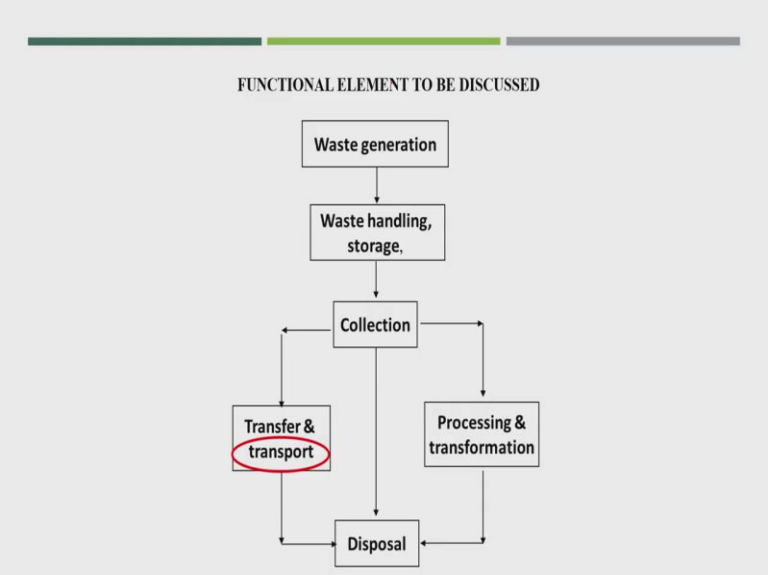
Municipal Solid Waste Management
Prof. Ajay Kalamdhad
Department of Civil Engineering
Indian Institute of Technology, Guwahati

Lecture No - 15
Transport Means and Methods

(Refer Slide Time: 00:38)



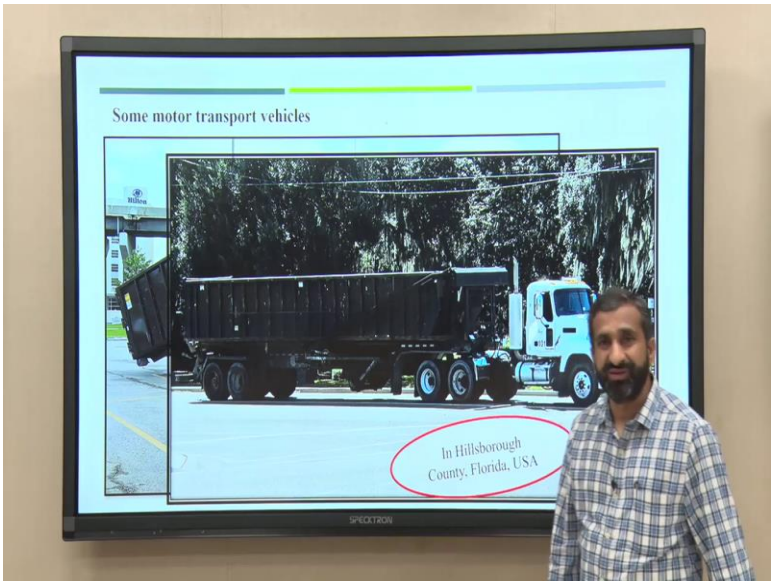
Hello students, so in the we are on module 6, transfer and transport. This is our fourth functional element, and today we are going to talk about the transport means and methods like in the previous lecture, right. I shared about importance of transportation and the factors which are of attractive to get the transportation and also what are the different benefits and advantages of transportation.

Now today we will be talking about different transport means, different method also we will be talking about the location. That is also one of the very important to finalize the location which today I am going to talk.

(Refer Slide Time: 01:26)

So we will start with different transport means. The first method is by a motor vehicle, which is a well-known means of transportation by road transport. So you see here the vehicles, the larger sized vehicles normally is using for transporting waste from the transportations to the disposal site or recycling facility by road.

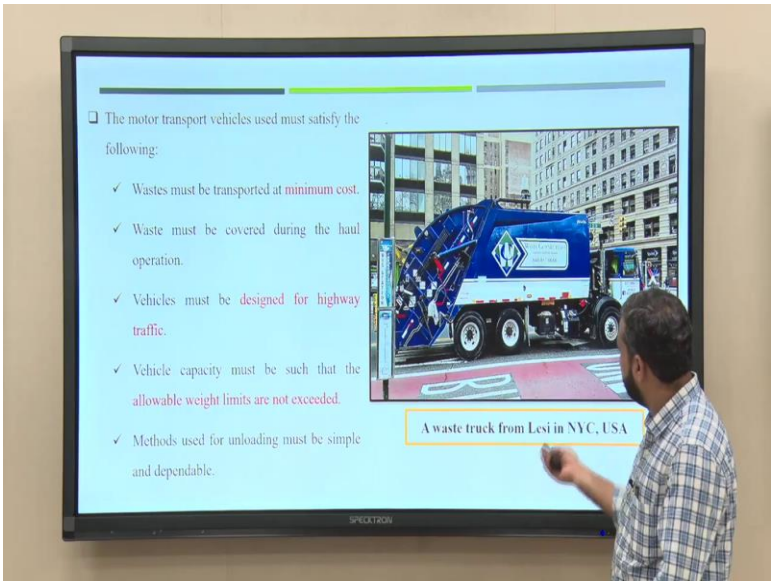
(Refer Slide Time: 01:54)



And few more also you can see here different kind of dumpers also could be used both could be possible. And here also we can discuss about all kind of containers could be used for all kind of vehicle. Also could be possible the stationary kind of vehicles could be used for the transportation of the waste. Now here because again, we have to be see that. How base the waste could be unloaded from the vehicle at disposal site or recycling facility?

He is another vehicle. So this is this is I do not think so is we can find it in the India such kind of vehicle is a photo from USA where the landfill site or recycling facilities very far. Sometimes goes to 100 kilometers 200 kilometers and most of this vehicle travelling by the Highways Major Highways ok under this vehicle never come to the inside the city because such kind of big vehicle traveling inside cities very, very difficult.

