So, similarly, another example on hauling of earth as I told you the hauling of earth or you can either go for a truck, even the scraper what we saw in the earlier slide the scraper also can is good for a hauling distance up to 1000 meter it is economical. So, even you can go for a scraper for hauling of earth. So, there are different hauling machines available you can either go for a truck, which is the best hauling equipment or you can go for a front end loader.

So, for shorter distances, say up to 100 meters you can go for front end loader or you can go for a conveyor belt. So, productivity requirement is more so, everything depends upon your job requirement. So, you work out the options workout the economics of all these options and whichever gives you the lesser unit production cost go for that particular option.

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Similarly, another example if you see about the concrete placement, so, you are prepared your concrete in your concrete mixer machine, now you need to transport the concrete to your

formwork where it has to be placed. So, there are different ways different methods of placing the concrete either I can go for this chute in claim pipeline, to place a concrete, if the distance is going to be shorter it can go for a chute or you can go for a power driven buggy like this which can easily carry the concrete from the mixer machine.

And take it to the formwork or you can even go for a pumping method which is more popular. Concrete pumping is commonly adopted for placement or you can go for a conveyor belt like this. If the placement requirement rate, the rate of placement needed is very high or they can go for even crane with buckets, if the concrete to be placed at a greater height, then I have to go for crane with concrete buckets even we can even go for a helicopter with concrete bucket depending upon your job site condition.

If the job site is not accessible by other machines, then you have to go for the option of even helicopter carrying a concrete bucket. So, there are different options possible for placement of concrete, you have to work out the economics of all these options, whichever is more economical for you, then you have to go for that particular option, that is why the productivity and the cost will be the guideline for you for the selection of the machine.

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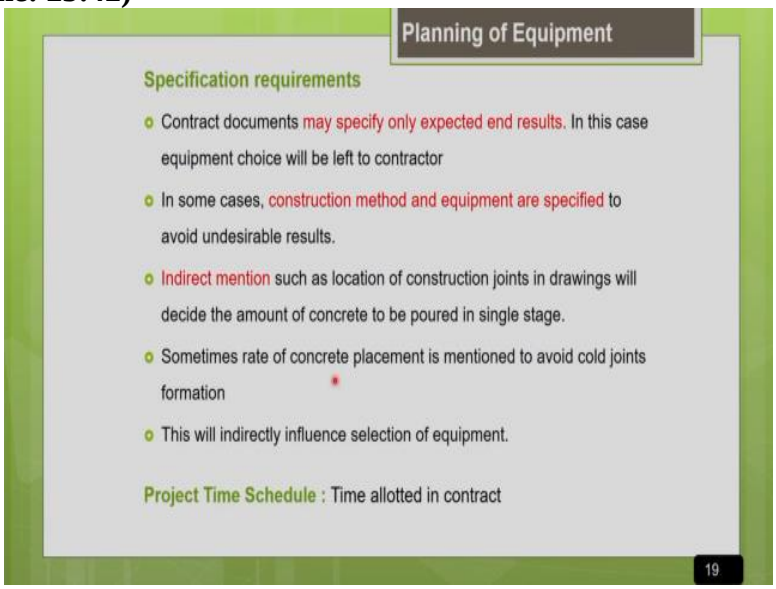

So, the next important factor which is going to govern the selection of the machine is your contract specification guidelines. So, what are all the guidelines which are specification in the contract documents, that is a very important guideline. But the thing is, as I told you, your contract document is only going to define the exact project time schedule and the time needed

for every activity is going to be dependent on the specifications given in your contract documents. And also the budget also is clearly mentioned only in the contract documents.

So, that is going to be important guideline for the selection of the machine, but the contract documents may not be sometimes clear some contract documents or specifications may specify only the expected end result say for example, they may specify for a particular concrete column, you have to go for M 30 grade of concrete with a slump of say 75 mm that may be the only specification.

So, there may not be any mention on what is the methodology to be adopted, how the concrete is to be made, what type of mixer machine you are supposed to use and what is the method of placement to be followed may not be mentioned. In that case, equipment choice methodology everything will be left to the choice of the contractor, but in some cases, your construction method and the construction equipment or specific very clearly in the contract documents to avoid undesirable results.

