Principles of Casting Technology
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Lecture - 08
Technology of Molding
Molding sands and its ingredients

Welcome to the lecture on Technology of Molding. In this lecture we will discuss about molding sand and its ingredients. So, first of all we will discuss, what is the molding materials, what are the different types of molding materials.

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As we have discussed, a molding material has to envelope the casting. The heat which is liberated from the casting it has to be extracted by passing through the molding material. So, the first requirement is that a molding material must be the one which must be able to pass all the heat which is extracted from the casting through it. So, in that category we have with us available different types of molding materials. The mostly used molding material is sand. The sand is used because we have plenty of sand around us. The other properties about the molding material that is it should be able to withstand high temperature of the cast metal that is also there in sand. So, sand is the most used molding material and we will mostly discuss about molding material as sand.

Sand is used as molding material on for mass production or batch production, then metals and alloys. Now there is certain characteristics of sand which is also good in sense and at the same time it has certain drawbacks like the heat transfer through the sand is less. So, whenever we need the heat extraction weight to be higher, we have to choose certain other material.

Now, in that basically metals and alloys are coming as the one, the metals and alloys are having better conductivity than sand. So, because of the large heat extraction weight the casting gets or the microstructure of the grey is in the cast product is final. Also in case of sand and molding material, every time the mold is to be broken. So, for every product for or for every casting, you have to make one mold that basically decreases the productivity if the aim of the foundry is to make large number of units and it has to meet the deadline or the production number of production of the product is quite high than this sand we used as molding material will not be suitable 1. So, in those cases we use metals and alloys and we have discussed there are some benefits of that metals and alloys can be used when you have to make the product on repetitive basis or for mass production also the product has superior qualities in terms of fine green materials and so.

Next material is plaster. We have seen that plaster is also used as pattern material, but plaster can also be used as the mold material because it can set easily it has a good compressive strength it has good strength. So, it sets quickly and you have the mold repaired in a very less time. So, plaster is also a material for mold. Next is ceramic it is similar to plaster; however, it has certain other qualities like good finish or so, so ceramic is also another material for mold. Next is graphite you know graphite is a good conductor of heat and it also gives good surface finish. So, this way graphite is also used as mold material and then in the end it comes rubber. Rubber also is used for low melting point alloys; sometimes we use the varieties of rubber as the mold material. So, we make dyes of rubber for casting the material mostly of low melting point alloys.

Now, since we are going to confine our studies on mold material that is sand because normally sand is principally used molding material. So, we will confine our studies to molding sand. So, molding sand means the sand which is used for making mold here are certain statistics you know sand mold which uses sand for 1 ton of casting, you may require 4 to 5 tons of molding sand it means the use of sand is huge.

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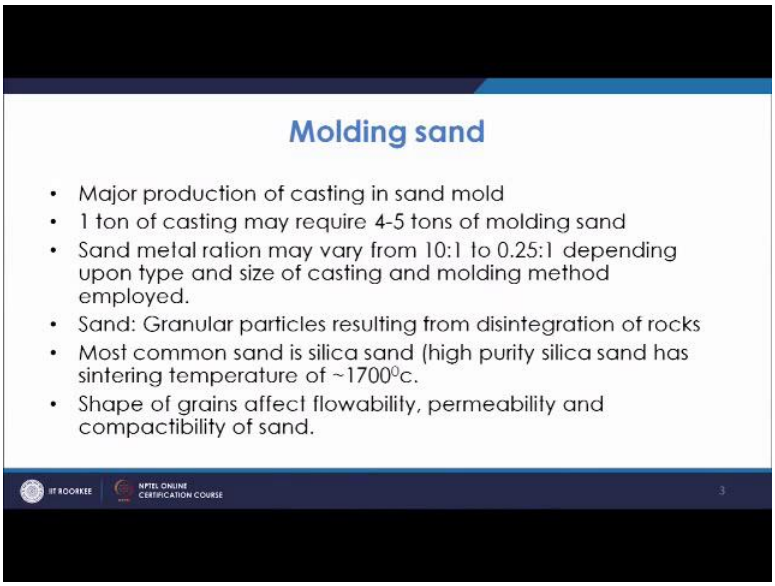