(Refer Slide Time: 03:12)



So what are the important issues that has to be discussed or has to be finalized before going for the road transport. So the first consideration has to be satisfied like waste must be transported minimum cost that is the important one because of that only we are planning for transportation. If the cost is very high for hauling of waste from the transportation to the disposal side, then there would not be any benefit of having the transportation.

Next the waste must be covered during the whole operation. This is also very important because huge amount of waste is getting hauled, maybe at 20 tons or 25 or 30 tons of wastes so obviously it has to be covered properly because this vehicle will also transfer from the highways. So obviously there are a lot of residential areas nearby possible. Especially in India number of rural areas are possibly nearby highways.

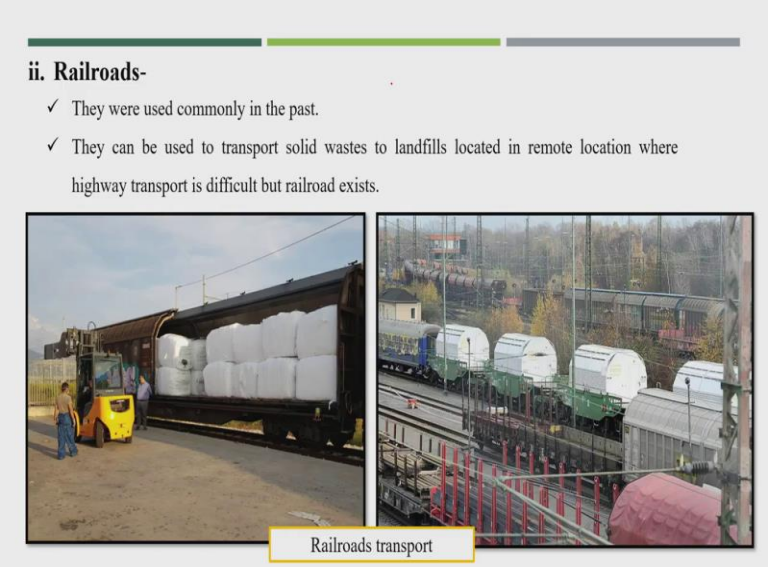
So vehicle must be designed for highway traffic, this is very important as your design has to be possible for highway traffic. On the highway traffic the speed of the other vehicle will be very high so needs to be see that how best this kind of vehicle will travel from the travel under the such kind of traffic and also because the length of the; you see here the length is very large.

Somewhere you will require u-turns so that also needs to be seen that whether such kind of vehicle U turning is very difficult or it could be possible that it will take lot of time also and also it will also create problem for the other vehicle traffic. So, the design also has to be seen that, vehicle capacity must be such that the allowable weight limits are not exceeded. This is also one very important issue, especially for the India, developing countries where need to know that how much maximum waste could be possible to hold by the vehicle.

We should not go for more than that the weight limits also need to be no that. And method used for unloading must be simple and dependable. This I was talking about whether you can go for the stationary kind of vehicle or haul kind of vehicle or special kind of vehicle. And why because your unloading must be very simple and dependable. You should not be that the unloading is very difficult at the disposal site.

Because at the disposal site of landfill site or recycling facility, I think we would not get lot of manpower for unloading the waste. So this should be dependable by the vehicles itself and should be very simple. So like other, this kind of vehicles also can be used specially for the design for the easy or simple unloading facility.

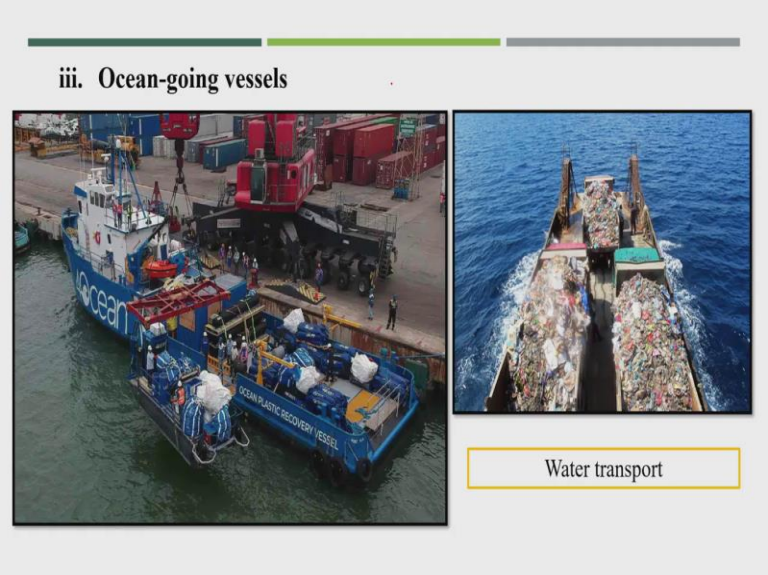
(Refer Slide Time: 06:31)



Now this is another way of collection or another way to transport that could be possible. They were commonly used in the past especially in the European countries and in the US the waste used to be hauled by the railroads in the past. Under which is also possible suppose somewhere some sometimes if you are finding the disposal site in the very remote area. So it is possible that remote area could be 200 kilometers 300 kilometers and no road transport is possible in such area.

As railroads are available, so by railway also we can haul the entire waste to the disposal facility. So you see here some of the photographs, this is also possible disposal of such kind of waste. So, maybe in the railroad I would not propose to hold biological waste, but at least the drive is can be easily hauled into by the railway operators. So you can see here, but the waste has been transported by the rail or railway.