Say for example, they mentioned like M 30 grade of concrete with a slump of 75 mm you have to go for ready mix concrete and you have to go for pumping method for placement and this should be the rate of placement of the concrete what is the value everything will be mentioned clearly to avoid undesirable results, but in some contract documents, you can see that mentioned maybe indirect, indirectly it may be mentioned say such as location of the construction joints in the drawing will indicate the amount of concrete that is to be poured in 1 single stage.

By looking into the construction drawings, you can see the location of construction joints that will indicate the concrete that has to be placed in 1 pour. So, that will indirectly govern the selection of your size of your concrete mixer machine. So, what is the size of the mixer machine needed or how many number of mixer machines are needed, it depends upon the volume of concrete that is to be produced 1 pour.

So, in some cases, if they wanted to avoid the cold joint formation, they will clearly mention the rate of concrete placement. So, that will be also clearly mentioned. So, the specifications varies, the way of measuring varies from there document to document, but it will give us a guideline on how to select a methodology and the equipment.

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So, another important thing apart from all is economics. So, which we need to consider is the conditions at the job site. So, the real site condition that is very important factor for selecting your machine, say the underfoot conditions that is going to decide the type of mounting needed for a machine say the terrain is going to be very rocky or it is going to be very sandy. In that case, it is not possible for us to go for this kind of wheel type machine or rubber type mounted machine.

We have to go for crawler type or track type, which will have a broad contact area, better traction better stability. So, for poor underfoot condition, people prefer crawler mounted machines, because that will give you better traction or stability. So, the underfoot condition is going to decide the mounting of the machine. So, another important thing to be noted is rolling resistance that will govern the selection of machine, what is this rolling resistance?

So, when your machine is moving over a particular road surface, how much resistance the particular road surface is going to offer to the movement of the machine. So that is called as the rolling resistance. So if your underfoot conditions are very poor, if it is going to be a rocky terrain or if it is going to be a very muddy terrain, so the amount of resistance offered by the haul route to the movement of vehicle will be very high.

So in that case, you have to go for machines with greater horsepower capacity, because we need more power to overcome the underfoot conditions. So, after overcoming the rolling resistance, the remaining power is only available for the machine to do the actual job of either

excavation or towing the load. So, first we have to overcome the underfoot conditions after that what is the remaining power is only available for the productive job of either excavation or for towing the load.

So, we have to see if the underfoot conditions are very poor select the machine with a greater horsepower capacity, so, that you can overcome the rolling resistance in the project condition and you can keep your machine moving and do your job productively or efficiently. So, what I am trying to say here is the project condition will govern the selection of your capacity of the machine not only the mounting, but also the capacity of the machine.

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Another important guideline which we should keep in mind is we should always maintain the haul roads, there are so, many equipment's to maintain the haul road, like either you can go for a grader or you can go for a compactor. So, you should maintain the haul roads clear all the short rocks so, that you can increase the travel speed of your machine. So, if you can increase the travel speed of your machine, the cycle time of the machine will be reduced.

So, your productivity will increase so, your total project cost gets reduced. So, that is why we should spend some efforts for maintenance of the haul roads in the project site that will really help you to reduce the cost of your project.

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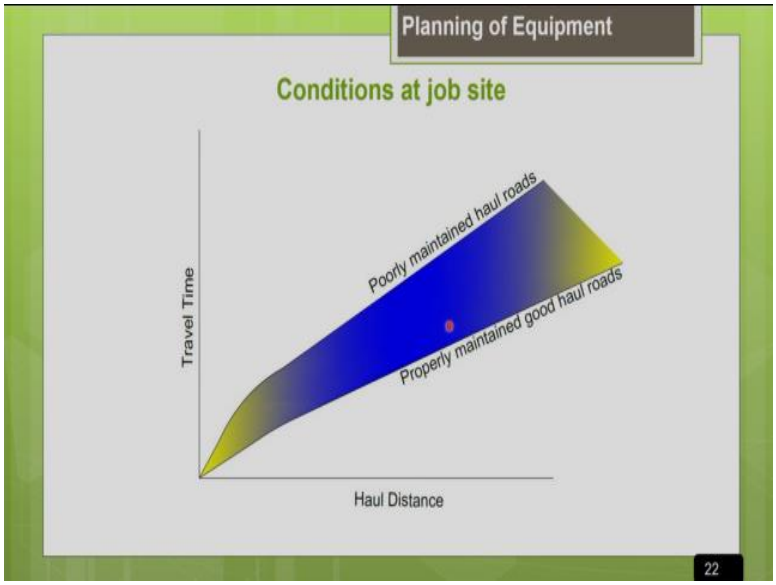

So, this graph shows you the difference in the travel time of a vehicle which is running over a poorly maintained haul road and another vehicle running on a properly maintained haul road you can see there is a significant reduction in the travel time of the machine. So, this will definitely influence or affect the productivity of the machine and the cost of the project.