Sand metal ratio may vary from 10 is to 1.25 is to 1. So, depending upon which type of process you are using that is type and size of casting and molding method is employed you may have the sand metal ratio. So, if you are having a metal casting of suppose 10 kg, sand may vary from 100 kg to maybe 2.5 kg. So, basically it depends which kind of molding method you are using which kind of sand you are using with binders and what is the type and size of the casting.

Now, what is sand? Sand is basically defined as granular particulars resulting from disintegration of rocks. So, there are yellow rocks. So, basically once they are disintegrated, then this granular particles which are originated they are sand. Now mostly common sand is silica sand. So, silica sand basically it has the purity silica sand is nothing, but it from quarge. So, now, depending upon the percentage of SIO2 you have the purity of silica sand and the sintering temperature of pure silica is somewhere close to 1700 degree C. So, even if you are going to melt something like a ferrous material, it is quite because the melting temperature of iron or steel is mostly in the order of 1550 degree centigrade. So, even having 100 degree of super heat is not creating much of a problem.

Then shape of grains affects flowability, permeability and compatibility of sand. Now what the sand which you get by crushing of the rocks it has different shapes the shapes may be round or sub angular or angular. So, you have different shapes of sand and

basically that affects it flow ability, permeability and compatibility. Flowability means its ability to flow and take the shape of the mold. Similarly the permeability is the property of this molding material of the mold to allow the gases which is generated by the casting bin certification to go out of the mold and the compactability is nothing but ability to be compacted. So, that it gets enough strength to sustain the metallostatic pressure as well as other strengths.

What are the desired properties of molding sand? Now we should this know what kind of properties molding sand must have. So, that you are able to cast the material and the material should have minimum defects or no defects. So, in that first is refractoriness. So, refractoriness is nothing but the resistance to withstand or maintain its identity at higher temperature.

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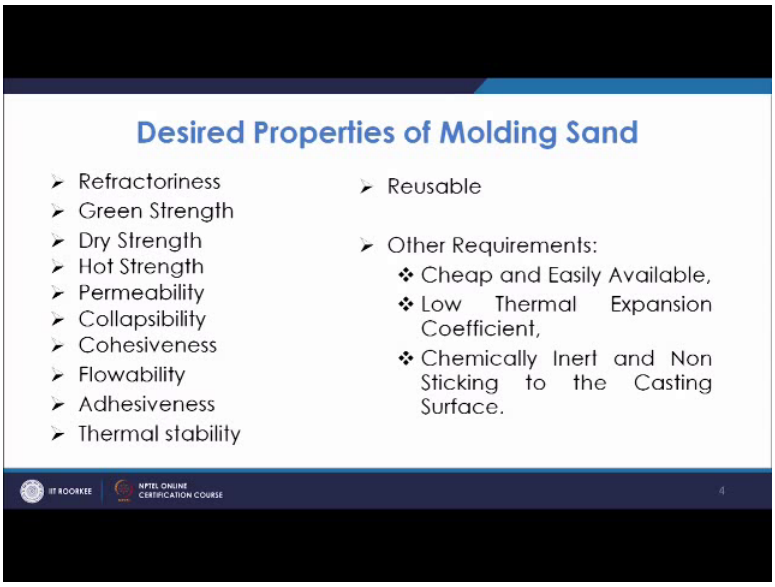

Sand because it is normally the sand has to be in touch with or be in contact with the molten metal which is at a very high temperature. So, it must not fuse at those temperatures at which it is cast. So, for that it must have so that property because of which it resists the fusion at higher temperatures this property is known as refractoriness. So, the refractoriness should be quite OK. It must not fuse at that temperature if the refractoriness is low the sand will fuse once it comes in contact with the liquid metal at high temperature and once if freezes, it may form lumpy masses and it may adhere to the

casting and if that is adhered to the corner sections or at weaker sections then once we tried to dispose them off the casting may break. So, this property is very much important.