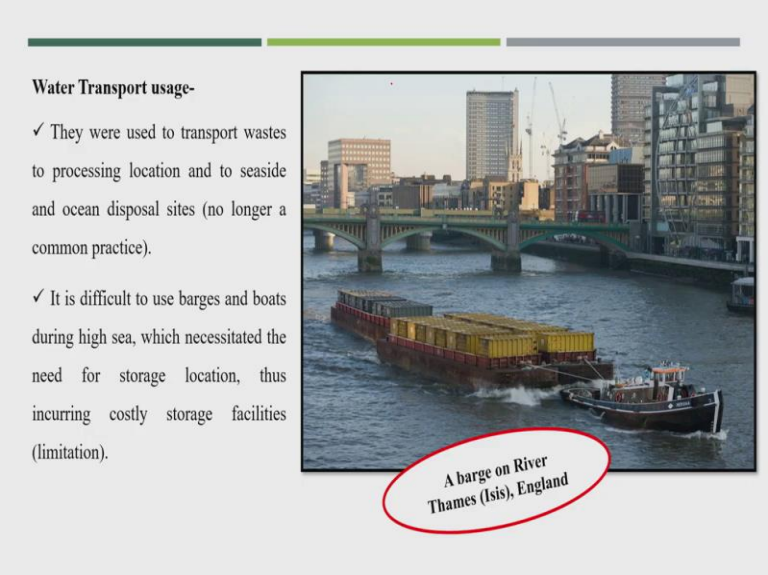
(Refer Slide Time: 07:57)



Is another mean could be possible that ocean going vehicles service here. These also water transport also would be possible that some of the country like Hong Kong or Singapore where I think nearby finding the landfill site is very difficult and earlier in the past also many countries they use to dispose the waste into the ocean now, I think is not permitted. Permissible is prohibited to dispose the waste into the ocean.

In that case also suppose from one location to another location in the same country is possible to travel by the water so that is also or from the sea also could be beneficial if the cost is very low for the water transport we can use the water transport also can see here. The waste is collected through water transport.

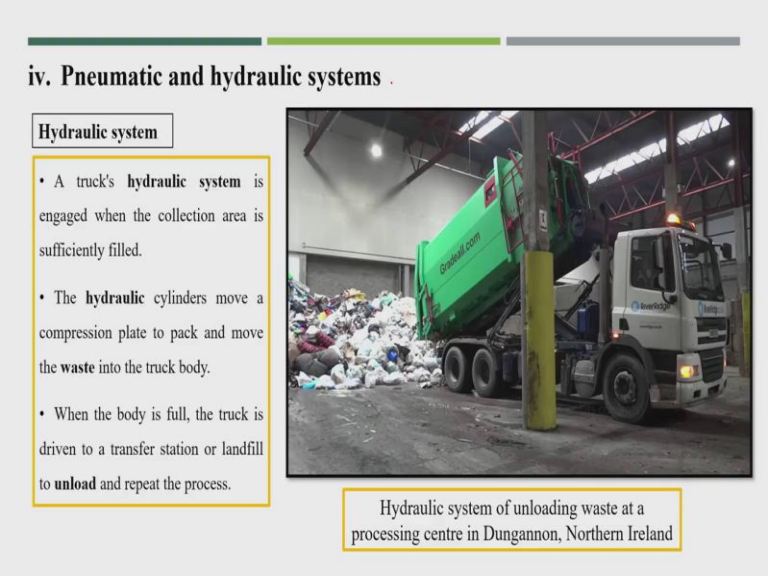
(Refer Slide Time: 09:12)



So this is another one issue that for water transport they used to transport the waste from the location to the ocean disposal site, which I was talking about now is a no longer common practice. This is one barges was in the thames River in London it is very well known river Thames River where the waste used to be collected from the water transport. So this was the one point that it is difficult to use barges or boats during the high see that was the one important issue in the water transport.

Even the river water transportation also sometimes will be very difficult. If there is a lot of rainfall in that case it will be very difficult.

(Refer Slide Time: 10:01)



Now another few more different means we can collect the waste are we can transport the waste could be hydraulic system or pneumatic system could be possible. So this is especially for the different kind of vehicles we can use and this could be possible by specially for the road transport only Hydraulic system special idea about hydraulic system how best we can load the waste and how best a simple way or easy way we can unload the waste from the vehicle.

So when the body is full the truck is driving to transportation a landfill to unload and repeat the process. This was the hydraulic system. Could be used for the specially for the unloading of waste to the disposal site for recycling facility.

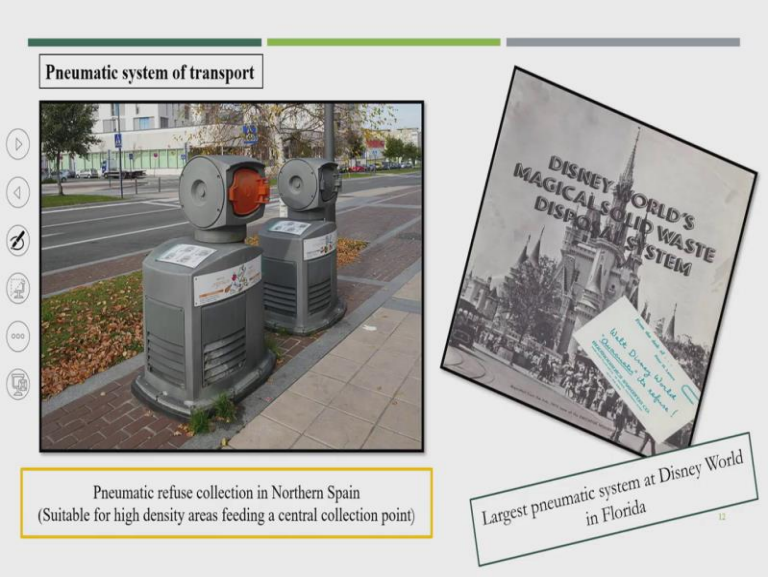
(Refer Slide Time: 10:59)

So this is another vehicle. So in this case I think there is no manpower only one driver itself is able to collect the waste and transport the waste into the disposal site.

(Refer Slide Time: 11:14)

This is another photograph, where we can see that a special hydraulic system so waste is getting collected and from this the waste is getting loaded onto the vehicle from the front to the real area. This is another kind of semi trailer using hydraulic pump for waste transportation in Italy.

