Bulk Material Transport and Handling Systems
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Lecture – 3
Fundamentals of BMH and Transport Capacity and Productivity Concepts

To this class we are going to continue with our discussions on bulk material handling and transport. You know that we have discussed bulk material handling and transport is an industrial issue and there they work as a system. So, we need to understand the basic principles behind designing such systems and then if we are to do a very cost effective safe material handling and transportation system we need to know few basic fundamental principles today will be discussing some of this.

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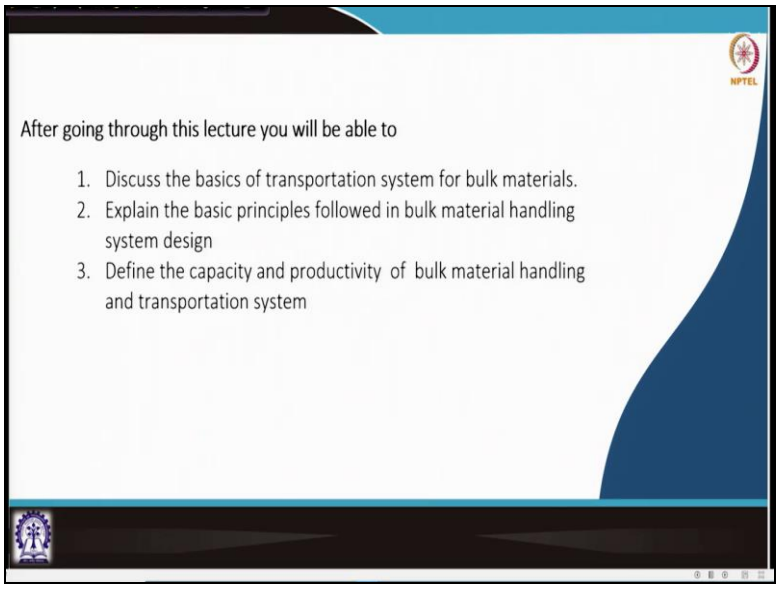

So, here after going through this lecture you will be able to discuss the basics of transportation system for bulk materials you will be able to explain the basic principles followed in bulk material handling and also we will be the and discuss how the capacity and productivity of such systems are calculated or how they are how they will be dealt in this subject in the subsequent classes.

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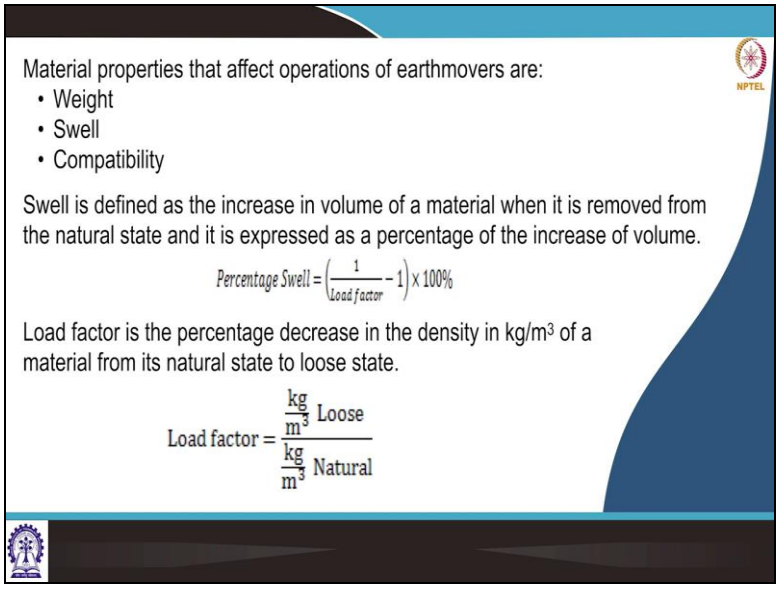

So, you know already we have discussed in the last class about the various properties of bulk material and how they affect our how they affect the transportation and handling systems. So, we know that these material properties which are very important those are exactly the weight swell and their compatibility. Compatibility means the material will have to be compatible with the system.

So, whether if it is in some cases we may have to drop the material from a height to a in that case it may break and shatter after breaking that material whether it will be suitable for the subsequent processes or not that is also to be considered. So, while designing a bulk material handling system or compatibility of the handling machinery with the processes and then with the main objectives should be considered.

Now the swirl is another very important property because whenever we are fragmenting a rock mass or any material its volume increases. So, we know that exactly the in situ volume of a particular say when it is there in a solid form in the minds in a as a art material it may not be having the that it is having a volume which we normally call it as a bank volume.

Now when we do the blasting of it gets fragmented the volume increases and then this exactly the it depends on this load factor which is exactly with the your the density or bulk density of the loose material and the bulk density of the natural material in situ that is called as a load factor and from that load factor we calculate the percentage of swell as

you can see it over there the swirl percentage is one upon load factor minus one into 100% this is the way how exactly we look into.

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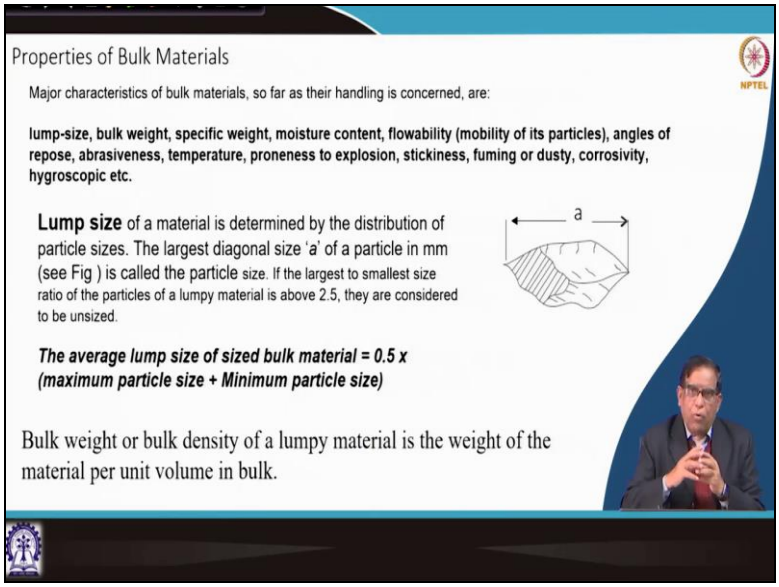

Now when we talked about these properties of material we have already said about different physical and mechanical properties. The most important that will affect our system design as a basic fundamental things of our whole material handling is the lump size the bulk weight specific weight moisture content flowability that is how the particles move then angle of repose abrasiveness temperature then your proneness to explosion stickiness these are the properties which we discussed in our last class.

Now when we talk about the lump size of a bulk material like your coal or rock or aggregates there it is very difficult. Sometimes we need to talk about the average size that is what are the minimum in that size available and what are the maximum size available but while doing telling that is the minimum size we do not consider some of the very fines and some very your small particles are not considered over there.

Whatever the lumps are there in that whatever the minimum size normally when they are passing through a screen on the side basis of that screen we sometimes tell about what could be the minimum size and then the size also it is an irregular step particles that diagonally they are measured. So, that is how in your studies because this rum size will be very important when you will be deciding the designing a conveyor belt system. What should be the width of the conveyor belt will be depending on this lamp size will be coming into those things while discussing conveyor belt.

Now this our the bulk weight or bulk density of lumpy material that which what is exactly we found we told in the last class about the bulk density and particle density these are very important.

