W2 and W3 are also mentioned. We have to find the best plant location among A, B and C. So, these are the ratings and these are the Weightage.

So considering these we have to decide which plant location will be best, what we have to do is we have to find the sum of weighted scores for each location. The site with the highest weighted score is selected as the best choice. So you have to take weighted score. So what we will do is, we will take say 65 into 0.4 + 60 into 0.35 + 55 into 0.25 and then we will add up. We will do the same for all locations A, B and C.

And then we will look at the location with the highest voltage score that will be our choice.

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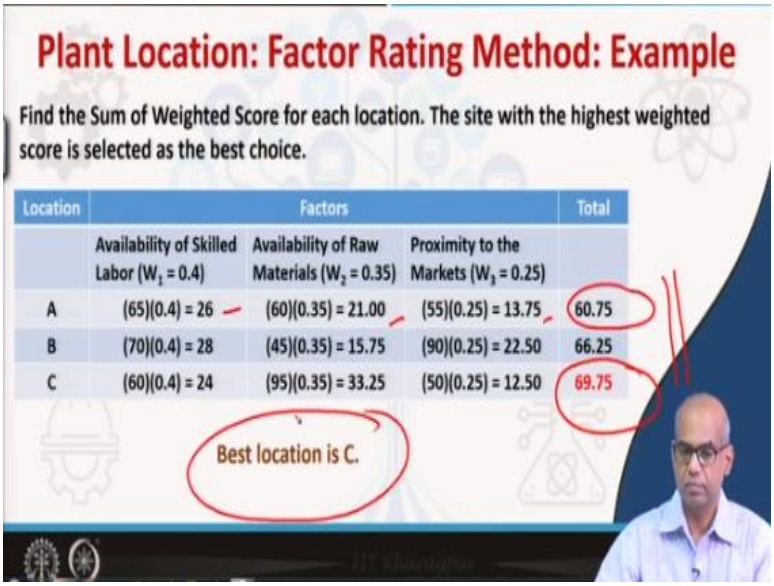

So, this is how it is done. So we have taken 65 and then multiplied by 0.4. Similarly this and when you add up you get 60.75, you do the same you find out the weighted score for each location and then compare these three, you get 69.75 as the highest weighted score. So the best location is C.

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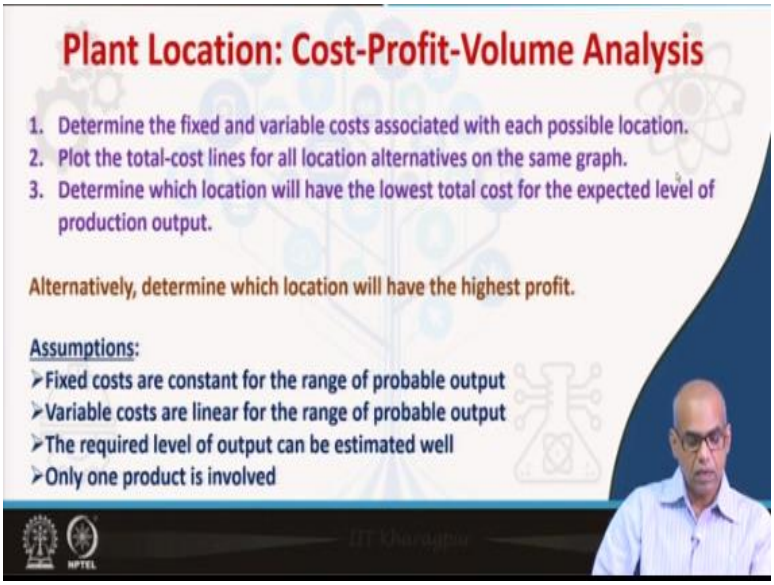

Now let us quickly talk about another method, another quantitative method known as Cost-Profit- Volume analysis. This is also a very simple method you determine the fixed cost and the variable cost associated with each possible location. Plot the total cost lines for all location alternatives on the same graph. Then determine which location will have the lowest total cost for the expected level of production output.

So first you decide what should be the production target? Then determine the fixed cost and the variable cost. From the fixed cost and the variable cost you find out the total cost and then plot the total cost for all the locations. Alternatively determine which location will have the highest profit. You will get the same result. Now, there are certain assumptions: Fixed costs are constant for the range of probable output.