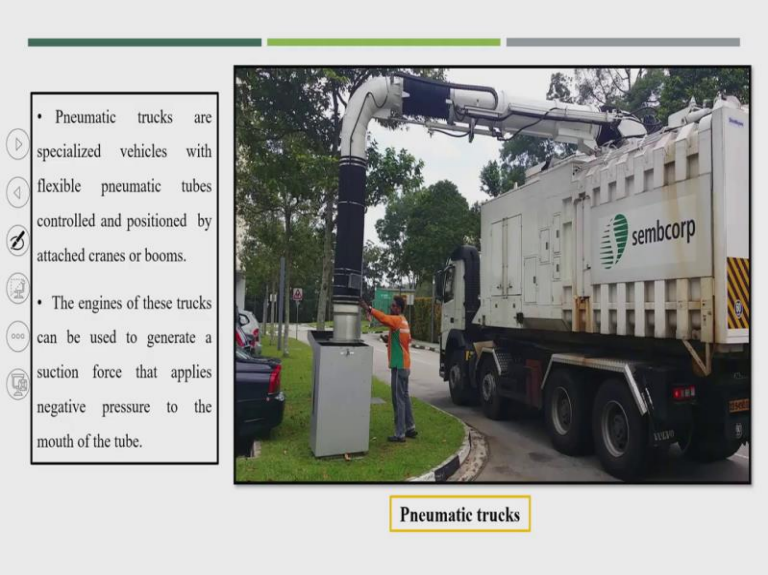
(Refer Slide Time: 11:36)



I will show you one more photograph like near the pneumatic system of transportation so in this pneumatic system i think there will be a pipes inside the earth and do with the pipes the waste is getting transported. So is pneumatic one by maintaining the proper vacuum waste is getting transported. Like here the largest pneumatic system in the Disney World in Florida so if suppose you for visiting anywhere, Disney World may be in the Florida are in the Hong Kong you will never see no dustbins available in entire area.

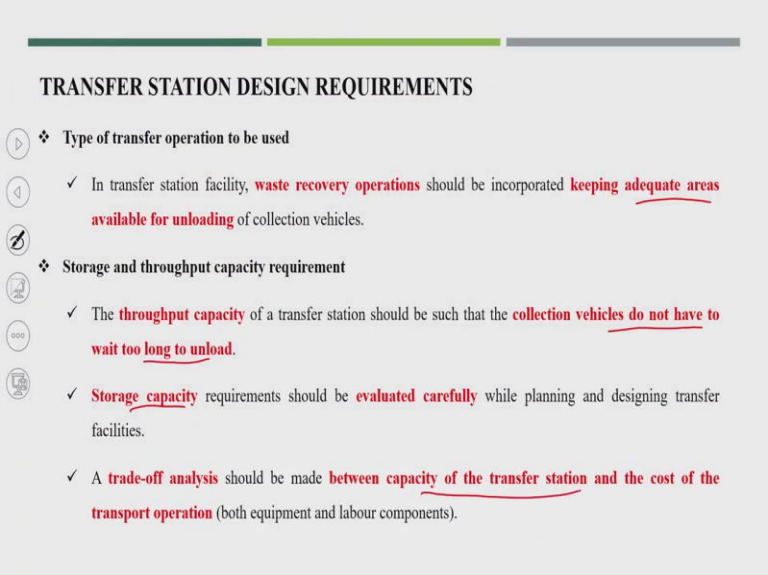
This is a lot of area that, is covered by the Disney world. But what is there you can find the pneumatic system. You can dispose the waste into small dustbins and this has been by pneumatic system. The waste is collected and are transported to the one particular location for the recycling and disposal facility. You can here if the one of the news.

(Refer Slide Time: 13:01)



This is a vehicle by pneumatic system. This is the dustbin where waste is getting collected. So, pneumatic talks are specialized vehicle with flexible pneumatic tubes control and position by attached cranes or brooms. The engines of these tubs can be used to generate a suction force that applies negative pressure to the mouth of the tube. So because of that waste is getting collected into the vehicle.

(Refer Slide Time: 13:34)



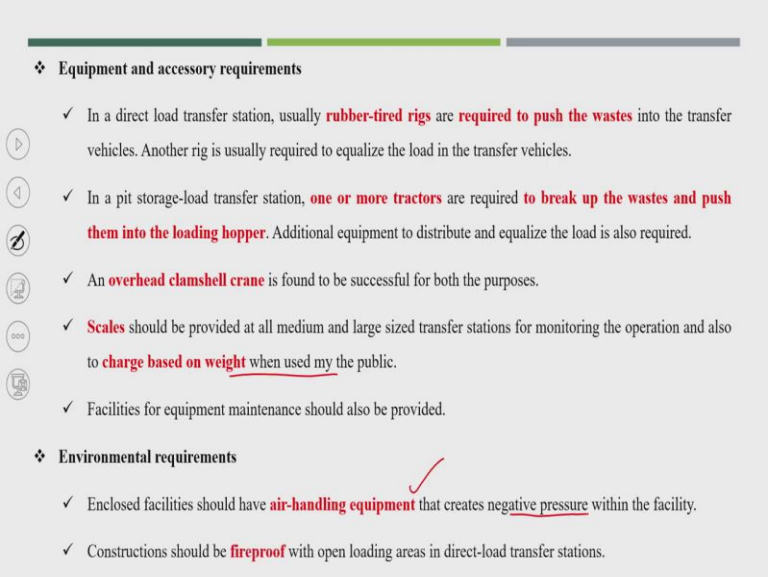
Now the transportation design requirement. So before going for the location, this is one very important issue need to be discuss about while design, in transportation. What are the different factors that has to be required or has to be seen before finalizing the design? So the first is the type of operation transfer operation to be used, this also is a very important thing that depends upon the goal of particular objective of the transportation, it is possible that we are planning for designing of the storage load or direct load and a mix of both.