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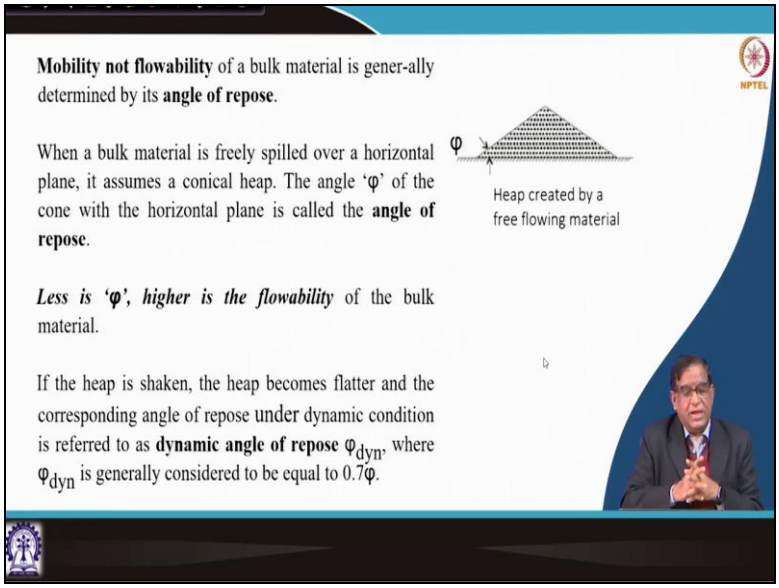

We have also talked about the angle of repose in last class once again to recapitulate the flowability that is your and mobility these two are the different things. So, that is which are exactly determined by angle of repose when you keep the material as you can see here if you pour the material from top it will take a shape like a cone like this. This angle it is called the angle of repose.

Now if you taper this particular place then at that time there will be movement of the particles then this angle will become flatter that is also called dynamic angle of repose and sometimes we tell it as a angle of structures. Say for example when a conveyor belt you are dumping the keeping the material the belt will be moving on the idlers at that time there will be a shaking on the conveyor belt surface at that time the material whatever the angle was there it will get flatter. And that angle at that time it is called your angle of structures or dynamic angle of repose.

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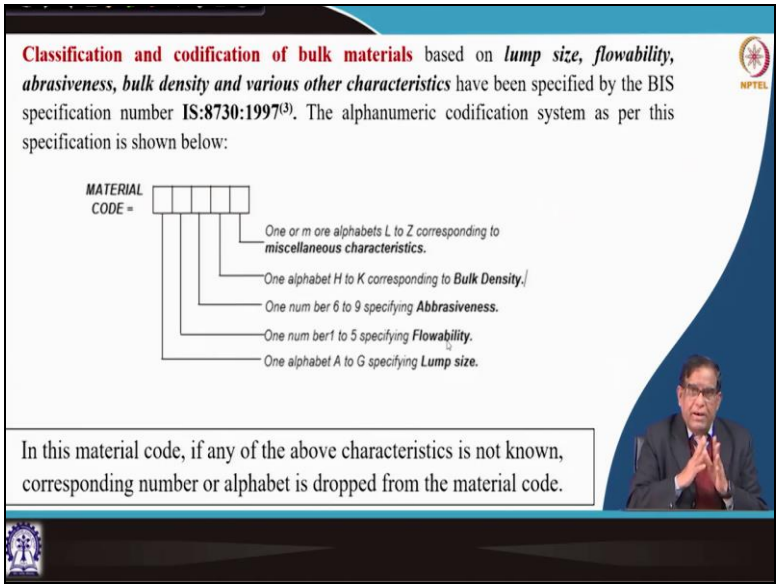

Now in if you read the book of Siddhartharai is a good book on bulk material handling system based on the book of by Apple, J Apple has written another book on bulk material handling you may find that for the standardization purposes the materials are given some code. And our Indian standard bureau of standards this particularly 87301997 it gives exactly in the industry how the bulk materials are considered as a code.

Sometimes this type of code will be necessary while you will be seeking some equipment or some of the systems you want to procure then the designer they will be requiring that once this code is given they can find out they can design the compatible system. So, this is what you should know that exactly these standards give a five digit codes the first number it is exactly one alphabet a to z it gives about the lump size.

That is your whether the iron ore if you are having that weather size is from which range to what range that is given by this code. Second number gives the flow ability whether the material is a flowable material or it is it is not flowable material because depending on the flow ability the handling system will be different. Similarly the third number gives a abrasiveness.

Because if it is a abrasive material then while handling it say for example some when you are crushing some very highly abrasive material in a jaw crusher that the jaw crushers this your that that it liner will be going wearing out similarly if you are having a hopper in that hopper when this abrasive material will be passing through then the

hopper wall made of if it is a made of steel it will get worn out and then sometimes it becomes very thin then may break and there may be an accident.

So, that is why such type of material when it is to be there it cannot be just ordinary silo or ordinary bin you will have to have some liner. So, that the abrasiveness is less. So, like that this materials will be telling what type of handling system you will be requiring. And of course that other number it gives a bulk density because in handling density is a very very important property.

Similarly the other code it is it is giving about the miscellaneous characteristics it has been kept open that is in a specific cases they can do it.

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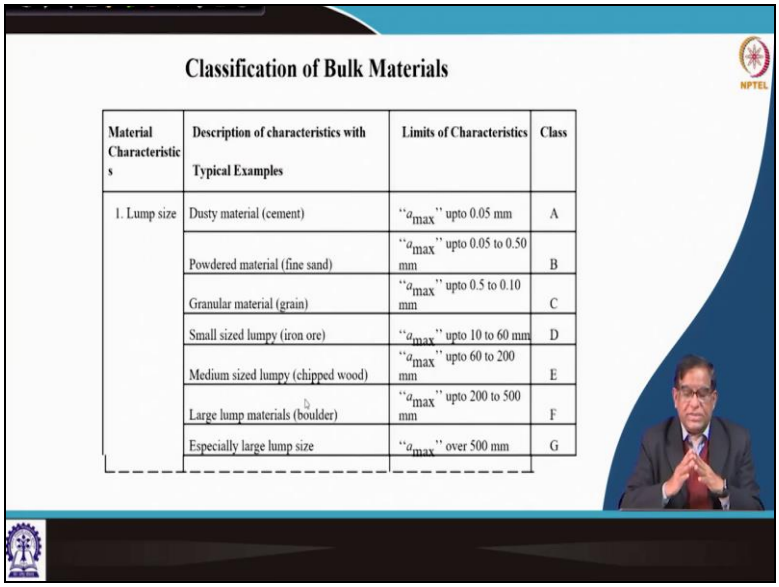

Material Characteristics	Description of characteristics with Typical Examples	Limits of Characteristics	Class
1. Lump size	Dusty material (cement)	"a_{max}" upto 0.05 mm	A
	Powdered material (fine sand)	"a_{max}" upto 0.05 to 0.50 mm	B
	Granular material (grain)	"a_{max}" upto 0.5 to 0.10 mm	C
	Small sized lumpy (iron ore)	"a_{max}" upto 10 to 60 mm	D
	Medium sized lumpy (chipped wood)	"a_{max}" upto 60 to 200 mm	E
	Large lump materials (boulder)	"a_{max}" upto 200 to 500 mm	F
	Especially large lump size	"a_{max}" over 500 mm	G

So, like this type of coding systems are there and then you can see here how they have given. If you go through that standard you will find that lump size that is your what is that a max the diagonal maximum size if it is up to 0.505 millimeter in powdery material they have given a and similarly when you are getting a large lump size where that is your size is over 500 millimeter that material will be called as a g.

That is by seeing the code that if you are a conveyor belt manufacturer and you are looking for some party has asked you to give a code at that time you will see what is the material code they have given and that is what exactly the coding system work.