Variable costs are linear to the range of probable output, these two are very important assumptions that we make here. The required level of output can be estimated well and only one product is involved.

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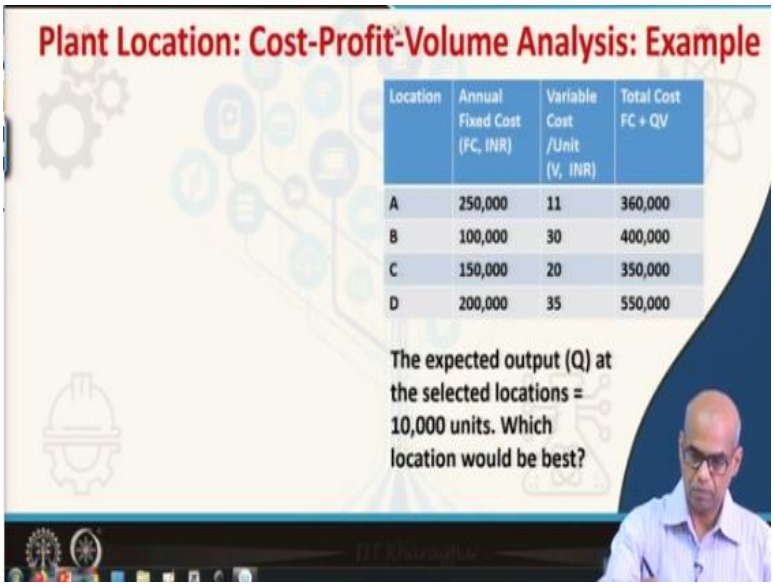

Let us take this example as shown in the table. So there are four locations A, B, C and D. At each location the annual fixed cost is given and variable cost per unit product is also given. And then you can find the total cost, which is fixed cost + Variable cost per unit multiplied by total unit. Now if we say that the expected output at each of these locations is 10,000 units, what should be the best location for me?

So the total cost you find out as Annual fixed cost say, 250,000 + 11 × 10,000 that will give you 360,000. So this way you compute for all locations A, B, C and D. In this particular case, you see that the lowest cost corresponds to location C. So locations will be preferred choice for 10,000

units. Now, let us make the plot.

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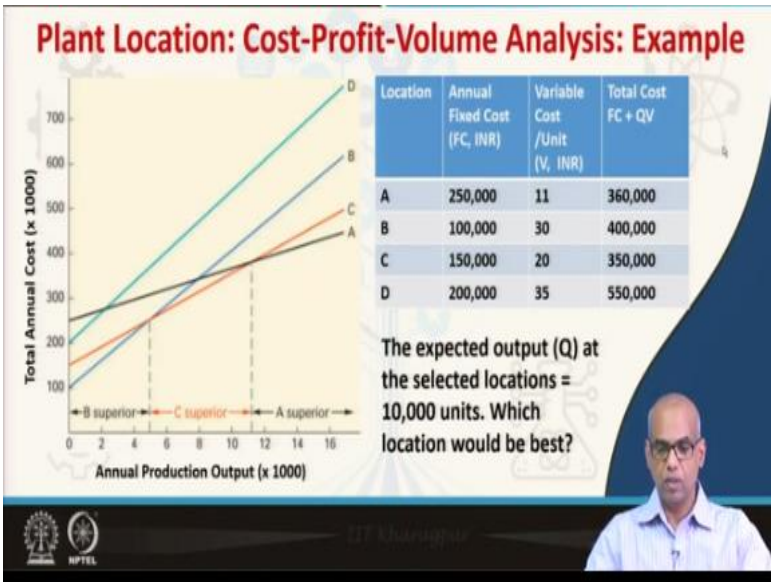

Now, if you look at the plot you will see that up to say about 5,000 units production target. You have a minimum cost given by location B from about 5 to 11,000 units, you have C as the preferred location. And beyond say 11,000 or so you have location A as superior. So it depends on the number of units that you are going to produce. So this information you can easily obtain from Cost-Profit-Volume analysis.

So here you can see why those assumptions were made. If you look at any of these lines, let us say for D, you have 200,000 as the fixed cost, so it starts at 200,000 and then varies linearly with the units. So, that was the assumption. So this way, you can make use of the Cost-Profit-Volume analysis to determine quantitatively, which location will be more suitable for you. With this we stop our discussion on plant location selection. Thank you for watching.