The Transport operation also will be changed the area requirement also will change, based on that we can design the type of operation that will be required for the transportation. So specially here that is an important point keeping the adequate area for available for unloading of collection vehicle. Now second is the storage and throughput capacity requirement. This is a very important one throughput capacity of the transportation should be such that the collection vehicle does not have to wait too long to unload.

So that is also need to be known because a number of vehicles will reach to the transportation from the residential area or commercial areas. So waiting time for the vehicle for unloading of waste into the transportation should not be very high, so that proper capacity of the transportation has to be provided again the proper area should be available and even the storage capacity also has to be looked upon to see that the entire waste could be unloaded into the transportation.

Storage capacity requirement should be evaluated carefully. The storage capacity which I was talking about to not keep the vehicle waiting. For the longer period and trade off analysis should be made between the capacity of transportation and the cost of the transport operation. This is also an important point if trade could be possible during transportation, so that also we can see that based on that we can design the capacity of the transportation and what will be the cost of transport operation based on that we can design.

(Refer Slide Time: 16:29)



Another point is an equipment and accessory requirement, it is obviously again dependent upon what kind of objective of the transportation whether is a direct loader or a storage load or combination of both. So in direct load transportation usually rubber tire rigs are required to push the waste into the transfer vehicle. Another ring is usually required to equalize the load in the transfer vehicle. So, obviously different kind of equipments and accessories will be required.

So in a pit storage transportation this was the first one, the direct load transportation second was the storage to transportation one or more tractor are required to break up the waste and put them into the loading Hopper that kind of facility will be required or accessory will be required and also the additional equipment to distribute and equalize the load is also required because again that has to be equalize with the different operation a different larger vehicle availability.

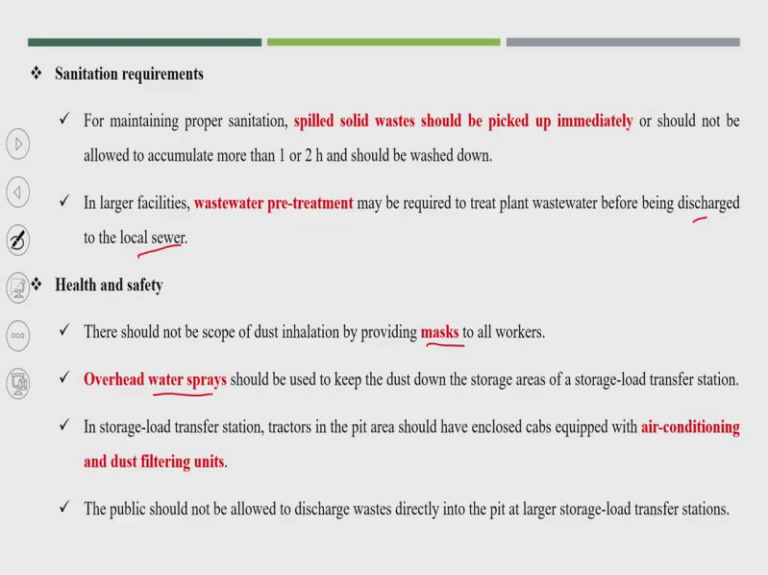
and overhead clamshell crane is found to be successful for the both the purpose that is specially for the distributed and equalizer load into the storage area. Scale should be provided at all medium and large size transportation for monitoring the operation and also charged based on weight when used by the public. This was the different idea this normally in India we would not use but at least the scaling should be possible that.

and facilities for equipment maintenance should be provided. So maintenance facility also should be available. Next is the environmental requirement, obliviously enclosed facility should be provided, how air handling equipment that create negative pressure within the facility. So the idea of this one these should be creating the negative pressure within the facility, so there would not be any odor will come out from the transportation. It is possible that we are locating the transportation very close to the residential area so always the odor will be the major issue.

Obviously that entire transportation will be covered up so from outside we would not see that whether waste is getting stored are getting hold from that particular location, but because of different operation it is possible that the odor will come out from the transportation and because that you will get a lot of complaints from the local residential area. So; obviously such kind of facility should be available on to the transportation.

And also the construction should be fire proof is also very important. Because we are seeing that in the transportation lot of drive matters also will come up and is a highly combustible matters. So fire proof facilities also will be required.

(Refer Slide Time: 19:50)



Now and other very important consideration a requirement is sanitation requirement. So, for maintaining proper sanitations field. Solid waste should be picked up immediately or should not be allowed to accumulate more than one or two hour and should be washed down. So this is one thought to maintain the proper sanitation. So there should not be any spilling of waste in the different location.

That should not be possible and wherever the waste is getting spilled out of that or wherever waste is getting accumulated that has to be hauled or that has to be cleaned within 1 to 2 hour otherwise the odor issue will come up or and time to time the proper cleaning also required into the transportation, because the cleaning will be required so it is possible that the transportation operations for 6 hours could be possible in a day or 8-hour operation.

and once the entire operation gets over obviously cleaning will be required. So because of that cleaning transportation wastewater also will be also produce that cleaned water. So, if it is possible that the small wastewater treatment plant also has to be design or whatever the wastewater will get generated that has to be again put it into the sewage along with the; we can mix with the sewage and should will be treated at sewage treatment facility. So that is what is being discharge into the local sewer.