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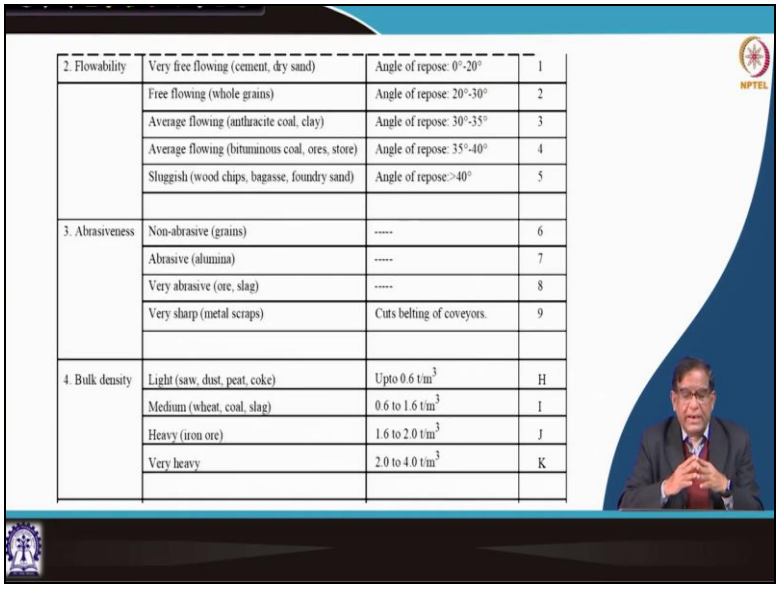

Similarly the flowability can be a very free flowing that means the angle of repose is only 0 to 20 degree. Say for example it is a some this a mustard sheet or this day can be if you make a hip mustard sheet will be flowing down that is a highly flowable there code number will be given one. But similarly if you are thinking on a show mill you are handling the show dust at that time the show dust will not be flowing it will be having sticking you have got more cohesiveness.

So, there your angle of repose is more than 40 degree you can have it is a say five. So, like that this code works. So, similarly abrasiveness has got some of this numbers by which you can get then the bulk density this is also if your very heavy material like our iron ore then your sometimes just copper ore they will be coming in the k category. But then some of this your the medium like wheat or coal they will be having category. So, this way the materials coding will be helpful in designing a system.

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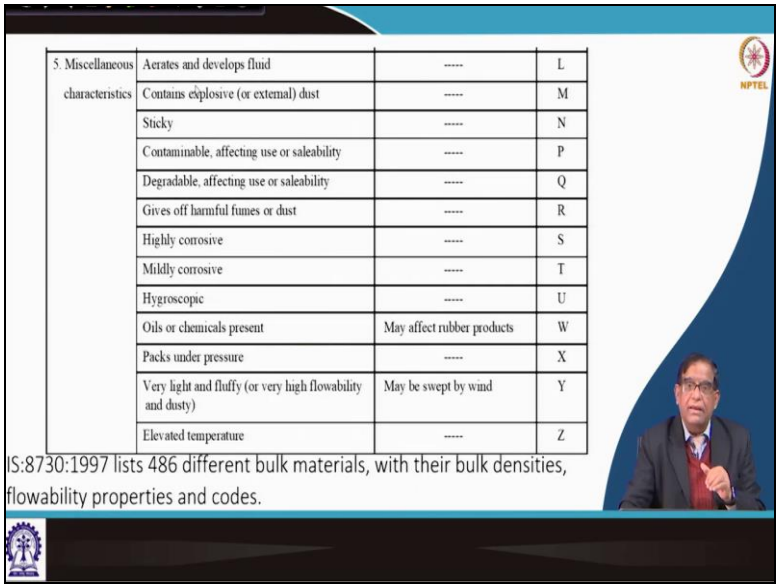

So, the miscellaneous characteristics can be different things. So, there you have to know if they have given some code here like that say if a sticky material you are you are having sometimes you are having the overburden which has got very high clay content that clay sticks say suppose on a truck you are taking the this rock mass from a mine where there is a lot of clay content.

Then what will happen that clay will be sticking to the dumper body then when the number is discharging the material there will be layer will be sticking over there then next time again when it will be carrying material another layer will be sticking. So, some dead weight will be all the time carrying though you will be counting suppose you are taking 120 ton of material but every time maybe 5% or 10% or 2% extra dead load you are carrying all the time.

So, in that case that dumper they will have to have say normally if it is a the moisture content will make the thing sticky. So, if the exhaust pipe of this exhaust gases of the dumper engine if it is made to go through some channel below the your dumper body then it will heat up and then there will not be this formation or sticking will not be there the scale will be dried and then it will be falling down.

So, like that in the designing of your machinery at that time also this characteristics very important. So, while thinking of a bulk material handling transporting you will have to take these things into. Similarly sometimes you may have a highly corrosive or mild corrosive then that there is a different type of code is there. So, while knowing this why I

refer to consult these standards means you will be industry ready after you take your graduation you know exactly what is happening in the industry.

So, while studying please refer to this standard and at least once just glance through. So, this will give you an idea of this. So, there are 486 different bulk material have been listed there then this will give you an idea that when I told in our introductions that why bulk material handling is an important subject and to be to be considered little bit more seriously in India.

Because you can serve the this our raw material supply industries like and there are 82 minerals are mined in different places as well as industrial mineral and then there are food grains a wide range of areas where this bulk material handling is taking place.

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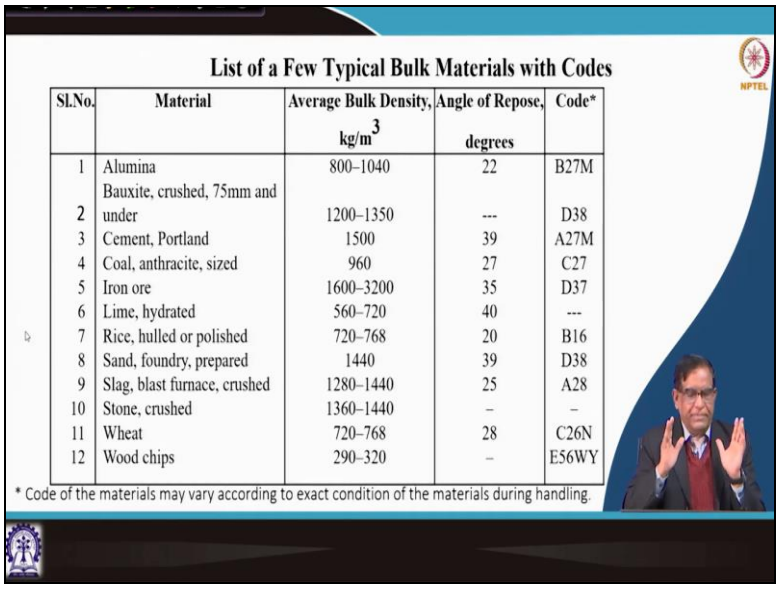

So, that is where how exactly depending on the bulk density and angle of repose some of the codes of some of the known material are also given you please go through the standards and you can see about it.

