Bulk Material Transport and Handling Systems
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Lecture – 2
Properties of Bulk Material Vis-a-Vis Different Bulk Handling Operations

Welcome to our discussions on bulk solid handling and transportation. As we have told that this in a bulk solid handling and transportations we deal with the different types of bulk materials like coal iron ore cement and also we talked of we need to handle liquid bulk like crude oil and this refined oil all those in different oil pipelines. So, now today we will be discussing regarding the properties of bulk material and then different handling operations how they affect.

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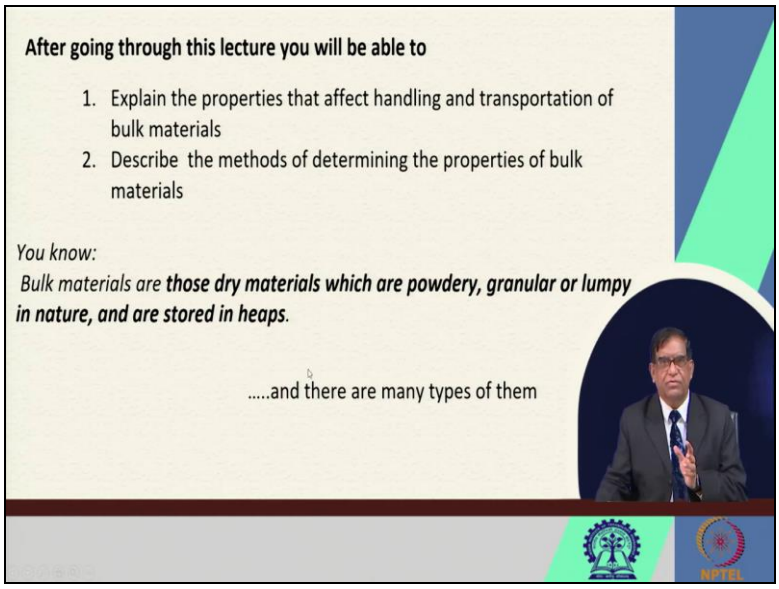

So, let us in this class we will go through some of the basic properties of material which influence the operations of the different machinery used in bulk material handling exactly this is the properties of material which matters a lot in getting the efficient operations from different machines and systems. So, after going through this lecture you should be able to explain the properties that affect handling and transportation of bulk materials and you should be able to describe the methods of determining the properties of bulk materials.

So, in this class it will be an introductory to different properties and then different how it affects as we will be going through the subject you will be knowing that how they will

be influencing and meanwhile you will be able to initiate some of yourself studies and self research in this particular area. So, you already know the bulk materials are those dry materials which are powdery granular lumpy in nature and are stored in heaps.

You have seen coal or iron ore heaps you have seen sand being taken out from the riverbed and then carried by different trucks and you have also seen in the steel plant how different raw materials for making steel are being brought and then they are exactly processed for getting extracting the metals. So, in those operations the materials which are coming from different sources from different types and that is why they require a proper machinery and those machinery will have to be designed operated.

So, that this during the handling and transportation there is no problem that is why the material properties is the very very important things.

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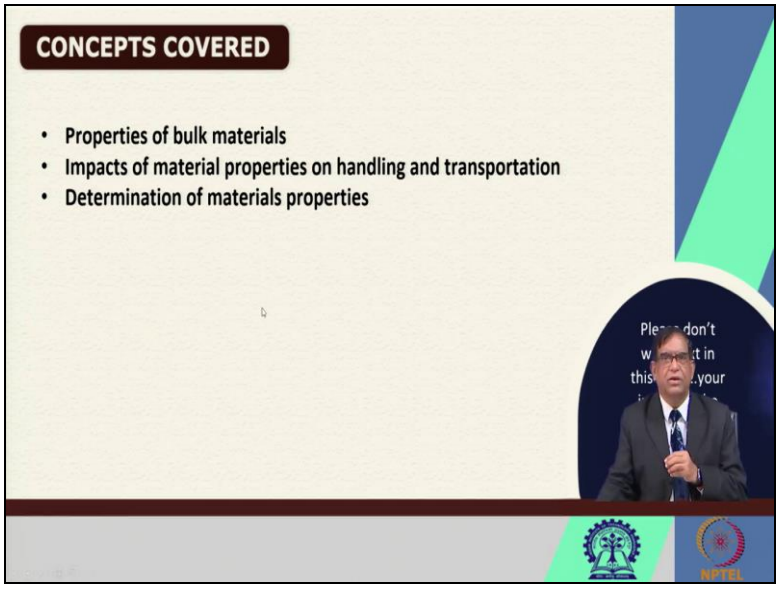

And as there are different types of materials we cover in this lecture that what are the properties of bulk materials then impact of material properties on handling and transportations and determination of some of the material properties though it will not be possible to cover in one class but it will be an introductory and so that you can go on exploring into different areas.

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So, now coming to the type of materials which you can find out that when we talk about the properties of bulk material you know that bulk materials are like this it can be in a powder form it can be in a different type of size mixes could be there. Now there are certain materials which are called abrasive material that means if it is going through or you are flowing through a chute the metallic chute that chute will get co eroded out because and then sometimes if they are just having a movement amongst themselves they will get a powdery form.

Some of them as we can see that there are you can get fluidized it can start flowing if you can put it in a heap it has got a that is a flowability is high then it will start moving sliding down you cannot keep it on a heap then some of the material may be hazardous material they are toxic if you touch then your skin may get affected or sometimes they may even radiate radiations maybe they are from that material.

And then there could be sometime large particles big boulders may be coming particularly when we do this fragmented blasted rock mass. There could be a lump of even one meter and 1.5 meter big lump could be there in other fragmented material there could be fine and then the mix of different sizes of material may be there. So, then there is a contamination sensitive pro products sometimes you will have to help manage with some of the bulk material in particularly in the food industry and all.

If they will have to be if they are kept exposed to certain environment they may become contaminated they have been some it may create disease to the people. So, at most care

will have to be taken for those material which can very easily absorb or adsorb some of the contaminants which is there in the environment. Similarly there are some materials which will have to be just like a it can it can be a pasty type of material that it can just put into you are handling it for pressing inside a tube.

So, those type of materials also are there that means very high viscosity materials will have to be handled in a different way then there could be certain material which do not flow properly. Because they get a very good that means they have got such a cohesion that they will not be flowing and sometimes some of the material may get stickiness that is it will be sticking to the that appliances and then you cannot release them out quickly.