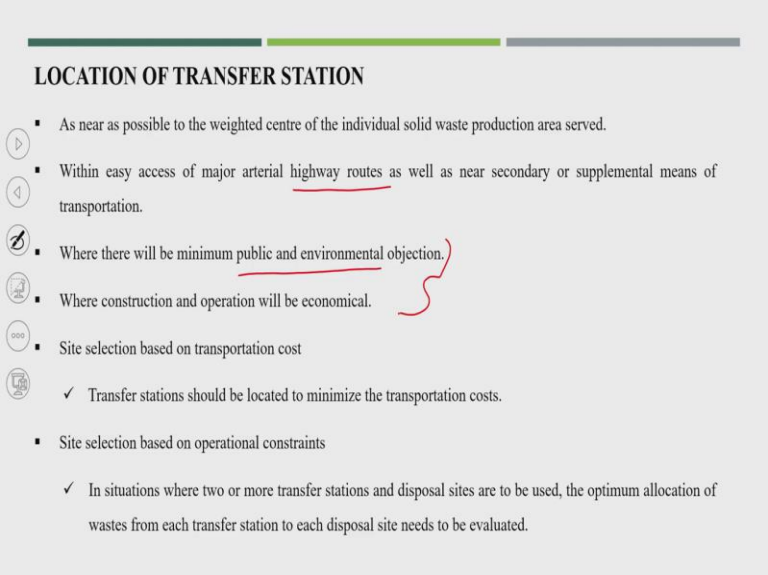
Health and safety: Now the sanitation requirement that is for the location for entire transportation. Now your health and safety for the workers or man powers are working in the transportation. There should not be a scope of dust inhalation by providing the mask to all the worker. This is also very important because a lot of Pm production (particulate matter) would be possibly produced during the operation.

But I think that those data are are not available (pm10 are pm 2.5) but it is possible that some kind of dust will get produced during the entire operation so the mask should be provided. Overhead water spray should be used to keep the dust down the storage area of the storage load transportation. Obviously this facility also it is possible to have water spray. To keep the dust down that kind of facility also could be possible to have.

So in storage load operation tractors in the pit area should have enclosed caps equipped with air condition and dust filtering unit, I do not think so in India such kind of things can be possible. But I think whatever vehicle could be possible ones that unloading the waste into the storage hopper or storage pit I think I need to see that there should not be lot of dust should not be produced during this operation.

And the public should not be allowed to discharge waste directly into the pit at larger storage transportation. So these local public or nearby residential people should not be allowed into the transportation because unnecessary health issues will come up.

(Refer Slide Time: 24:02)



Now the important discussion that is a location of transportation: So the location there are few points I have noted here before finalizing or sighting of transportation. First point is that as near as possible to the weighted centre of the individual solid waste production areas served. So this has to be seen that because your primary collection should not be very costly. That should be also economically.

So to make it economical you have to find the transportation location as near as possible to the waste generation area, and also this was one point and they should be easily get access to the highway routes. The highway route accessible, so finding such kind of location is somewhat difficult because should be very close to the residential area also and easily reachable to the highways because the larger vehicle will be used so it should be a close to the Highways so that the larger vehicle can easily transport the wastes or waste could be hauled to the disposal site.

And there will be a minimum public and environmental objection. I think this is a very important point. There will be always public objection, but I think is again depends upon the how best we can operate the wastes. So I already proposed that we should how the third type of transportation where combination of direct load and storage load. Here because already we are segregating the waste at the generation area or household area or commercial area.

So the waste will go to the direct load. So there would not be any storage of the wet waste was so there would not be any odor issue or there would not be any kind of biological degradation of that kind of waste, only the dry waste will go to the storage load facility. So, that we can put it into the storage pit and whatever the recyclable matter or some kind of operation, we can plan there and after that that which will also get hauled to the disposal facility in different vehicles.

So if you are planning that obviously the public objections will be very less and specially the environment, because we are not touching. Nobody is directly touching the biological waste. So because this is under the direct load so I think even environmental objections also would not come up because there is no storage. So there would not be any leached production. There would not be any odor or odor production could not be possible in such cases.

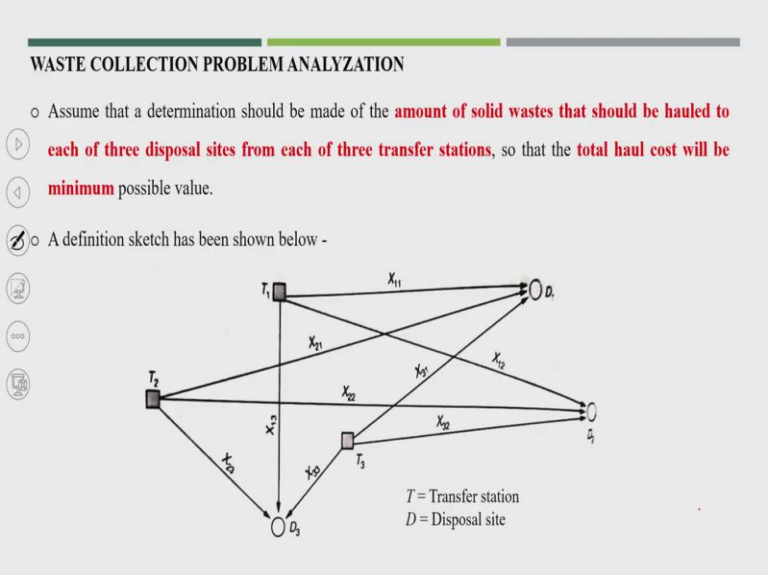
Because of that I think we would not get much objection for the transportation and where the construction and operation will be economical. So I think other factors we can easily do but I think these are the important factor where public objections and how best and easy operation we can do on to the transportation. Now under Swachh Bharat mission. I think many cities have started the transportation.

But problem is that if you are planning for transportation, you need to have proper vehicles in the both the cases for the primary collection also and for the secondary collection that the larger vehicle that that is also required under specially for the small cities like in the district level for class two towns. I think they are not directly connected with the Highways or Highways are there the traffic issues are huge.

So in that case, I think having special kind of vehicle is very important in such cases. So when you are planning for transportation, you need to be ready for the proper primary collection and proper secondary collection. Now if you are planning for transportation without having any recycling or recycling facility, I think that would be that economical because to make the economical transportation also need to be seen that how best we can recycle the recyclable matters.

So I think there are a lot of issue has to be discussed before planning for transportation. And the site selection based on the transportation cost ,is the important one. So transportation should be located to minimize the transportation cost. And site selection based on the operation constraint like in situations where two or more transportation and disposal site are to be used the optimal allocation of waste from the E- transportation to its disposal site need to be evaluated .