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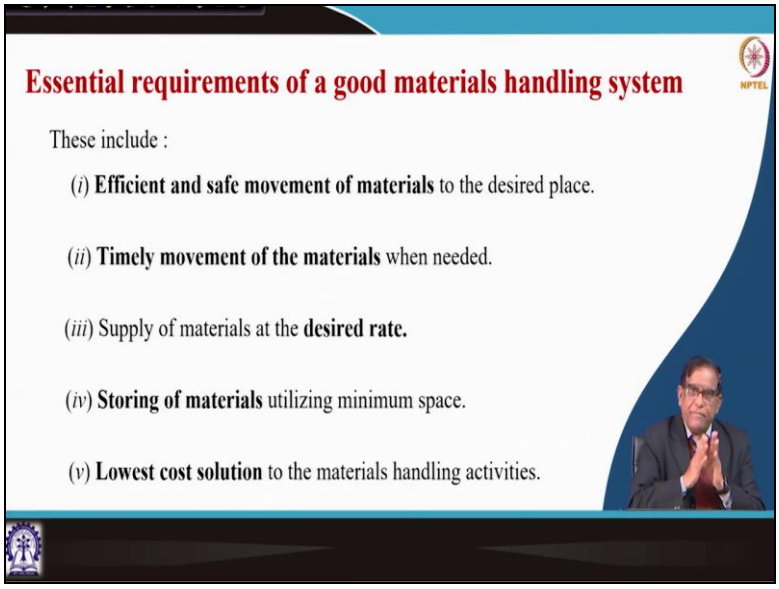

Now as a fundamental things in designing a system for handling and transportations you must know that what are the requirements that one thing is there will have to have an efficient and safe movement of materials. Safe move that means while the material is going it may be transferred from one to another it will be carrying out over there then it may go at a different speed.

So, at that time it should not give any problem to the people around it should not give any pro that is pillage or it should not cause any environmental damage. So, it must be safe that is the first principle will have to follow then timely movement of the material. So, that means there should not be a lot of deadlock that is your exactly store is there from there it is not getting cleared that means the system will have to be decided in such a way that that is wherever there will be number of points at some point it will be coming over there.

Some processing will be done and after that again it will be going like that in weather it is say for example in a steel plant in the steel plant there will be different materials will be coming over there and they will be going to the blast furnace and the blast furnace they will be getting out the slags and all that will have to be disposed. So, there will be lot of bulk material handling job in the steel plant.

Now in that that everywhere the time should be maintained. So, that the operational continuity and productivity will be related to that so, that is why when we say that the basic principle is to improve your productivity improve your operating efficiency and

there the most important point is consider about the movement that is whenever a function is to be there you will have to maintain that the motion is going on there if there is a motion there is progress.

Then there should be that at what rate we are telling ok that your material is moving but on a conveyor belt you can give a small heap of material the conveyor belt is running. So, but that means the whatever the thorough put will be there that how many meter cube of material is being taken every hour will be less. So, that is why you will have to move material at a desired rate and when you will have to store you may find you go to any mines or any steel plant.

And there are some stock years heaps of big materials are there and then also in the mines you will find because while taking out the available mineral you also excavate lot of overburden and waste rocks and all they will have to be kept somewhere and most important thing is that space is money space is a crisis if you are utilizing more space in that may be creating more environmental damage and then exactly space need to very serious considerations in the past.

We thought that ok that art everywhere wherever is there you dump it over there nobody bother about but from eighties onward you know that how we are concerned about the environment and we always talk of a environmentally friendly operation green operation in that your; the storing of the material will have to be seen very carefully and then of course the profit we want to do a business for earning money and then why will have to do the cost minimization.

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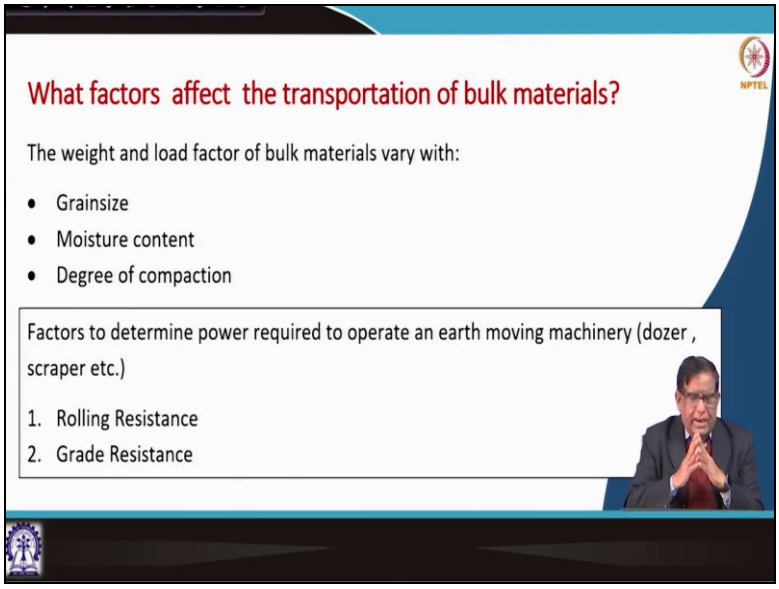

So, then there are these are the basic principles but when you will be going to design a particular transportation system or a handling system you will have to that is your consider number of factors it will be coming we will be discussing in our whenever we will be discussing say for a storage system design where we will be talking about the transporting by conveyor belt or transporting by truck or using a hoisting.

So, those are the different material handling system will be discussing but you should know about the because right now you are discussing about the material properties that in that the grain size moisture content and degree of compaction thus I told yesterday in the last class that regarding the microstructure the materials need to be properly analyzed and seen that is very, very important.

Many times we neglect that and then we face into a problem. For example that in your mining when you are talking about the productivity of handling and transport we tell about that how many trucks have given how much ton of productions. But very, very quite often we ignore the road and tire interactions particularly how the rolling resistance and grade resistances will be affecting your productivity and capacity.

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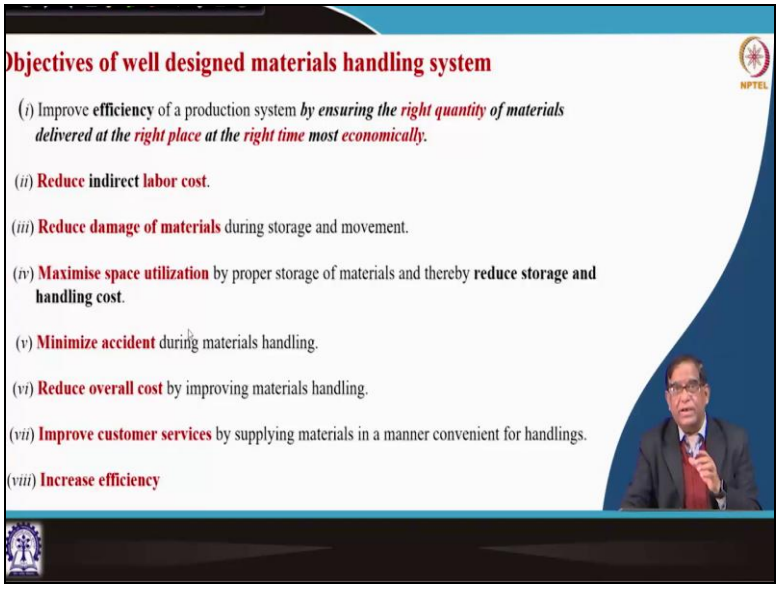

So, this rolling resistance means when it is going over a when the material will be running over a road surface at that time that tires and that your road surface if the rolling resistance is high they will be giving a that means your more fuel will be consumed. So, productivity is again you will be learning it is input by output that means if you are to for the same material to handle if you use more amount of quantity of diesel then your system is less productive.

And there it will be affected by the rolling resistance of the road. So, that is the way how your total system will have to be an integrated approach will have to be taken. Now in a when you are to design a very good system will have to see that the efficiency and that can be ensured by right quantity of material delivered at the right place at the right time economically and that is why from the rolling resistance to great resistance to the dust generation to the water suppressions that is how the whole road will be maintained.

Or that how your exactly truck plant preventive maintenance and condition maintenance of the truck and how you will be monitoring the diesel consumptions of the truck all things come. So, then you will have to reduce the labour cost then where but you will have to monitor each and everything. So, there where you will be using information technology where you can use IOT these things exactly to reduce cost for a higher efficiency.