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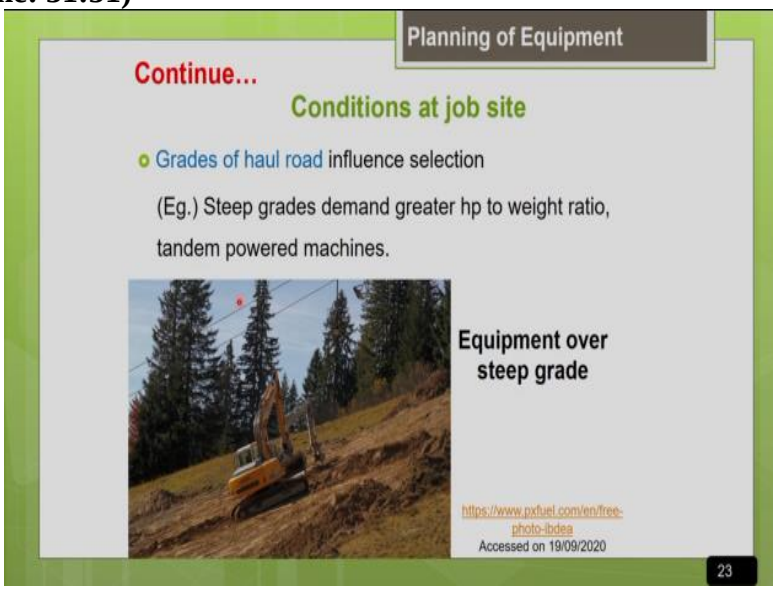

So, another important thing, which you have to take into account, is your condition at the job site, the steepness of the grade. So, sometimes your machines may have to work on a very steep terrain. So the slope may be very steep. So, your machine has to climb the particular slope and work. So, in that case, as I told you earlier, we have to go for a machine with a greater horsepower capacity, because the machine has to overcome the particular grade resistance and then only you can do the actual job.

So, you have to select your machine with a horsepower capacity, so that it can overcome the grade resistance it can climb the particular slope and do the required job. So the steep grades demand greater horsepower machines and on steep grades, we have to go for tandem power machines. So what are tandem power machines? Basically there are some special machines where all the axles are powered all the axles of the machine will be powered.

So, there will be twin engine component which will deliver more power to the machine. So, particularly for tough conditions like this like steep terrain or poor underfoot conditions, if you go for tandem power machines, you can have a very high productivity. So though the cost of this machines may be higher, but the production it will result in a higher productivity. So, your total project cost gets reduced. So you have to work out economics and go for the selection of these kinds of specialized machines for the poor project conditions or tough project conditions.

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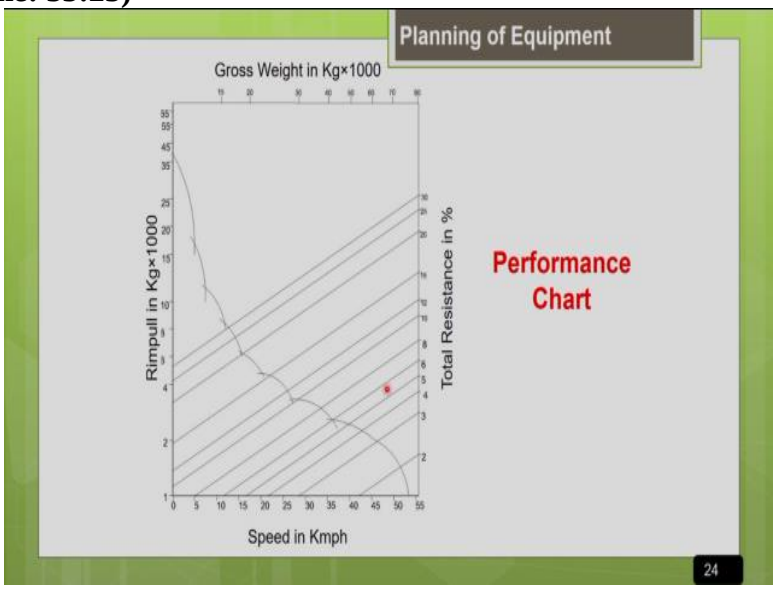