(Refer Slide Time: 29:18)

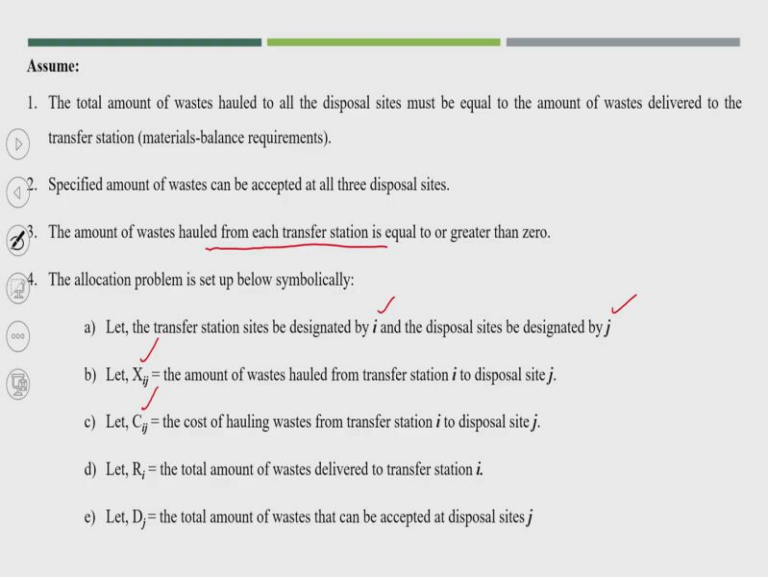


So on this same point will discuss like if you have the two or more transportation and we have different kind of disposal facility or recycling facility. So the proper analysis has to be do to found, the optimum allocation from the transportation to the disposal site that will go with the one example. So I assume that the determination should be made of the amount of solid waste that should be haul to the each of three dispersed site from each of three transportations.

So that the total hauls cost will be minimum possible values. So this is the one example is given so we have three transportations that is T 1 T 2 and T 3 and we have three disposal site D 1 D 2 and D 3. Now is connected because we have to see that so from first transportation T 1 to the first disposal site that costs could be x 11 and from T 1 to another disposal site that is D 2 that is X 12 so that is X 11 X 12 and from third disposal site X 1 3.

Similar way from the transportation T 2 and from transportation T 3 now we have to see that the optimum location has to be finalized.

(Refer Slide Time: 30:57)



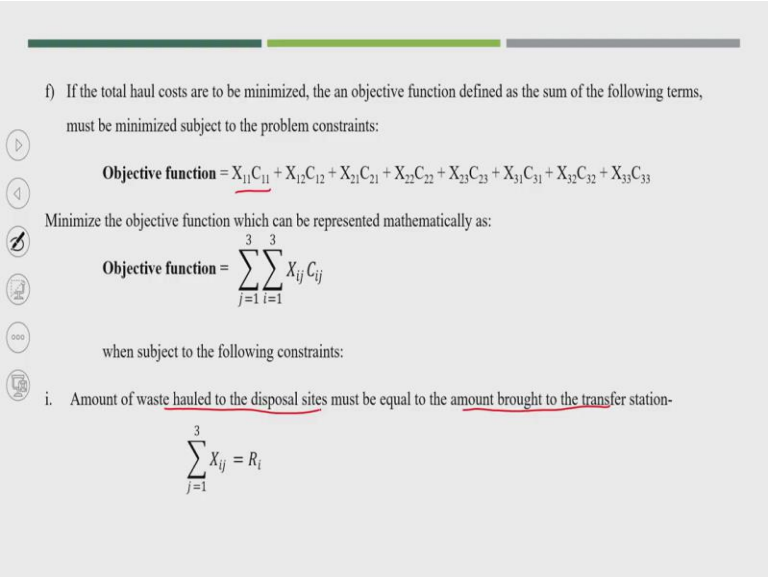
So before finalizing the optimum allocation you have to assume few points like the first point is the total amount of waste haul to the disposal site must be equal to the amount of is delivered to the transportation. This is the important assumption ok, so whatever amount of waste is delivered at transportation that the same amount should be haul to the disposal site, the 2nd is a specified amount of waste can be accepted in its all three disposal site.

Ok specified amount of waste means whatever the storage facilities available or whatever the space available in the transportation. That much amount of waste could be accepted at the transportation and from that disposal site. Third point the amount of waste haul from east transportation is equal to or greater than zero. This is also one important assumption because whatever the amount of is hauling for the transportation is equal to or greater than zero.

I think there would not be any negative value. Negative value means the waste will come from the disposal site to the transportation that should not be possible. Next is the allocation problem is set up below symbiotically. So I think that is what I shared this, let the transportation be designated by i transportation and disposal site designated by j. So here X ij is the amount of waste haul from the transportation i to the disposal site that nominated are designated by X ij.

A similar way the C ij that is the cost of hauling waste from the transportation i to disposal site j that is C ij and i that is the total amount of waste deliver to transportation i that is a R i and D j that is the total amount of waste that can be accepted at disposal site j that is the j and R i is the amount of waste deliver to the transportation i.

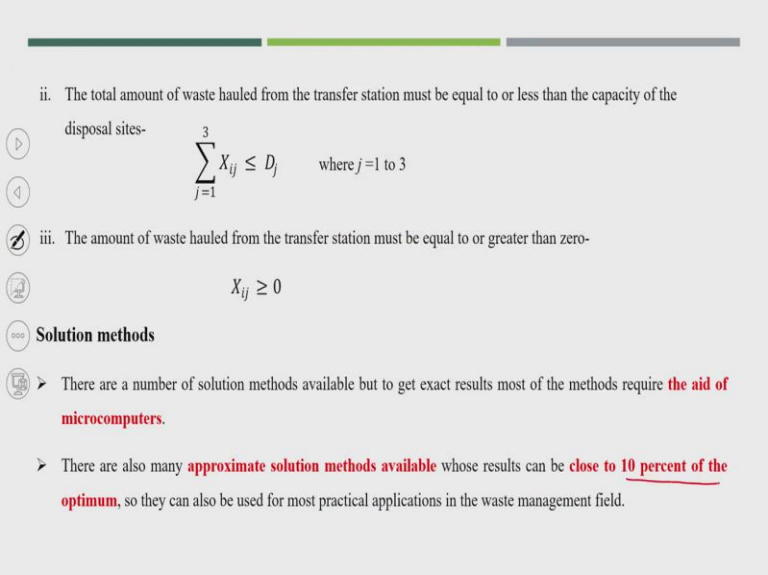
(Refer Slide Time: 33:23)