Then during the transportation or handling the material should not get damaged that is damaging means sometimes say for example if you produce lot of fines then the from the

fines in a say iron ore while taking the things from the mines to your plant if you have produce lot of fines you cannot load the fine iron or finds to a blast furnace. Because the blast furnace that the gas which will be coming out if it is not a lumpy that pines will be just going away along with the flue gas.

So, that is why you will have to see that the material is not getting damaged during the handling and transportation and as I said already the space utilization accident will be minimized reduce cost improve customer services that is also another thing because in a different industry you may work if you are working in the mines your customer is the plant or the metallurgical plant. So, their requirements will have to be maintained. So, and then increasing efficiency are the basic things.

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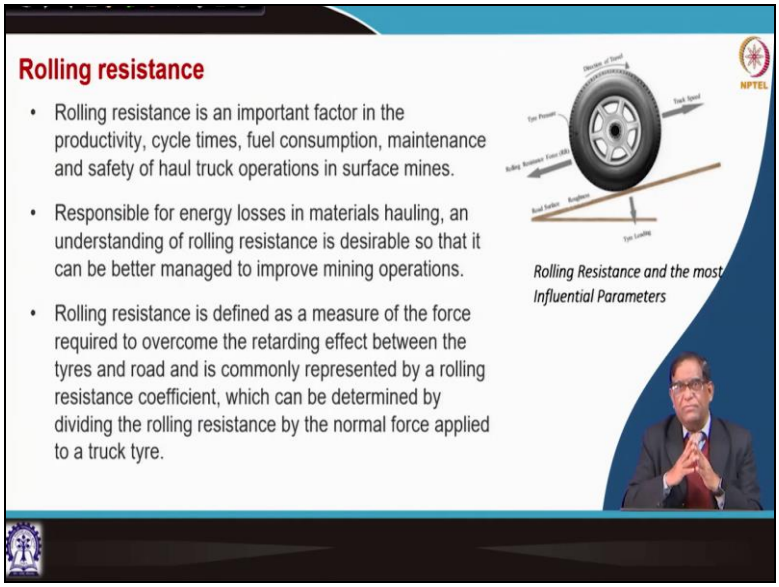

As I was telling about the rolling resistance you know that that when a tire is moving over here that whole traction will be taking place because of the resistances over here. Now this tire has got those trades and this they will be running at a different speed. So, the rolling resistance which will be opposing the speed affects the things. So, there will be when will be discussing about the truck.

And when will be discussing about the whole road design for an transportation purposes we will have to take a lot of care about it and by proper design of the road surface you can save a lot of diesel and also you can protect the environment much better way these are the things we will be discussing in our course.

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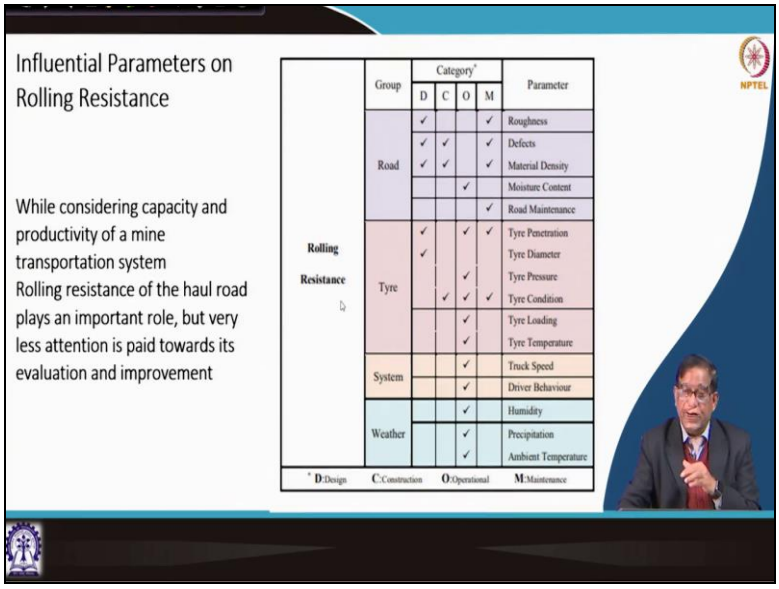

So, there are influencing parameters on rolling resistance that rolling resistance you have said. Now here I am giving you a tip that why you should be studying these things little bit more deeper that simple rolling resistance this can be affected by a that is we are considering the capacity and productivity but that rolling resistance can affect a number of thing that is exactly the road, tire, system and weather everything can be affected by the rolling resistance.

Now there in the designing of the road to the construction of the road for the operational as well as the maintenance of machinery every aspect and which aspect is affected by what? If you see that rolling resistance for that is your the roughness of the road will be considered for designing it that what material will be used whether will be doing it that is where the dozer will be required for maintaining heater motor grader will be required for maintaining it.

Or will be that in the particular area whatever the in the mines mine material itself can make the road or will have to buy some outside material to make the road. So, that means that a whole of your handling efficiency will be determined by this rolling resistance one factor. Similarly in the tire that exactly tire the if your there is penetrating to the road surface is very soft at that time the rolling resistance will increase.

So, that is here but again if your tire inflation is not proper it will be having more surface area in contact and there will be the rolling resistance will be increasing. So, that means the me looking into the tire and one thing you must you will be discussing while you will

be discussing about those machinery that the tire of some very large capacity dumpers like in the mines you will be using say 300 ton dumpers or 500 dumpers and as in foreign countries.

In India also we are having 270 ton dumper their size of the tire is having your more than 10 feet 12 feet this diameter. So, there la dumpers tires is a very costly one tire will be costing about 20 lakhs rupees. So, in those tires if it is getting damaged because of the rolling resistance will be your total cost effectiveness will go down. So, while bulk material handling even some of small research initiatives you can take on finding out the effect off.

And then even we do not have a database of our country that in the whole surface binding operations whole querying operations in the country if it is brought on a that GIS fund and then getting the rolling resistance of different places we can find out that what should be the market of our tire and then what will be our how we can exactly save in some of the; because large capacity large size diameter large diameter tires are not manufactured in India.

That means we are our foreign exchange is getting used for that foreign the quantity foreign money reserve get reduced if our rolling resistance is less. So, this type of that big data analysis work can also be carried out in this.

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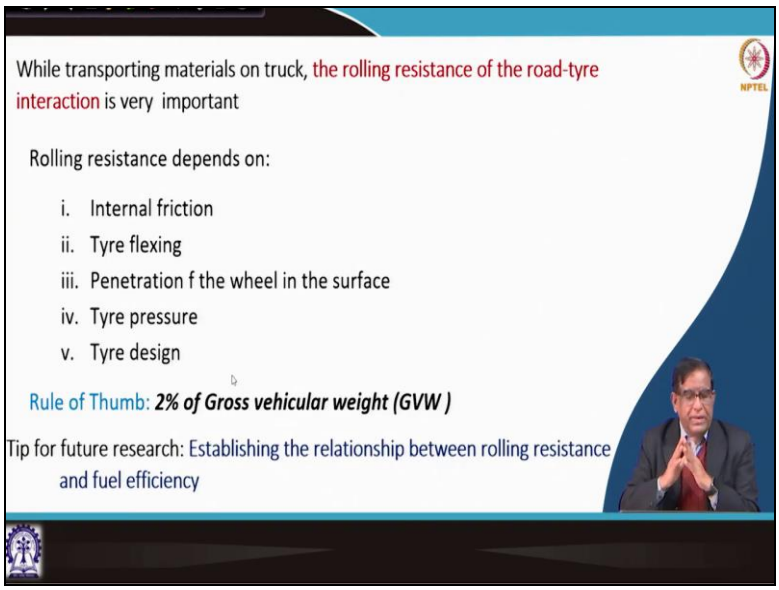

So, that is exactly the rolling resistance of the rotary interactions is one of the fundamental things which will have to be studied over there. Because the rolling resistance depending on how it affects by internal friction how it is affected with the interact with the tire flexing how the penetration of the wheel in the surface road surface will affect tire pressure how it will be affecting or the tire design even the thread design how it will be.