This basically depends upon the type of sand we are using and also the quality and the purity of the sand suppose we are using a silica sand, the silica sand has the refractoriness and if it is pure silica sand the refractoriness is quite high; however, if it is impured or if it is impured with either oxides or even if we use more binder or clay in that case also refractoriness decreases. So, if you have depending upon the material to be cast you have to maintain the refractoriness of the sand.

Green strength; green strength means the strength when you the moisture is there in the sand so that you can prepare a mold and it can stand on its own so that you can cast the metal into it. So, green sand means in the moisture state moist state of the sand when sand is used with binder and water basically in normal case you use sand plus a binder that may be like clay and then you also use water. So, in that case you have moisture into it you are putting it. So, that it has the flowability and you can give it a shape. So, that it can stand on it on its own and you can further dry it. So, that strength is known as the green strength of the mold or the molding sand.

Then comes the dry strength. Now what is dry strength? So, dry strength is that strength of the sand because of which the sand can sustain the high temperature of the metal and the pressure of the hot metal.

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Then what happens that if you have a cavity if this is a cavity in which filled with molten metal. So, you have on all the sides you have the molding material. So, this is your molding material. So, what happens when the liquid metal goes into this cavity and since the sand is in moist state, this is having moisture? Once it touches here the sand which is present at this point it loses its moisture the moisture evaporates quickly and it becomes dry and in that case it has to sustain the pressure and the heat because of this molten metal at this interface. So, normally at 100 degrees C, basically all these moisture will be have will be evaporated and that strength it has the sustain the metallostatic pressure and the heat of the metal and it has to be at its place that strength is known as the dry strength.

Then comes the hot strength. Now hot strength is further ahead. When the liquid metal has been here and after that all the moistures have gone and the temperature of the whole mold is becoming very very high because of the intimate contact of the liquid metal and here and the heat transfer which is passing through the molten metal. Now at that high temperature the ability of the molding material to have its shape to go to resist against the metal penetration that property is known as hot strength.

Then comes permeability. What is permeability? Permeability is nothing, but its ability to allow the gases to pass through it. So, what happens once you have the liquid metal poured into it and once it is solidified and also this moisture is getting evaporated and the gases which are entrained inside the cavity as the temperature comes down, the solubility of most of the gases will decrease drastically? So, the gases which are entrained inside as well as the gases which are generated here all these are to be driven off. So, these gases have to come out now the ability of this molding material to allow these gases to escape through it is known as permeability. So, it has to be like a porous material which should allow the gases to escape through it.

Then comes collapsibility. Now what we discussed earlier that once you have the metal solidified, this metal basically removes all the moistures slowly. It becomes very hard now it becomes very hard and if to certain sections it is stuck or it forms a very hard mass or very strong like a lump and it does not break. In that case it will be difficult and there may be damage to the casting part. So, basically there should be the property of the molding material so that with small forces, they should be removed easily and they should rather not be sticking to the material. So that you use hammers or you have to use

forces to remove this sand lumps or masses. So, that property by which it can be removed all around the casting easily that is known as collapsibility it should be collapsible it should collapse quickly and it should be removed

Cohesiveness, as we know cohesiveness is nothing, but the attraction between the sand grains itself. So, if there is attraction between the sand and grains, it will help in making them have a proper shape of the mold. So, because of this cohesiveness they are together and once they are put in certain shape they maintain the shape of the mold.