So, this graph shows you a typical performance chart. So, these kinds of performance charts you can find in the equipment handbook, supplied by the equipment manufacturer, so, equipment manufacturer will provide these kinds of performance charts for every model of the machine produced by him. So, by looking into this performance chart, you can get an information on what will be the speed of the machine for a given project condition say for this particular underfoot condition.

And for this particular steepness of the slope for this particular grade, grade percentage. So, for this particular rolling resistance, that is a project condition actually. So, for this total resistance, what will be the speed of my machine I can get from this graph. So this chart I will explain it

in detail in the upcoming lecture or when we discuss about engineering fundamentals of earthmoving operation.

So I am just trying to introduce you the topic that advantage of this performance chart. So, this performance chart shows that the project condition is going to govern your machine selection, because a project condition the total resistance, the rolling resistance, the grade resistance, which depends upon the underfoot conditions, that is going to decide the speed of your machine. So if you want to the greater speed, in a very poor underfoot condition, you have to select a machine with a greater horsepower capacity. So the underfoot conditions or the project site condition is definitely going to affect your selection of your machine.

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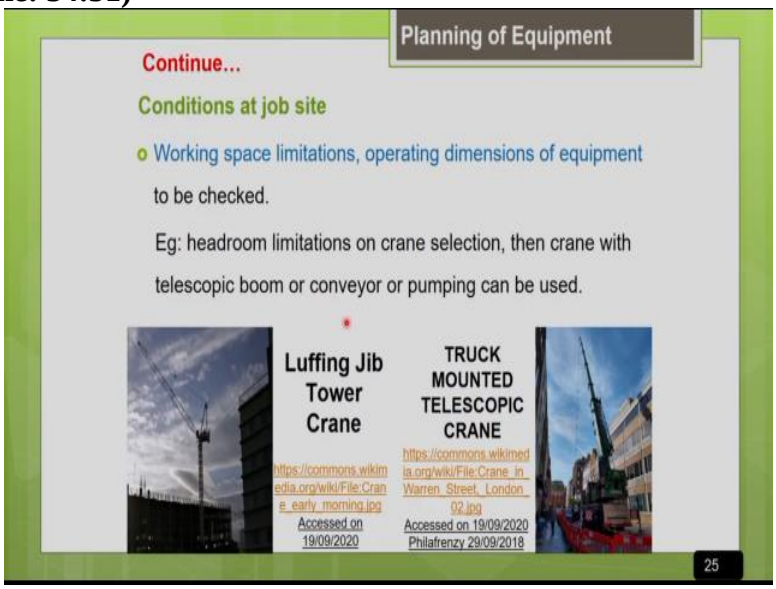

So another important thing which we need to consider is your working space limitations. And you have to look into the operating dimensions of the equipment which you are planning to select so, whether there are sufficient spaces for the equipment to fit in your project site. So, that is a very important factor to be decided before planning for the purchase of a machine. So, you have to visit your project site and you have to see whether there is any working space limitation or working space constraint with respect to the equipment size.

So, these kind of issues very often we face with respect to crane selection, when you select your crane, we have to see whether there is proper overhead space availability for the movement of the boom of the crane. So, particularly when you are working in a congested sites like in your project site is near an already existing structure. So, when the site is very much congested, you have to analyze whether there is overhead space availability or not.

So, as I told you this beginning of the lecture, there are different models of cranes, there are some cranes, where the boom is fixed, you cannot change the angle of inclination of the boom of crane. So, those cranes are called as horizontal boom crane. So, those cranes are not possible to be used in the congested sites, because the availability of space for the movement of the boom of crane may be limited.

So, in congested sites, they have to either go for this kind of luffing jib crane, you can change the angle of the jib of your crane according to your requirement. So, this is one advantage to work in the congested side. Now, there is working space limitation working space constraint. Similarly, I can go for a telescopic crane, we will be discussing about different types of cranes, different characteristic features of cranes and productivity estimation of cranes in the upcoming lecture.