So, this you can go deeper inside in but normally in the mines you will find a rule of thumb reduced the 2 percent of the gross vehicular weight is taken as a rolling resistance and we do the calculations and by that you can find out because of using such thumb rule whether we have lost some money or we are gaining some money.

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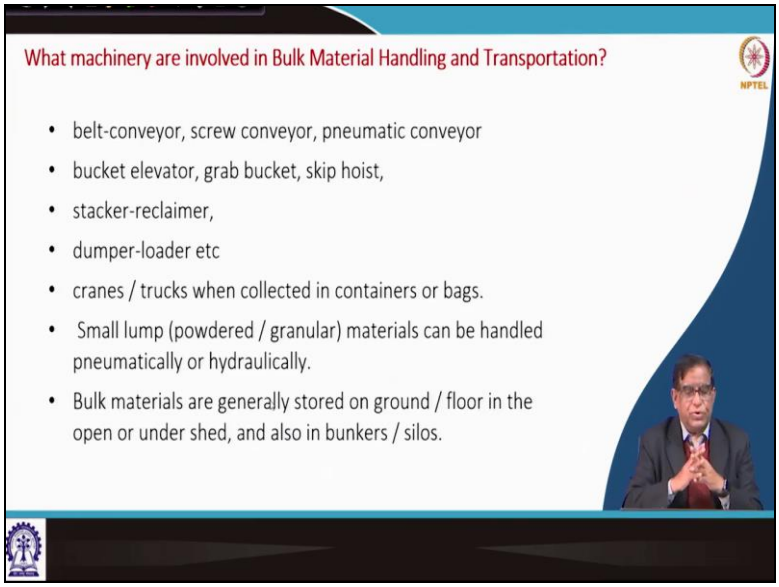

So, these are the some of the things you should do it then what machinery are involved in the bulk material handling you know already in the first class introductions I have said the belt conveyors screw conveyor bucket elevator sticker reclaimer dumper loader crane truck then your you have got number of pneumatic and hydraulic transports you have also sometimes been bunker silos for storage will have to be studied.

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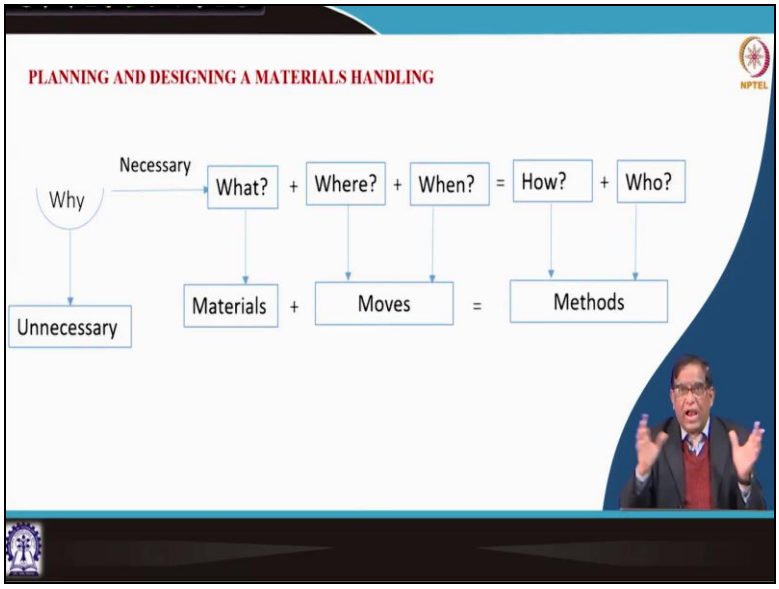

So, then when you design the system will have to look into that planning the whole principle will depend on why is it a necessary or unnecessary if unnecessarily do go ahead but when necessary what that for transportation and by handling it will have to material that material must move that material moves by what methods and then exactly what material where it is going when it is to be given how it is to be given and who will monitor and maintain that whole total system will have to be designed and there you will have to follow certain principles.

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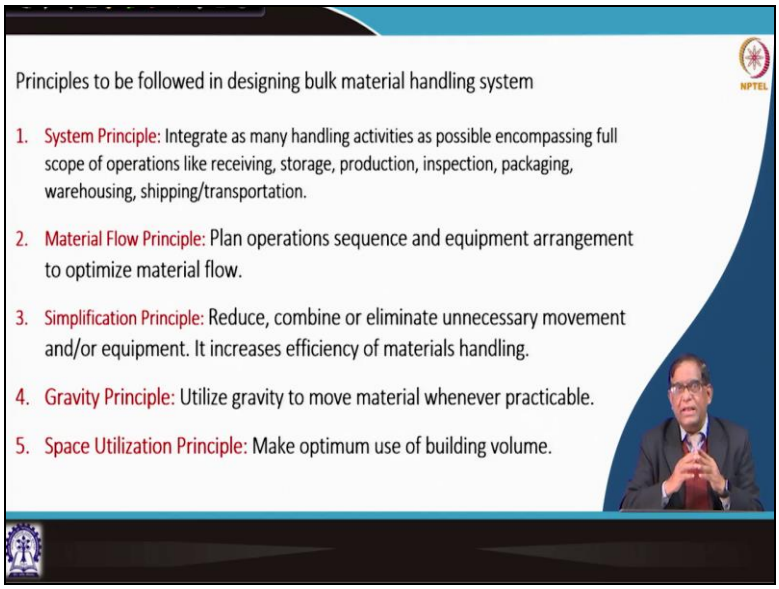

So, that your system principles that is your integrate the many handling activities of encouraging full scope of operations like receiving storing production inspection packaging warehousing shipping transporting that exactly different subsystems are there in that whole system. This is one here all this principle you can form a group of your

four students four persons together you can make an online friends with your four participants who are there and take one of issues and find out what are the factors involved.

What are the different designs involved say for example if you are supplying coal from mines to a thermal power stations then what are the different subsystems involved where it will be received where it will be stored where it will be what type of inspection will have to be carried out whether we have to get some packaging or where they will be given as a container or where they will be giving standing on a conveyor or in a pipe.

So, different things can be as a brainstorming or as a some points you should find out. So, that in our future study will be more effective. Similarly pro principle you need to plan that what are the how it will be flowing in between where it will be storage is there any temporary storage whether at what rate it is going. So, in the way material is getting flown similarly you will have to principle of simplification that is you do not have any unnecessary movement you do not have any unnecessary handling.

So, what are the unnecessary handling they could have then even you can think of that is your when you are in your hostel or that food stuff come that is a handling material handling whether this by if you are having in your college 10 hostels that how the vegetables are exactly procured and how it is gone and how it is washed and how it is going for the cooking.

There is a lot of handling system is there can there be a semi mechanized system for doing it and then how it is done. So, but the operation will have to be simple and it will have to be cost effective. Similarly the gravity principle when you are thinking of sending say iron ore to a steel plant then from a hilly side it is coming and then are you using the gravity principle sometimes that is some of the energy of the gravity.

But no mines anywhere in India is exactly getting the advantage of the direct gravity flow without energy can we that is a node such type of shoots and bunker systems are not there in our country. So, you can think of where gravity principle can be used then space utilization principle each of this principle have got number of points which can be

discussed and which can be do doing in a brainstorming exercise among students may be four or five persons group you find out what are the pertaining.