Flowability, flowability is the property of that molding sand by which it can flow into the different corners of the molds. So, when you are making the mold when you are putting this mold material around this pattern that time it should go into all the corners. So, that property is known as flowability. So, it should be flowable, you are making this sand flowable by putting the binders and hardener and all that. So, basically by flowability it goes into all the cavities and also takes intricate shapes.

Adhesiveness, adhesiveness is basically whenever we are making. So, this is a molding box and once we have sand into it and there is a pattern and we have sand here. So, adhesiveness is nothing but the attraction of the sand between this sand and the mold wall or box molding box boxes are here on the pattern surfaces not here, but mainly at the walls this attraction is known as adhesiveness because that attraction is required because if there is no attraction and if you try to invert the molding box and keep this portion on the drag portion, suppose this is the coke portion in that case it will automatically fall down and your mold will break. So there has to be certain attractions attractive force between the sand particles or molding sand and the boxes, surface of the boxes inside surface of the boxes this property is known as adhesiveness.

Thermal stability means it must be stable; it must be able to maintain its shape and size at higher temperatures. So, similar to that hot strength at higher temperatures it should not be able it should not be in a position. So, that it should swell or go out of dimension. So, that property is known as thermal stability. One of the property which is important is reusable we have understood that sand mass is used in a huge quantity for quantum of casting suppose we are using lots of tons of sand now if we are not in a position to reuse it, it will be a problem even for the environment and also we will be lacking and there will be availability problems the good quality of sand is that it is reusable you can further

use it. So, apart from certain portions which is on in intimate contact and getting fused most of the sands you can use by controlling its composition and adjusting it.

Other requirements are that it should be cheap and easily available. It should have low thermal expansion coefficients certainly otherwise it will lose its size, it will lose its shape and that will affect the accuracy of the cast product and the last one is it should be chemically inert and non-sticking to the casting surface. So, this is very important that it should not be the one which should react with the molten metal, if it reacts with the molten metal that is harmful for the cast product because the surface may react, the surface chemistry may change and the surface appearance may change. So, it has to be chemical inert and also it should not stick to the casting surface. So, these are the desired properties of molding sand.

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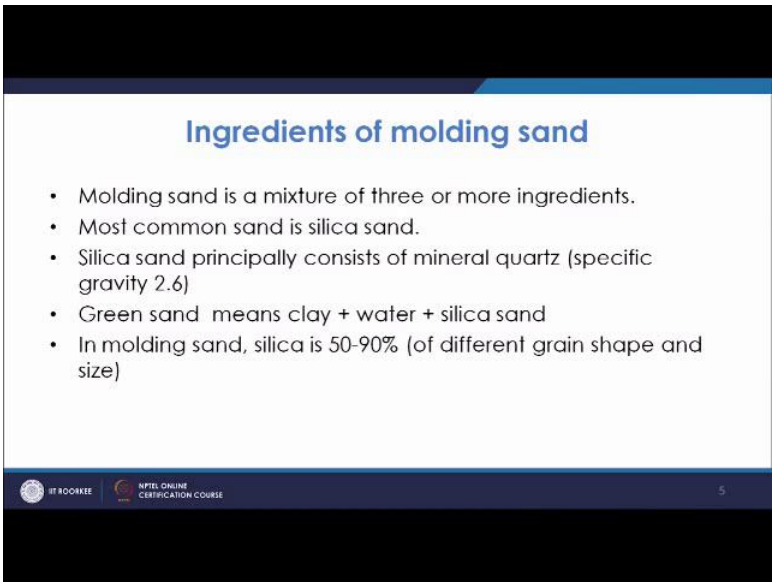

Now, what is the ingredient of molding sand? In molding sand basically you have 3 or more ingredients. So, in that you have normally clay plus water plus silica sand. If you take the silica sand as the normal molding because mostly the silica sand is used as the molding sand, in that case you have silica sand plus clay plus water, but then apart from that you also use adhesives that we will discuss later.