So, this type of things will have to be handles differently. So, some of the materials are free flowing if you put it there it is like a sand if you make a heap then it will start flowing that is how the angle of repose will be affecting those things also will have to be looked into in this while studying the properties of material. Then the moisture content in the material is another big important property.

The moisture content it affects handling as well as in some processing. If your iron ore is having a lot of moisture then what will happen that is exactly the it will consume more energy while extracting the that your iron from the ore. Similarly in a coal if there is a the lot of moisture it will have exactly the calorific value that will be obtained by burning will get reduced.

So, and then there is a heterogeneous mixture of different material that there in bulk material you will hardly get any homogeneity. So, you are heterogeneous even the composition wise of different particle may have got different compositions because even if we are doing reminding from a iron ore from one particular pit but there you will not get the equal quantity of the same level of say phosphorous or same level of silica same level of alumina will not be there all around the pit.

Because there will be different similarly sometimes with that there will be say bended hematite quartzite may be there will be some lemonade may be there different type of rocks also can be they are lying at the same time. So, that is why it is a mixture it is a

heterogeneous then when depending on the processing required you may have to handle it differently.

So, there are some material called primal material it will be breaking that say these are the different type of material you will be handling and then depending on their properties your transportations will be. I think it is clear to you that the bulk material has got some of the properties and will have to take it very carefully study the each and every things of that.

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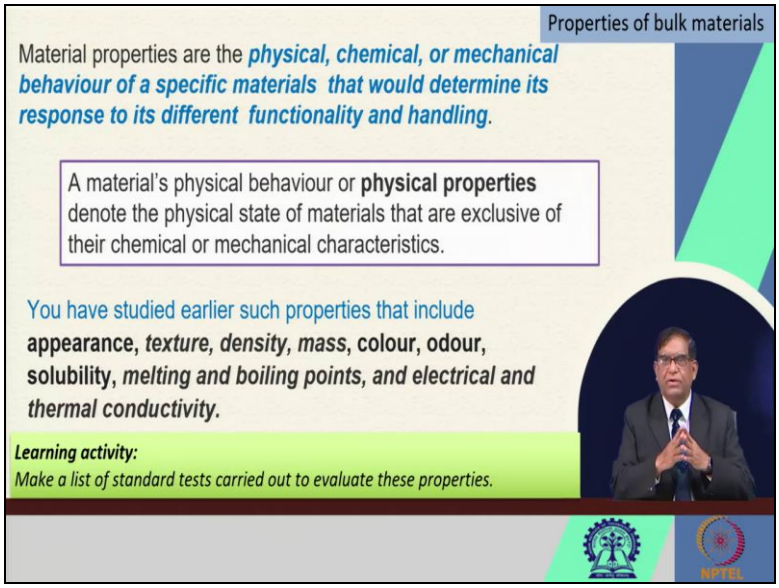

Now what those properties are the properties normally these are all just a recapitulation of what you have learned from your high school days onward that physical chemical and mechanical behaviour of some material how they do how they exactly behave or respond when you are giving some physical forces or you are bringing some physical environment change on that.

Then what type of chemical in its how it react with different type of liquids or how it is exactly if you are applying forces to break it and how much it will resist. So, like that it has got a different behaviour and exactly while you are doing some functions with it at that time depending on their these properties they will be behaving and they will be giving. So, a materials physical behavior or physical properties they know the physical state of the materials that are exclusive of their chemical and mechanical characteristics.

There could be different chemical properties different mechanical properties but the physical properties which you have studied in your earlier classes that it include your appearance how it look like its texture its density mass color order solubility melting and boil boiling point your electrical and thermal conductivity these are the things. So, you just recapitulate all whatever you have learned earlier and you can take a learning activity to make a list of the standard tests carried out to evaluate these properties.

Some of the things you have done already in your school and in your fundamental studies for engineering. Now you just keep a new note of that.

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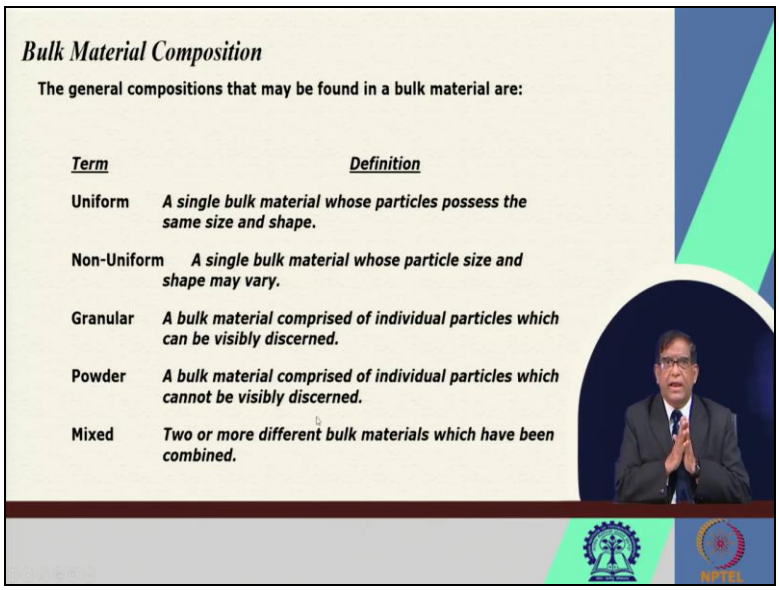

Now this is a another thing is the bulk material they vary according to their compositions. Now this is a composition wise bulk material can be uniform it can be a non uniform it could be granular it could be powder or it could be mixed as we have said already. Granular means it will be having a different particles which can be visibly discharged you can just see that again and powder which are of very finer size particles and that in that way you can find this whole material whether it is a heterogeneous homogeneous uniform non uniform you can study about that.