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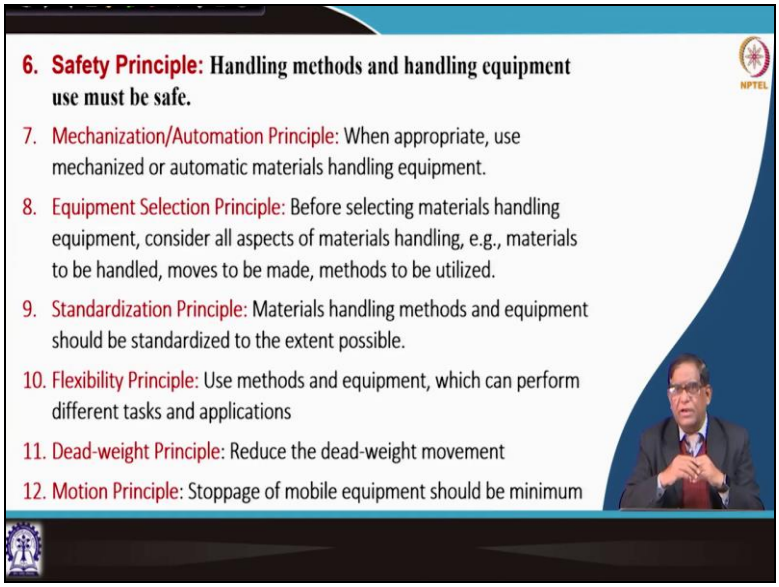

And for knowing a guideline you can as I have said you read process Siddharth Roy's book Siddharth Roy is a good expert in the material bulk material handling he was a professor at the Teacher Training Institute in Kolkata that book is a very good book published from Delhi. Then mechanization and automation principle that wherever you can do a automation that is now another way will have to go for studying that.

Now the basic fundamental thing is that your how will be selecting the bulk material handling equipment. So, that what are the aspects to be considered and then how the movement will have to be done that equipment selection principle is another very fundamental things need to be done. Similarly the standardization principle means when you are doing the work you do not you do not become an admin out whatever the available in the market as a standard from there you take otherwise if your anything goes wrong to get a spare parts will be vapor problem.

So, that means your system will have to be constructed with some standard equipment and components. So, that it can be easily replaced and maintained and meant like that. Similarly you should have a flexibility principle if because situation may change accordingly your system should be adopting that that is also then dead weight principle as I said in the dumper dead weight carrying you should avoid carrying the day to it.

So, there should be proper monitoring and how will be incorporating that similarly stop motion principle that is your stoppages of the system should be minimum that is your if you are having a railway gate in between the trucks with a load of a lot of your load is waiting over there you might have seen because exactly in our country many that our road and railway transport network they are never that is your design properly with having a over bridge and all that thing and many places in a railway gate the trucks full load of materials are waiting.

So, that type of material handling system is not expected that is why your rapid loading system has come your silo and bunker loading has come that merry-go-round system has come. So, those type of systems are based on the motion principle that merry-go-round system means one will be that you are storing the material on a big silo it is automatically being loaded when the truck is coming your railway train is coming over there and the train will be going and discharging the system will be almost a continuous system it will be working.

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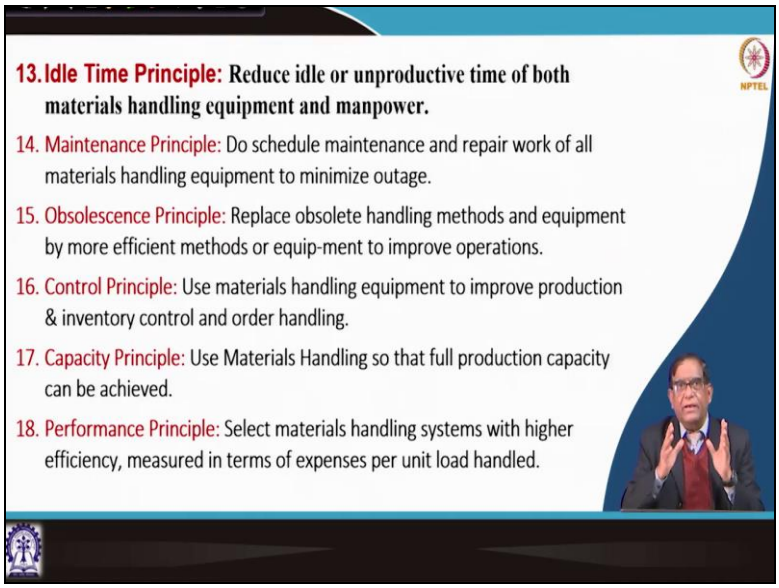

Idle time will have to be avoided so that will have to be also seen then maintenance principle will have to be followed. Then optional is principle you should have a while designing when this system can be should be replaced do not keep on because the technology is changing fast and then whatever you have taken today will become obsolete.

So, that is why do not plan having a things that your investment will be say 20 years of uses do not say like that your return on investment should be quicker and so that you can replace the system as and when it goes. Similarly the control principles you will have to have a proper control on the things capacity principle that is your full production capacity can be achieved in that we should say.

And the capacity utilization is one of the biggest drawback in our many of the systems we have invested tax payers money for buying big machinery big systems constructed everything but those machines being spent were purchased are used say 35 to 60% of their capacity utilizations they may be available 90% but the effective working hours or capacity utilization is very less.

So, that is not a judicious thing. So, how to do that that can be done by properly designing the system. So, that there is also a performance principle will have to follow.

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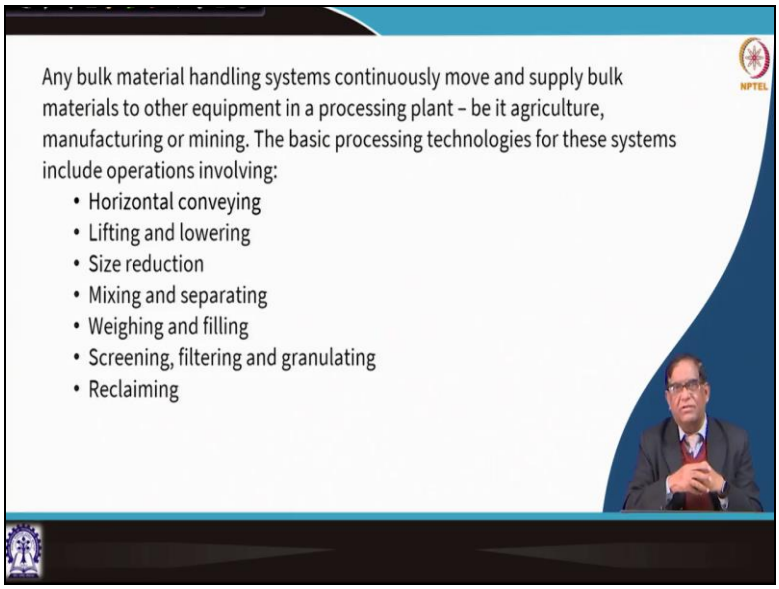

So, as I said on the basis of this you will have to get a your some group please start working on it and then that will be your learning activity and which can be submitted it can interact with us then any material handling system continuously move and supply bulk materials. So, that could be whether it will be taking a horizontal conveying it will be lifting or it will be a mix type of things.

Whether there will be a waiting and filling whether there will be screening filtering or that different processing work will be going on or they should be dumped or somewhere

to be reclaimed those type of things also will be coming in the bulk material handling system.