Most common sand as we discussed the silica sand which is principally consisting of mineral quartz and which has a pressure gravity of 2.6. Now in molding sand you have silica fifty to ninety percent of different grain shape and size. So, you have SIO2 that is

50 to 90 percent as we go on increasing the percentage of SIO2, the properties of the molding sand will certainly be changing like the refractoriness will change. If the molding sand in the molding sands silica is less, the refractoriness will be less and if clay is more or sand is less I mean silica sand is less in that case the refractoriness will be less than strength may also be less so all that depends upon the grain size.

Now, shape, grain shape and size. So, grain size means the crushed grains may be finer or it may be somewhat coarser. So, as we go finer and finer, the compactability may increase, but the permeability may decrease. So, basically this affects the size of the silica sand grains, affects the different properties of molding sand similarly grain shape as we discussed we have 3 main shapes of sand. So, one is the round shape which is the most favorable one which has minimum surface area is in contact in that case you have maximum probability. Then you have angular and sub angular. So, as we go from round to sub angular to angular you see that the properties vary like a permeability may decrease the strength also are be effected and maybe there in some sense the strength if it is increased the permeability will be decreased like that basically the size and shape of the grains of the sand effects the properties of the sand.

Apart from the silica sand you have different other types of sand which are used now among the silica sand we have already discussed that you have majority of the sand as silica sand in that 96 percent is so that is silica and then you have some impurities in the silica sand impurities basically should be minimum because impurities try to make the sand inferior main source is the river sand with or with or without washing shape can be round sub angular, angular and very very angular.

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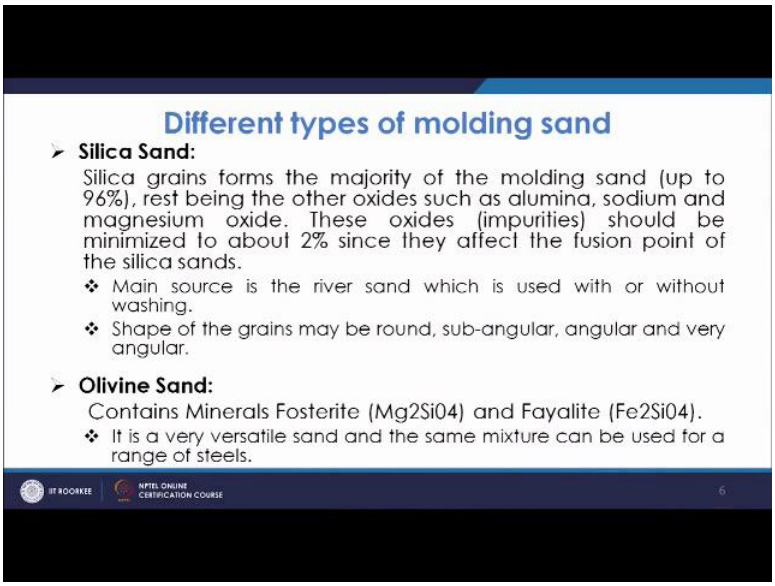

Then the next variety is this is the special kind of sand apart from the silica sand which are used in special circumstances for special materials which has somewhat modified refractoriness values or other values that we will see. So, the olivine sand is from it is containing the mineral fosterite and fayalite. So, it is very versatile sand and it the same mixture can be used for a different range of steels then one sand is zircon sand. So, zircon sand you have zirconium oxide and you have iron oxide silicon oxide. So, you see mostly it is mixture of zirconium oxide and silicon oxide and then you have some amount of aluminum oxide and iron oxide.