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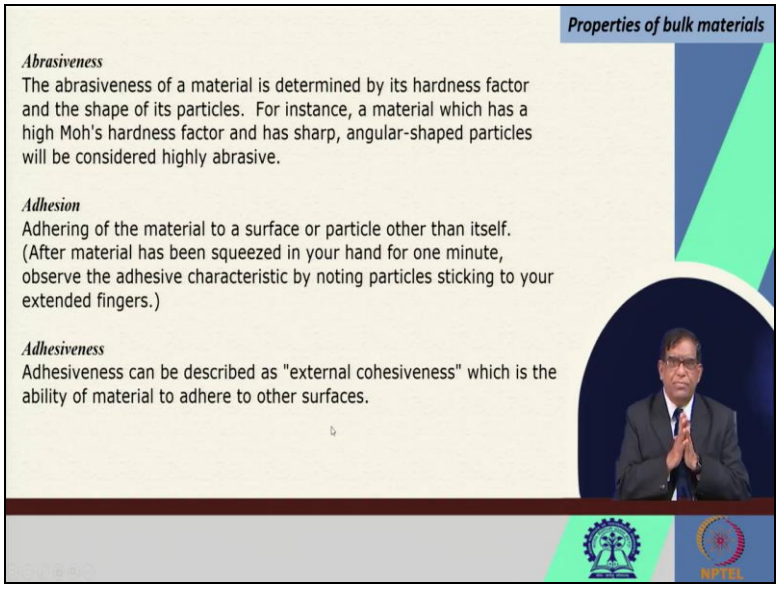

Some of the properties which you know that exactly the abrasiveness I said that how it will be exact wearing out the carrying surfaces that is your if your rock is having highly abrasive it has got surfaces depending on the quads content in the material sometimes it becomes you know the different materials has got different hardness. And depending on the hardness if it is there on a another softer surface when it move it form a groups and the material goes out.

So, that is the abrasiveness now that abrasiveness can be measured by successor abrasivity index. So, like that that you have studied in your basic rock mechanics also if you have studied if not there are the exactly standardized method accepted all over the world. So, you will have to know about that similarly adhesion that is exactly how it is having a attraction to the other particles that is a adhesive properties which is also important that adhesiveness it is as an external cohesiveness.

Cohesiveness is that within the particles how they are exactly having a bond a resume to the other particles how it get exactly stick to.

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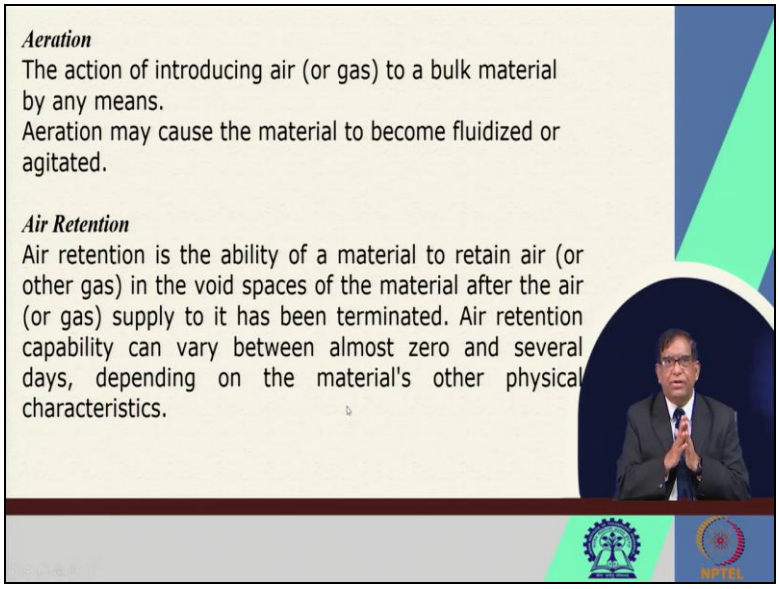

So, this then there is an aeration that means the action of introducing air to a bulk material by any means. So, that is that how you give a aeration it will take or not say for example the if you are having a as lot of moisture content in some of the soil material and you have kept in a say silo or a bin then the material will not be flowing through because it will make a earth formations you will be knowing about when we will be discussing that but there if you can pass air if the aeration can takes place it can make again flowable.

So, like that your how it will be exactly subjected to introduction of air that type of properties comes under erections. Now there is a also called the air retentions that means that is a how when a or inside that air when it passed through whether it will be sticking to there or it will be just passing out it will not be available there that means air stay there or that is exactly it has got a adjusting sensor in within the pores under a pressurized form air can be stayed there.

Depending on the situations how it will be there that is the air retention and sometimes if you say exactly if the material is getting heated up you know that this air will be going and at that time the void space will be shrinking and that compactness will be increasing that air retentions will be decreasing. So, those type of relationship and the properties are also there.

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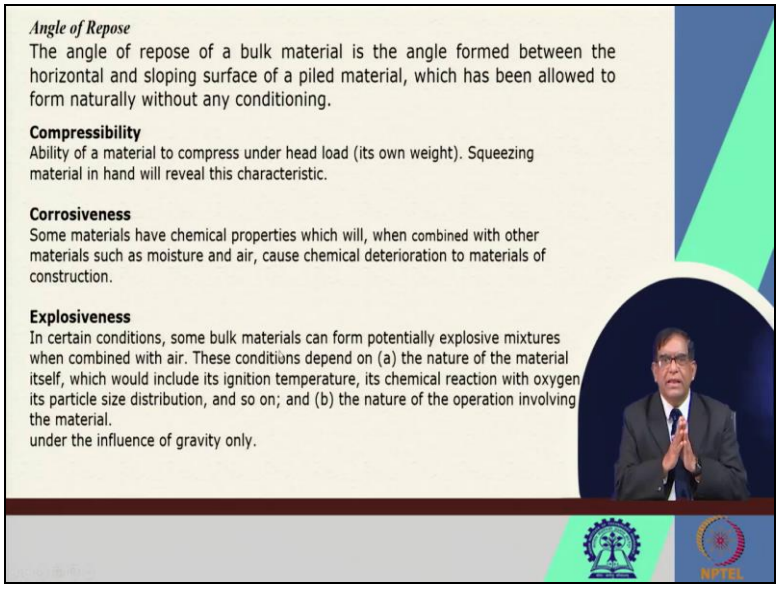

Similarly angle of repose is another very important property if you take a that is a handful of sand and then you start flowing it over there you can find that there is a triangular that a conical step will be formed that means with the horizontal the edge of the heap is making an angle that angle is called your angle of repose. Now this is a very important property while you are making a heap or dump.

And if you are pushing the putting the material if it is just going your mode on the angle of repose it will start sliding and then it may go exactly whether you are having any what type of situations you are or where you are making the heaps that will have to be designed that that will have to be considered. So, there are lot of things this type of properties will be coming in handling and transporting of bulk material.

The angle of repose will be influencing that at what angle a conveyor belt can carry the material and then if your that you are lifting through a conveyor belt then how you will be making the mechanical arrangements will be coming their of repose is a very important property. Then there is also a compressibility that certain materials whether you can squeeze them and then you can make them harder that means you are you can increase the density by applying pressure that is the measure of the compressibility.