This is just an introduction on how to select the machine with respect to the working space limitation. So, coming to this truck motor telescopic crane, you can see it is just like a telescope, you can just extend or retract the length of the boom of the crane. So, according to your requirement, you can extend the length of the boom or retract the length of the bottom of the crane. So, in congested sites, these kind of cranes will be very much helpful than going for fixed horizontal boom crane.

So, according to your space limitation, you have to go for the selection in worst case, and you can even drop the option of crane when there is the space constraint, you can go for the pumping method. Next, for example, if you are going to plan the selection crane for concrete placement, you can go for a pumping method for the placing the concrete or even you can go for a belt conveyor. So, you can work out the economics of all the options as well as consider the site constraints and make the decision.

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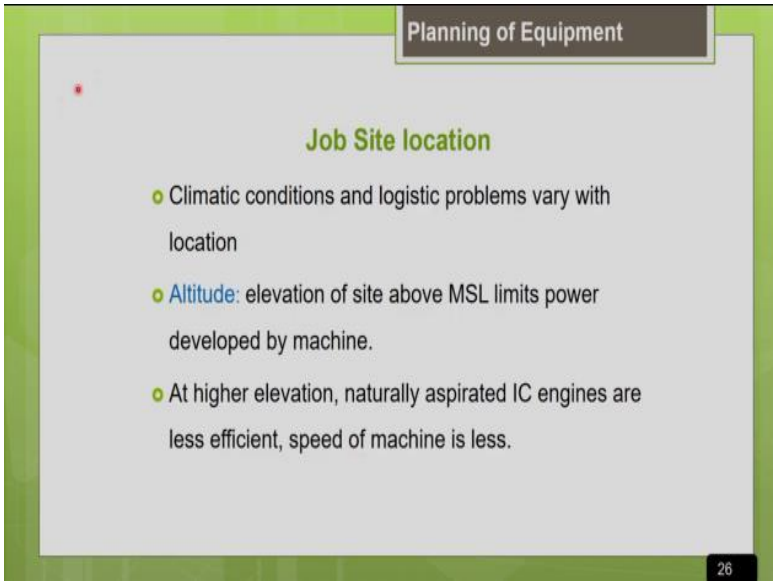

So, far we discuss about the job site conditions now we are going to see how the job site location is going to affect the selection of the machine. So, that is basically it is going to affect the climatic conditions of the place and other logistic problems involved with the mobilization of the equipment at the particular site. So, all these things are dependent upon your job site location.

So, one important factor to be considered is the altitude of your job site say all these machines, most of the machines what we use in the construction project site, they are IC engines internal combustion based engines, these internal combustion based engines rating, there is a horsepower rating is done at standard conditions say at a standard temperature and its standard atmospheric pressure say for example, SAE Society of Automotive Engineers.

So, there are prescribed the rating of the machines, but the standard temperature of say 15.5 degrees Celsius and atmospheric pressure of 103.3 kilo Pascal. So, the horsepower rating is valid for that particular standard temperature under pressure. So, if your machine is going to work at a place where the temperature is different from the standard condition or the atmospheric pressure is different from the standard condition, then you may not be able to realize the same efficiency as prescribed by the manufacturer.

So, your horsepower at a different condition may be lesser than the value prescribed by the manufacturer. So, as I told you, the internal combustion engines for its efficient operation, the fuel to air ratio has to be maintained it is very critical for the combustion mechanism. So, if your job site is located at a very high altitude, say above the mean sea level, your atmospheric

pressure will be less. So, when the atmospheric pressure is less obviously, the density of the air is going to be less.

So, the amount of oxygen which is available for the combustion mechanism is going to be reduced. So, in that case, we will not be able to maintain the fuel to air ratio for the combustion mechanism of the machine. So, in that case obviously, your efficiency of the machine is going to get affected. So, this is how the altitude of your location is going to affect machine performance, because at higher altitude, the availability of air, for the combustion mechanism gets reduced.

So, the engine would not be able to perform at the same efficiency as a machine at the mean sea level. So, you would not be able to realize the efficiency prescribed by the manufacturer. So, in that case, what are we supposed to do? So, that is what is mentioned this slide at higher elevation naturally, aspirated IC engines are less efficient. So, since they are less efficient, and the speed of the machine will also be lesser. So, how to overcome this problem?