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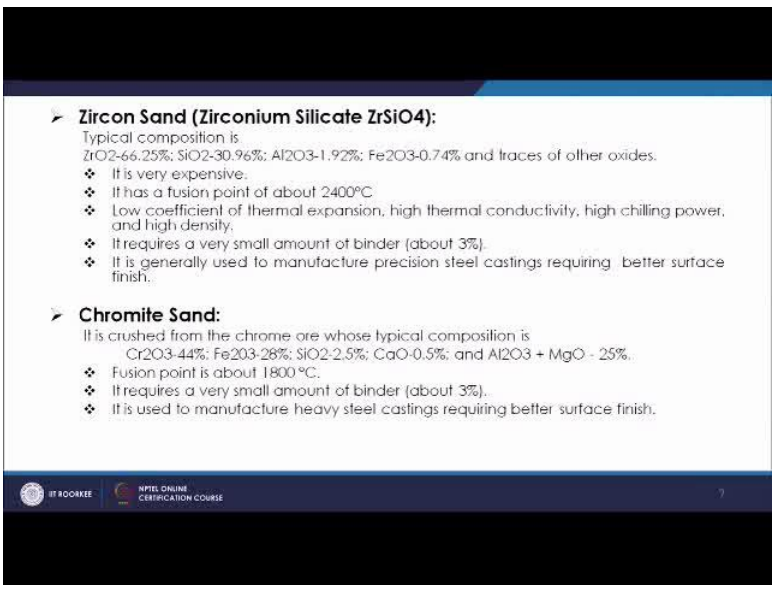

Very expensive it is expensive, but it has high refractoriness values. It has refractoriness value of degree 2400 degree centigrade. It has other qualities like low coefficient of thermal expansion high thermal conductivity high chilling power and high density. So, if you take in the advantage mode these high chilling power high thermal conductivity they will certainly increase the grain properties or the fineness of the grains near the boundaries of the of the casting.

It also has the quality that it requires very small amount of binder and used for precision steel castings. Then 1 of the other special kind of sand is chromite sand which is we from the chrome ore which has the composition Cr2O3 as 44 percent, Fe2O3 as 28 percent, SIO2 as 2.5 percent and then the mixture of aluminum oxide and magnesium oxide that is 25 percent. So, this is chromite ore or chrome magnetized sand which has fusion point of 1800 degrees centigrade and very small amount of binder is used for this also and it is used for manufacturing heavy steel for castings requiring better finish.

Now, these are the different special adhesives that we discussed apart from the sand which contains see in the molding sand, you have sand plus clay plus water. Now they do not give all the properties which you are required for the better cast product. So, you also use a lot of special adhesives which are giving some additional qualities like some may give you a better hot strength, some may give you a better finish, some may give you a good expend, I mean good collapsible quality qualities like that. So, these are the different kinds of different adhesives which are used for different purposes.

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And in that serials which is nothing, but these corn flour which is used to ground corn flour which is used. So, it gives better dry strength and green strength also good expansion qualities this pitch and asphalt. So, they are basically the byproducts of either petroleum or. So, they are basically giving you know good hot strength then seacoal. So, this is seacoal, which is used for better you know finish graphite that way gives good moldable qualities apart from the molding sand plus the binders in terms of like clay and water you also use special adhesives to impart the special properties.

In that you have these different materials which give different specific properties like cereals which are nothing, but the corn flour that gives good green and dry strength and good collapsible properties.

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Pitch is the byproduct of coke making asphalt is the byproduct of petroleum distilled products. So, they are basically giving good hot strength and good casting finish in case of ferrous castings, seacoal gives you good you know moldability and good ease of cleaning properties, then graphite is giving you a good finish, fuel oil is giving you good moldability, wood flour is giving you the void spaces. So, good expansion properties is achieved silica 4 gives you a good strength to the mold and also it gives a good finish because it is used at the surface of the I mean interface of the casting and the molding material then iron oxide is used to give quite good hot strength value molasses and dextrins, these are used they are basically the byproduct of sugar sugarcane industries. So, they are used to give good collapsible properties or good expansion properties.

Apart from that there are many other kind of adhesives are there which are giving good special type of properties that we should know and that should be used. So, this is how you are using these adhesives.