Sometimes the corrosiveness that means it is chemical properties it can corrode the material that that type of properties also will have to know. Sometimes the explosiveness some of the milk material particularly if you see that is your some of the that coal dust if

it is there in a mixture in the when it mixes with air at a certain time if it it become explosible that means a little spark can make a big blast over there.

So, this explosiveness or explosibility of certain mixture or some materials are also as an important property.

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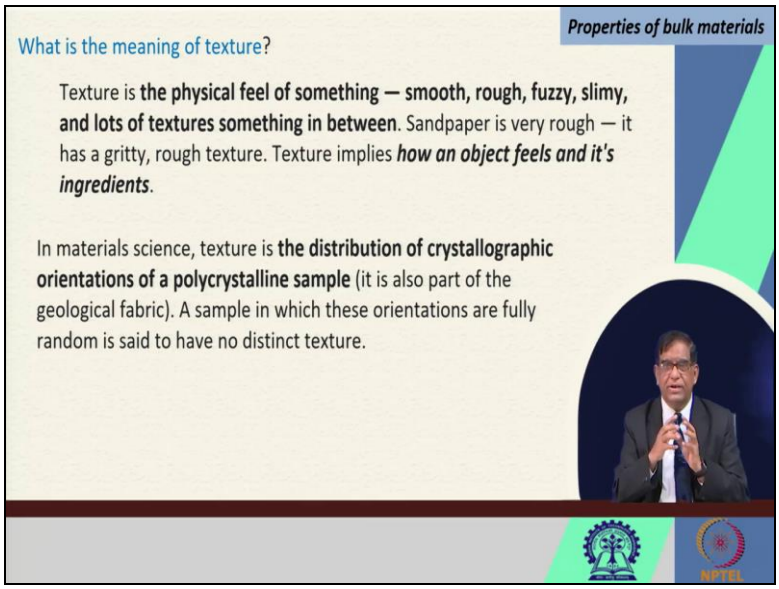

So, another things you might have been hearing that is a texture that is a when the bulk materials may they may be looking like smooth they may look like rough they may be fuzzy slimy and many way we can describe the texture that how it looks like and sometimes with that some of the your engineering properties may be correlated and then you can have a first impressions about which while handling what type of appliances will be exactly useful.

So, for that that is your this texture is coming basically the inner structures of the material where the crystallographic orientation of the poly crystalline samples if you take of the material then you will find that how inside the material is composed off.

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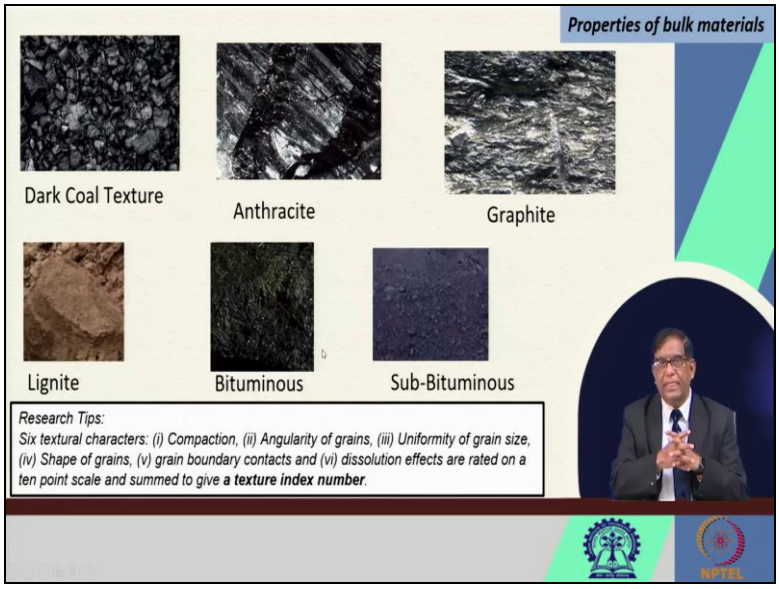

Now today when you are studying materials we need to study the texture and that there are good instrumentations are available and by studying the texture you can find out that while we are talking of use of this bulk materials for different purposes and then say forever coal. In the coal how it will be burning and how you are getting its calorific value and then there will be certain relationship with the texture because in the microstructures what type of impurities are there those things also can be studied.

And then you can see that by seeing only also you will be knowing that this is a dark cold structure is there whether it is a bituminous coal or it is an anthracite coal by fill also you can touch it. So, that is why when you are using this type of bulk material then you need to study this textures along with the other properties for example that how it is exactly compact that because the inner structure that will be determining how it is exactly it will be react with different type of physical forces.

Now then the grain size inside how it is there if it is a say in a sandstone if the sandstone particle can be made of a fine quartz grain could be there or a very rough quartz grain will be there and according to that grain size how it will have braiding on another surface or when you want to do a drilling over there then how the drill bit will get where will be depending on that.

So, that is why that while studying the properties you investigate the textures and the factors which affect that property which is coming from the inner structures and all.

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Sometimes some of the materials of course their textures you might have seen that asbestos which has got a fibrous textures or a copper ore you can see the texture with the roughness with the colour that chalcopyrite things which is a bluish nature will be coming. So, many a time the bulk material handling you need to see you can find out whether there are lot of unwanted materials are coming over there or not and then how they will be handled will be depending on those properties.

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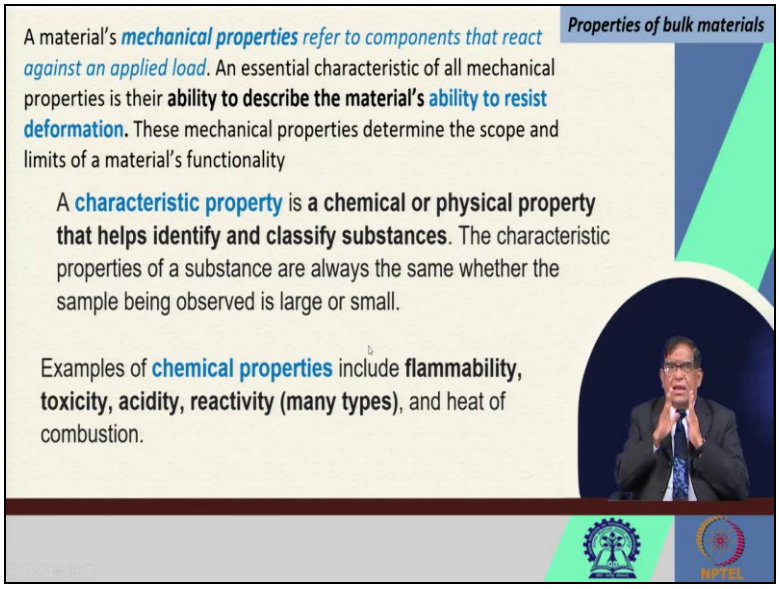

Then the mechanical properties exactly what, it is the mechanical properties are how it react against an applied load ok. So, that means it is a it is a very essential characteristics the mechanical properties because it gives the ability to describe the materials ability to resist deformation because this will be coming when we are say crushing a particular bulk material say for example iron ore when it is coming from the mines as a run of mine

ore then you will have to crush it to liberate the that your particles from where the iron will be extracted.