So, now here if the total haul cost is to be minimized, then the objective function defined as the sum of the following terms must be minimized. Subject to the problem concerned, so the objective functions will be so this X 11 multiplied by C 11 + X 12 to C 12 where X 11 is the now in this case X 11 is the amount of waste hauled from the transportation 1 and disposal site 1 ok that is X 11. And C 11 is the cost of hauling waste from the transportation 1 to the disposal site 1.

So, based on that this will be the objective function and mathematically we can represent this objective function sum of X ij to multiplied by C ij and where I used 123 and j 123 this subject to the following constraints this objective function. The first constraint is amount of waste haul to the disposal site must be equal to the amount brought to the disposal site. So this is the first constant the amount brought to the transportation equal to the waste haul to the disposal site that we can mathematically we can write sum of X ij is equal to R i. Ok where j is 1 to 3 where i is 1 to 3.

(Refer Slide Time: 35:12)



Similar way and other constants could be possible that the total amount of waste hauled from the transportation must be equal or less than the capacity of the disposal site. This is also very important constraint has to be fine that we can mathematically we can write X ij where j is 123 should be less than or equal to D j. That is D j is the amount of waste haul to the disposal site where j is 123.

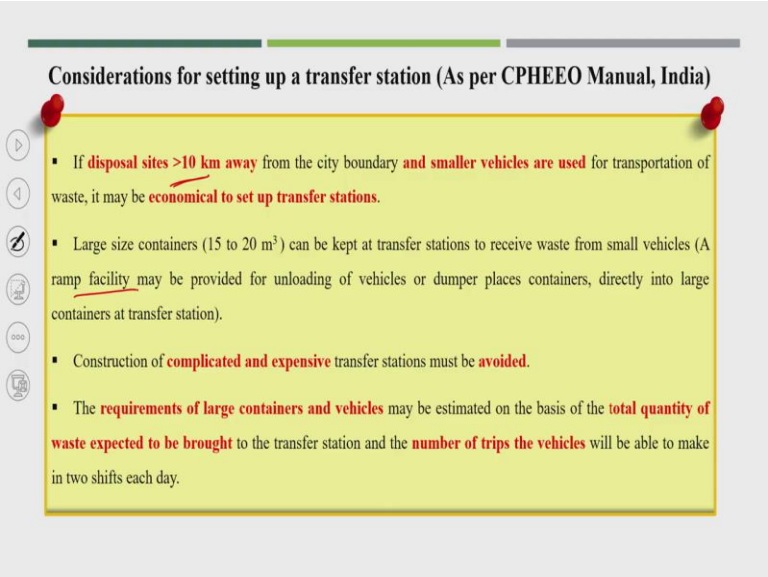
And third constraint the amount of waste haul from the transportation must be equal to or greater than zero that was one of the assumptions while finalizing the solution of this problem, and that we can write X ij always greater than or equal to zero. So now I think we have three different constant has to be solved. So there are different ways. There are a number of solution could be possible to get exact result most of the method required the help of microcomputers.

So a lot of solutions will be come up by finalizing the three different constraints. Based on that we can finalize the entire operation and there also many approximate solution methods available whose result can be close to the 10% also is accepted to the optimum so that they can be used for the most practical application in the waste management area. So I think there could be a lot of solutions could be possible.

And the suppose the solutions will come up very close may be 10% to the optimal also that is also acceptable based on the; whatever applications could be possible in the waste management

area. So based on that three different constraints we can finalize which particular transportation will go to the; which particular disposal site based on that we can finalize by having the solution of three different constraints.

(Refer Slide Time: 37:20)



Now there are few considerations for setting up a transportation. This is based on the CPHEEO manual CPHEEO (Central Public Health and Environmental Engineering operation) this manual says that disposal site should be 10 km away.

This is simplified if the disposal site is greater than 10 km away from the city boundary and the smaller vehicle are used for the transportation of waste. It may be economical to setup transportation and the all 2 lectures I was talking about distance of 20 kilometers, 30 kilometers or 40 kilometers or 100 kilometers but what this manual suggested if disposal site is greater than 10 kilometers and smaller vehicles are used for the primary collection.

So it is possible to set up a transportation in the economical way, another point is large size containers like 15 to 20-meter cube can be kept in transportation to receive waste from the small vehicle ramp facility may be provided. The simple ramp facility may be provided for the unloading of smaller vehicle or dumper pressure container directly into the large container a transportation.

This is the simple and the first kind of transportation direct load. So in the direct load we have seen that one ramp will be available. Then the smaller vehicle even the dumper vehicles will be on this ramp directly the large container could be unloaded. These vehicles will be unloaded into the large vehicle and its large container could be possible like 15 to 20-meter cube size also we can take. And next point is construction of complicated and expensive transfers and must be avoided this is also one point is mentioned.

That I think should not be complicated means I think I was proposing that recycling facility issue could be possible at transportation. I think that manual says that that will be a complicated one because when you are planning for recycling facility that would be expensive also. But I think it is possible we can plan such kind of facility and the requirement of large containers or vehicle may be estimated on the basis of the total quantity of ways expected to be brought to the transportation and the number of trips the vehicle must be able to make in 2 shift each day.

So I think this was just a suggestion, but I think it is again dependent upon your primary collection operation of primary services operation how much amount of waste would be possible to come to the transportation and what kind of large containers could be utilized at the transportation. So this was the discussion on to the transportation, thank you.