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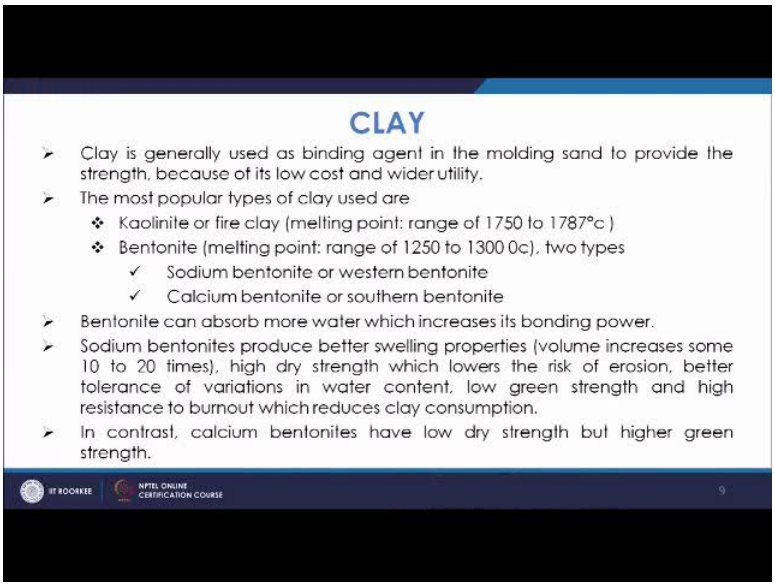

So, we have seen, we can also see that you use the clay basically clay is of different varieties, but you mostly use the mont to montonite group of clay that is sodium bentonite and calcium bentonite apart from that you have kaolinite or fire clay. So, basically the this purpose of clay is to coat the grains and then there is because in presence of water there is affinity between the clay particles and the sand and that is how the sand grains are attached to each other and also they have better swelling properties. So, they these sodium and calcium bentonite somewhat differ and depending upon the availability or depending upon the qualities we use either sodium or calcium bentonite.

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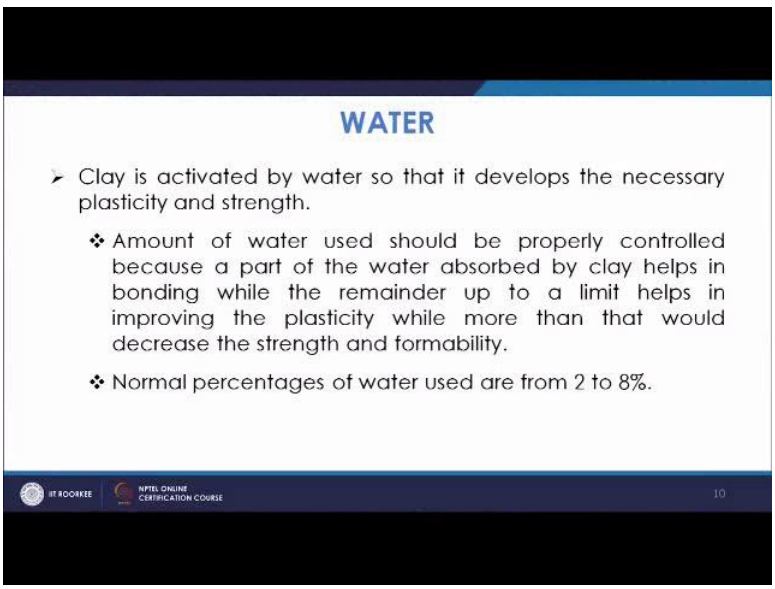

Then the use of water because waters purpose sees purpose of water is to activate the clay and form a bond between the clay because clay is being coated on the sand and the water quantity has to be maintained. So, that the optimum strength of the molding sand is achieved. So, you have tempered water and water percentage is normally from 2 to 8 percent. So, this is how you get a good mold having good molding properties, good properties what we require.

Thank you.