Similarly before placing into the burner that the coal also will have to have a particular size you cannot make a one meter big lump to be placed over there. So, now while crushing that how much energy will have to be given over there to the under how much force whether we are giving the amount because if you are applying more than necessary you are wasting energy if you are putting less than necessary you are not being able to do the that is your result ultimate result will be poor.

So, that is why the mechanical properties must be certain. So, similarly there are the characteristic property there is also that some of the characteristic property which is it distinguishes it from the other. So, there will be the that what type of dose characteristic property it when we particular mineral or particular material bulk material is studied say whether we may be handling sometimes the sawdust in a sawmill that saw dust which are coming that need to be say they that taken out from the place from the mail and then do this place disposed somewhere or from the dust we want to create some boards and all that thing for that handling.

It has got certain things that whether it will be if the part if you are taking on a conveyor belt now if there is a wind is there all the particles will be going out. So, there will have to think in a different way how to handle it. So, that is why the characteristic property will have to be seen over there.

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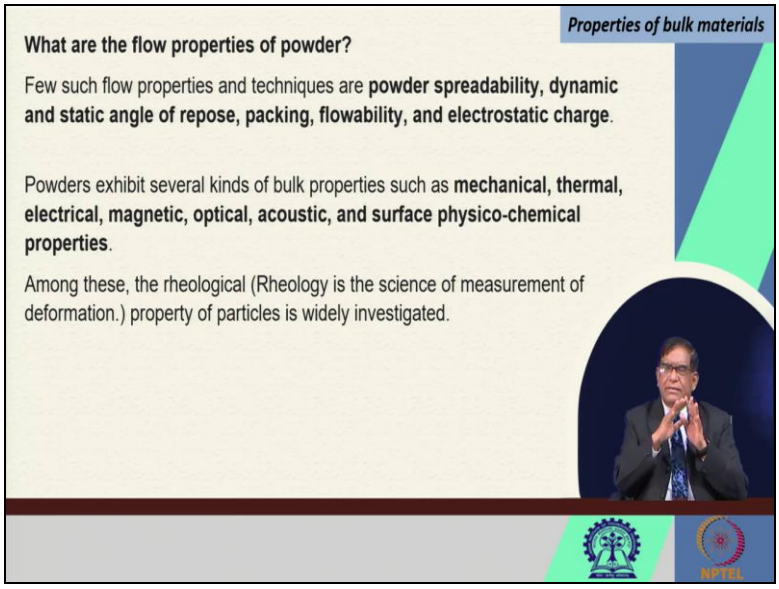

So, then there are chemical properties and then there are flow properties the powders and all that will have to flow properly if you are making a paste that paste how will be at how much pressure will be there. So, that the if you are keeping a toothpaste that then what should be the size of the tube and how it will be placed over there. So, those properties as a flowability they are pecking capability how you can peck it and all those type of properties also need to be sent.

And other than that that we need to know that thermal electrical magnetic optical acoustic then different surface physico chemical properties it come depending on the materials that you will be handling. So, there is another very important aspect is the rheology in the liquids or in a solid everywhere how under different stress conditions the strain comes that stress strain behaviour that is also very important.

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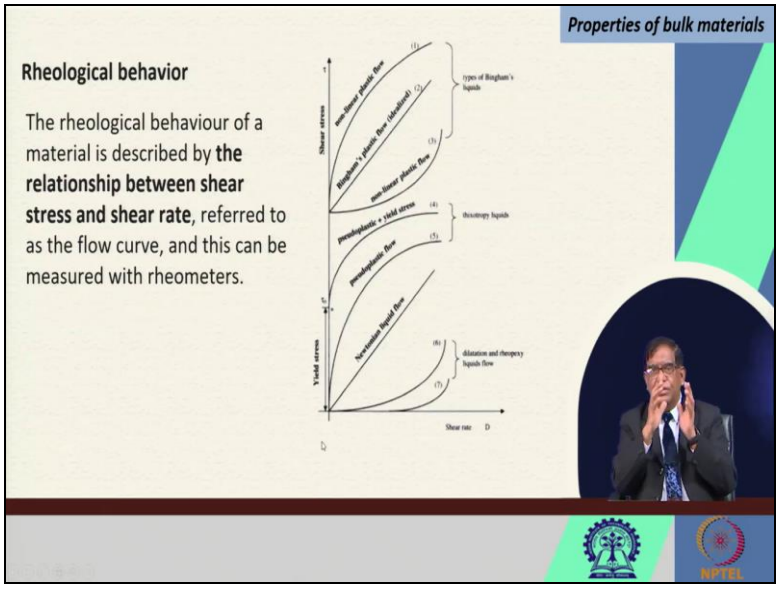

That rheological behaviour we always tell that is your up on the how does your shear stress and yield stress vary with the shear rate depending on that exactly you might have studied in your rock mechanics or in your that mechanics that stress strain behaviour of particles and also that material. So, now that rheological behaviour it can be just how your shear stress and shear rate are related depending on that we can have a plastic type material like a brilliant plastics where there is a uniform rate.

Then there is also that whether it will be a plastic flow whether there is a non-linear plastic flow how it will be behaving in a flowability will be coming it is just by studying the rheological properties of material it can come that while this is discussing your liquid flow will have to see the rheology even in sometimes when you are making a heaps of some powder materials you need to look into that.