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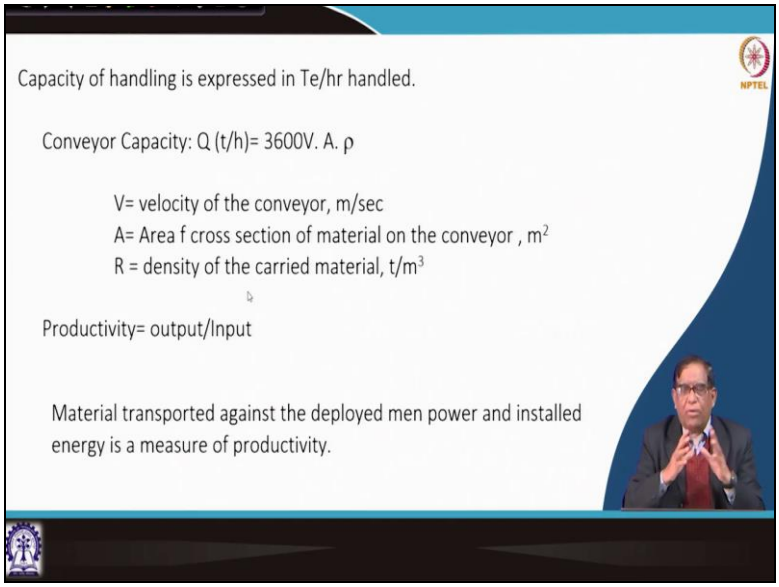

So, normally when we talk about the capacity it is that your carrying capacity that means how much is the conveying capacity. If your say on a belt conveyor if your velocity of treble is a v meter per second and then area of material on the cross sections of that cross section of the material on the conveyor belt is A and if that density is rho then your simply you can calculate how much is the tone per hour taken.

Now based on the stone per hour taken will have to design that what should be the width of the belt how the belt will be then and all that thing and then the productivity concept is very simple that in output by your the input. Now input comes may be different way whether how many total man hour is being used how many rupees have been invested for producing that. So, that is a root that is how much meter cube how much is your exactly rupee is required for per meter cube you can say.

So, in opposite way you can say that is your rupee per meter cube your input by output you can say about that that is the productivity.

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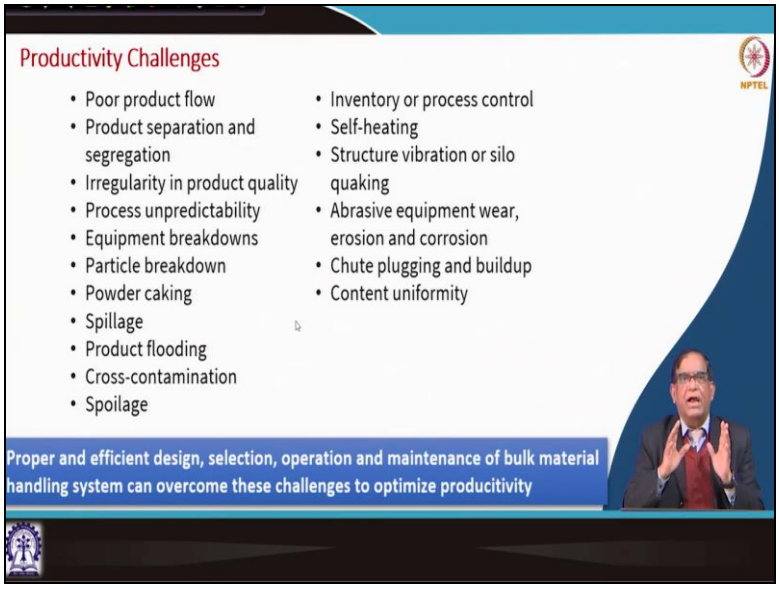

Now this productivity will be having number of challenges in a material handling system is your poor product flow product separation and segregation irregularity in product quality process unpredictability equipment breakdown particle breakdown powder caking spillage lot of things may give a challenge to the productivity as and when we will be discussing a specific handling system will have to understand these challenges.

And how to in a engineering way how by use of modern technology we can reduce this that your productivity reducing factors.

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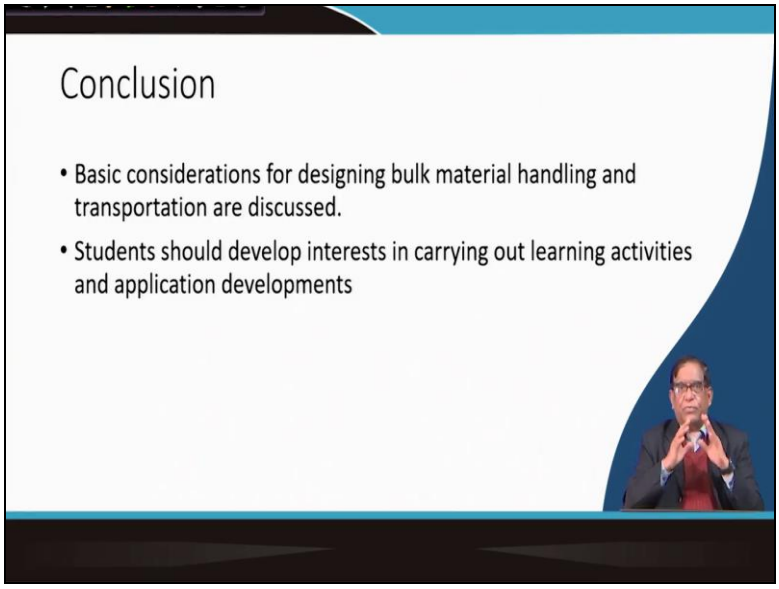

So, what we have said here today the basic considerations for designing bulk material handling and transportation we have very briefly told you over here. But what I encourage here you should develop an interest in carrying out some learning activities

and application developments and that application development you can discuss amongst your friends.

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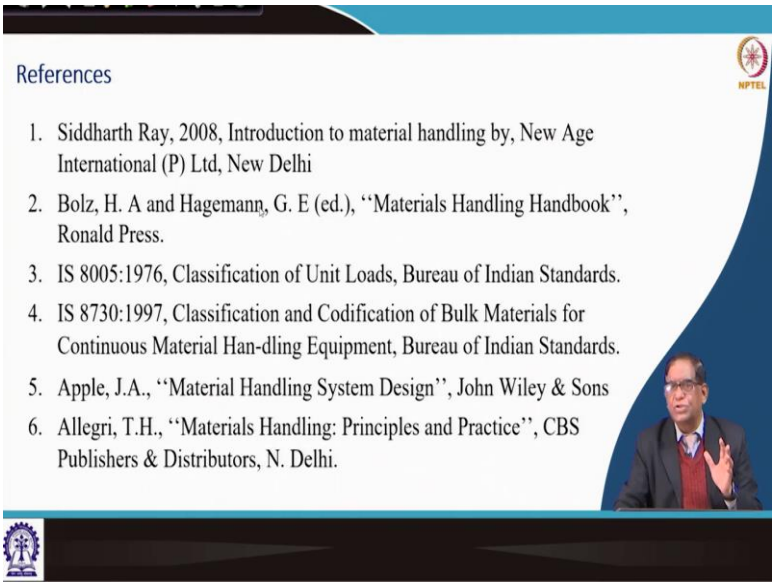

I have given some of these books that which could be very good at the same time the basic principles that mechanics of bulk material handling by Norman Crook is also one very good book where you can study the basic mechanics of bulk material handling which we will be discussing in our subsequent classes to some extent. So, I hope with this you have got an idea of what is bulk material handling but yes you as it is said that **(FL: 38:32)** if you want to you will say relaxed and without work today then you may not get the education and wisdom.

You will have to work hard that is what that sloka says and I wish you take up some learning activities, thank you very much.