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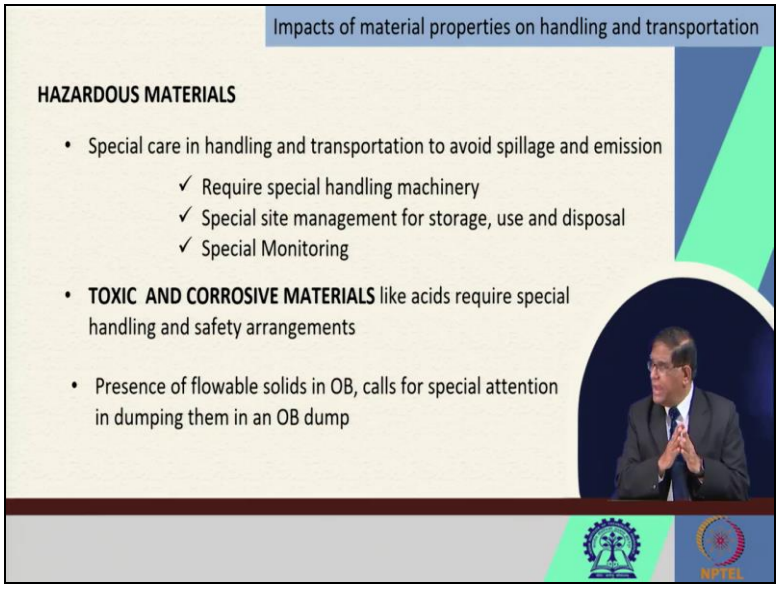

So, now handling the hazardous material that is another issue that is you will have to very carefully find out that what will be the special handling machinery needed what will be the specific site management required what will be the special monitoring required. So, that that exactly the hazardous material is not getting liberated to get any persons or other that environmental exposure emission should not be there.

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So, that is why we will have to know about those properties and then the handling will be coming depending on the properties required. Say for example sometimes in a mine will have to have a mobile slope conveyors you can have a that conveyor belt which can be placed over here and this whole machines can be flowing because there is a different type of orientation their properties of material to be handled.

So, there could be a pipe belt conveyor or that is called your tear drop conveyor belt where your toxic or that material which has to be carried out. So, that it should not make the environment. Similarly we have got some systems can be developed that is we are not bringing any diesel exhaust over here by electrically a just a grass upper conveyor we will be discussing this type of systems mechanical systems how they are designed depending on the material to be float.

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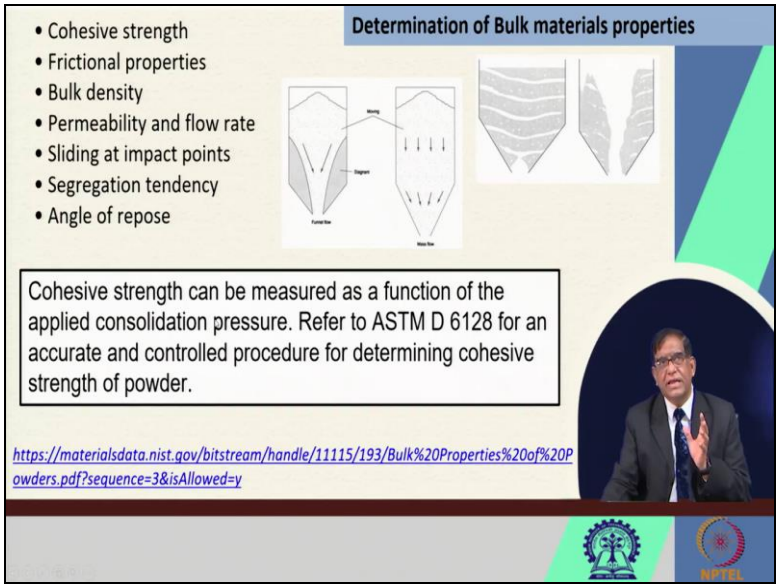

Similarly when you skip a material in a bin then it may sometimes get blocked say you can see here the material do not flow out because in from there they have created either a red hole or they can create an act. So, this type of things we have to study the materials cohesive strength frictional properties bulk density permeability flow rate sliding at back points these are the things need to be studied for designing such type of systems.

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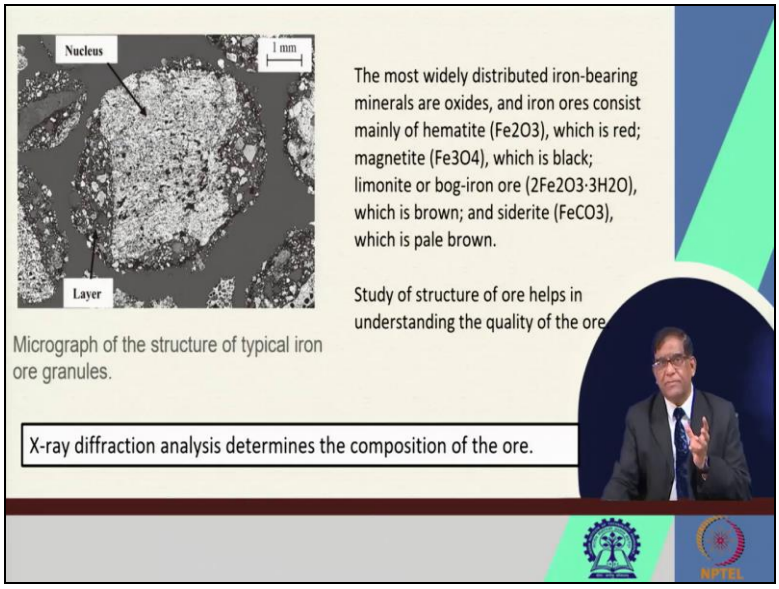

And for that another thing is that the structures of the material in a micro graphs you study and then you find out that how exactly the in a bulk material that where your iron or your other material are present in which form then how they could be liberated in by handling them by processing them. So, these are the things we need to know.

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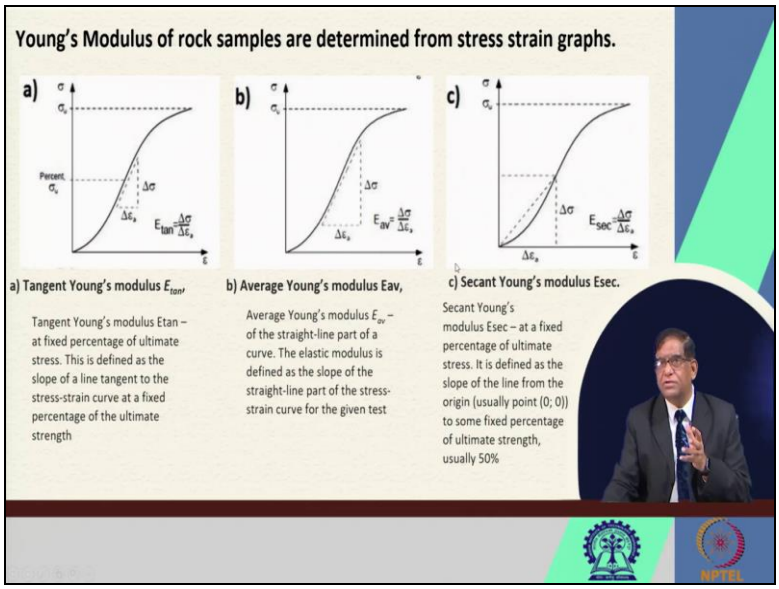

So, similarly for the mechanical properties that Young's modulus that is a very important property of bulk material it can be a tangent young modulus just a stress strain ratio how you can find out that is your when you are putting the stress and then the strain ratio it depending on in which zone you are calculating you can give that average Young's modulus or you can get a second Young's modulus.

These are the properties which are calculated it is more important to know that whether exactly with the young's modulus with different compositions different type of granularity and different type of moisture content how their properties vary.

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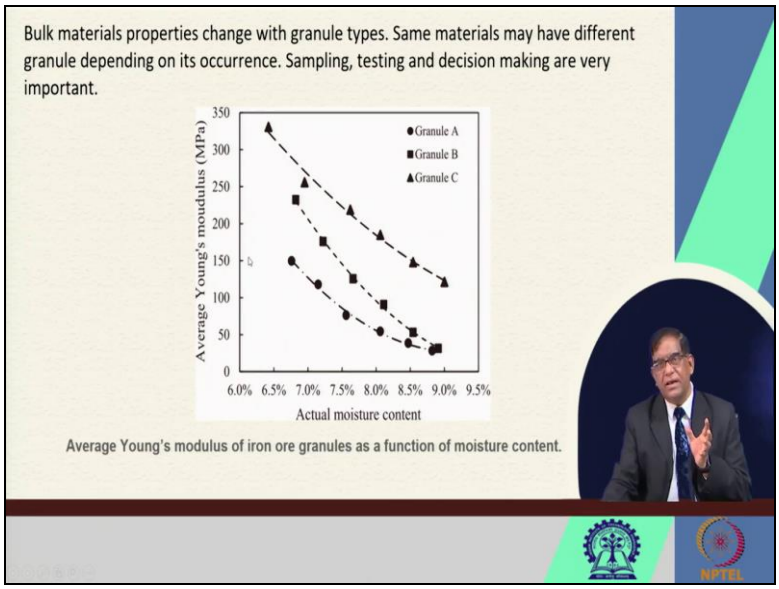

I am telling you this thing. So, that you can think of while you are doing any project work when you are initiating an individual research that how you can correlate how you can study a material. So, there is a lot of things are yet to be done around you can find out the properties.

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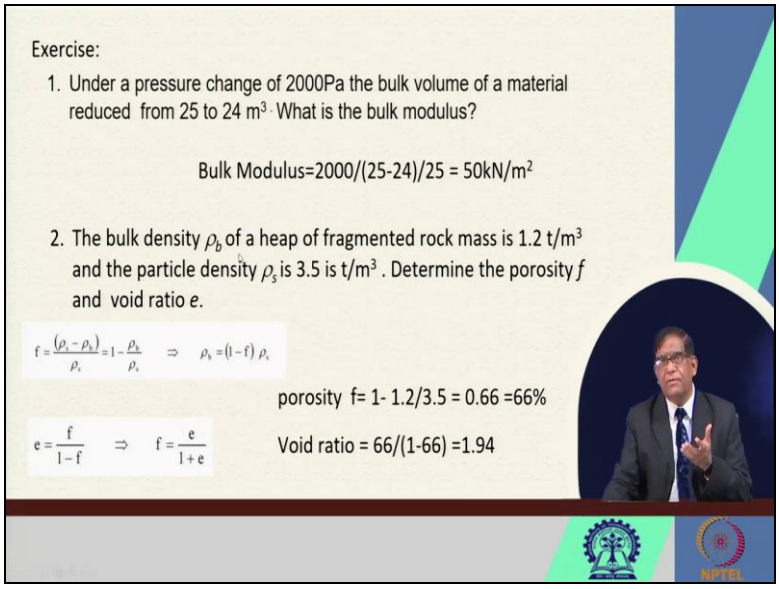

And then you can do a some simple calculations that under a pressure change of 2000 Pascal the bulk volume of a material reduced from 25 to 24 meter cube what will be the what is the bulk modulus? You can find out the calculus the bulk modulus is nothing but

the pressure and then this how it has changed. So, that means you are you can calculate the bulk menus from data you can find out.

Similarly if you know the bulk that is a bulk density which is the total volume that a mass upon volume and then if you are knowing that particle density if you take the particular particle you will find the particle density is higher than the your that average density that is the bulk density of the material. If you know that thing then that means in between that when all the particles are aggregated to make a bulk there are a lot of your volume that pore spaces.

Now those pore spaces are measured by that porosity or a void ratio and their relationships you can find it out. So, for example in this particular one your porosity is you can find out from these equations that is one minus your this if you can find out the bulk density as a one minus your of the this you are finding out this ratio of the particle density the difference of the particle density and the bulk density over the bulk density. So, this ratio is giving you and you can find out the porosity calculate it out like this.

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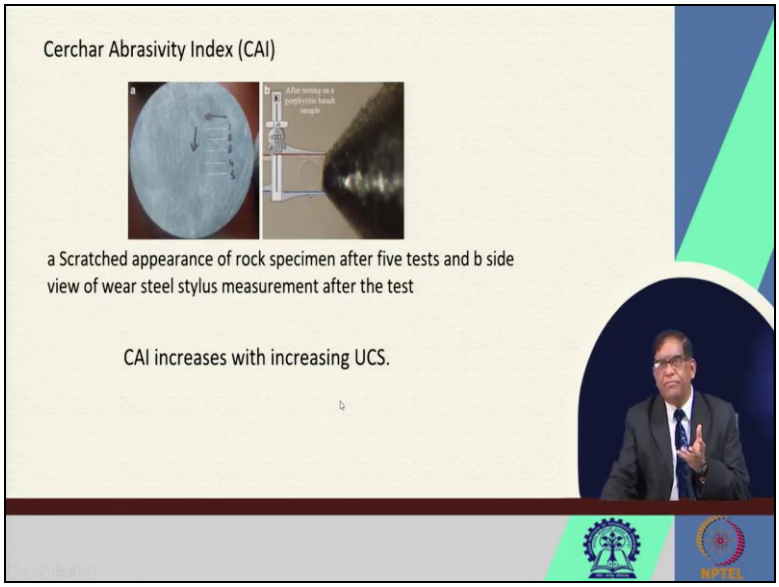

So, you can do also the abrasivity is measured by sensor index you are taking a stylus and that stylus is making say five mark over here after that the stylus has got worn out. Depending on that exactly you can find out that is what is the abrasivity of this particular rock samples such type of things and then researchers abrasivity index it will be if the universal compressive strength of the rock is more there will be more abrasivity. So, such type of relationships are very important.

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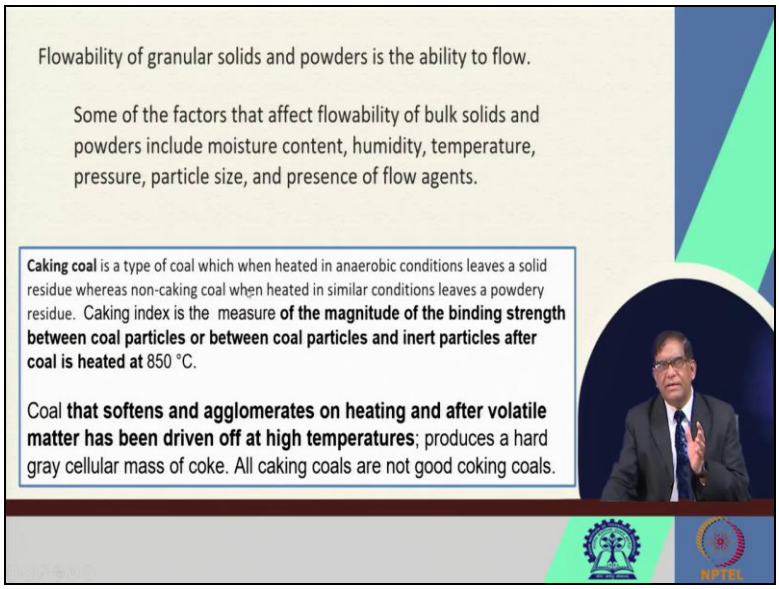

This similarly the granular material how it is doing you will be studying about what is the caking coal or the coking coal in the caking index these are the properties of coal you will have to go through find out these things and they say exactly the caking index is the measure of the magnitude of the binding strength between coal particles and between the coal particles at a particular temperature.

So, that by which exactly it determined whether a particular coal can be put into a blast furnace or not that is why even though we are having. So, much of coal in our country but we do not have a metallurgical coal why it is. So, that those are the properties of that bulk material you will have to investigate on this.

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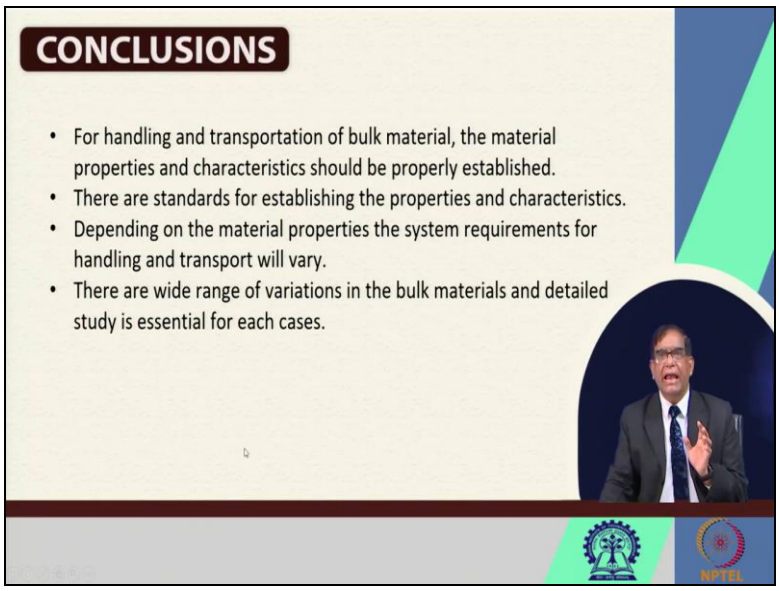

So, like that we can find out that for handling and transportation of bulk material, material properties and their characteristics should be properly established and there are standards to for establishing these properties. There are standard methods of the determinations. So, you will have to make some self learning in this respect make a list of the properties and that what are the standard laboratory tests and what are the advanced testing facilities which are now helping the scientists to find out the material properties.

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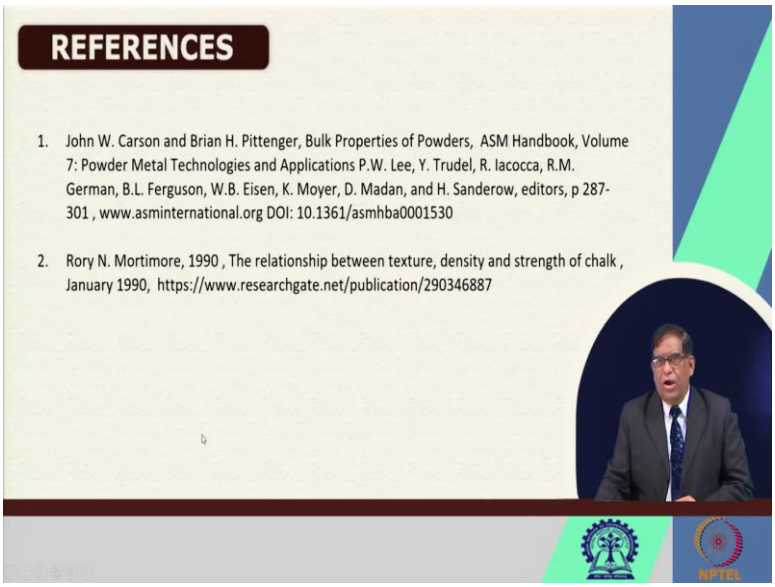

There are lot of research papers you should make a habit of reading some of the research documents and make a list of such readings. So, that tomorrow you will be generating such type ok. So, I hope you have understood this bulk material properties and how you will be doing it in futures. We will be coming to the next class regarding another aspect of this bulk material handling.