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So, particularly for the higher altitudes, which are very much above the mean sea level, so, there are some specialized arrangements, the possible in the machines like a turbochargers so, these turbochargers can be fitted to the equipments this will facilitate to maintain the fuel to air ratio, even at higher altitude. So, you can see this mechanism of the turbocharger the blue color indicates the air movement.

So, there will be a compressor arrangement which will help you to artificially and supply the air and maintain the fuel to air ratio for the efficient mechanism of the machine even at higher altitude, where the density of air is less. So, when you are going to work at higher altitude, go for these kinds of special machines with turbo charges, otherwise, you have to go for either larger equipment or more number of machines to compensate the loss of efficiency at a higher altitude. So, depending upon your altitude you have to make your equipment selection, so, that the efficiency of the machine would not be affected even at higher altitude.

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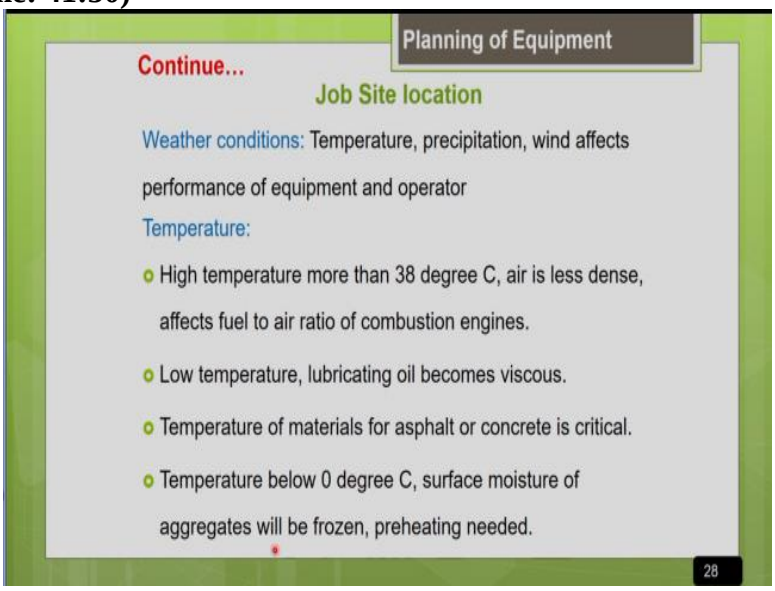

So, another important thing which you have to keep in mind is your job site location is going to influence the weather condition obviously, the climatic condition depends upon the location of your job site, your temperature, rainfall, wind, everything is going to affect the equipment performance, even the operator performance and also the equipment selection. So, in your job site, the temperature is very high.

So, in that case, obviously, you will face the same issue as we faced with the higher altitude location, you can see that as the temperature increases your density of air will reduce. So, the amount of the fuel to air ratio which is needed for the combustion mechanism gets affected in places with high temperature. So, in that case, you have to select a machine with a turbocharger so, that you can maintain the fuel to air ratio without affecting the efficiency of the machine.

Similarly, a lot of issues you can face in the low temperature places also. So, in low temperature like your lubricating oil in the machine, may become viscous, so, you should have some preheating, I mean heating facility inside the machine to heat a lubricating oil to maintain the

viscosity. So, particularly for the places where the temperature is freezing cold weather countries you have to look for the machines with special arrangements to maintain the viscosity of the lubricating oil some heating arrangement.

And another important thing to be noted is your material like concrete or asphalt, the working range of the temperature is very critical. So, you have to maintain its temperature if that particularly in the cold weather, if you say like before preparing the concrete. So, the materials are not stored properly, if they are stored in open spaces, if the aggregates get frozen, so, the surface moisture of the aggregate may get frozen.

So, in that case, we cannot directly mix your aggregate and cement and water for preparing the concrete. So, in those places, you should have some facility in the mixer machine to preheat the material to preheat water preheat the aggregate then you prepare your concrete. So such kind of pre heating facility is needed for cold weather countries. Similarly, your asphalt it is a thermoplastic material.

Obviously, its viscosity is totally dependent upon the temperature. For a very cold weather, you can see that it is viscosity will be significantly affected. You would not be able to work with asphalt. So you have to maintain the working range of this particular material like asphalt or concrete by using some thermally insulated devices. So, you have to protect this material from the severe climatic conditions in places with aggressive climatic conditions.

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So, this picture shows you an insulated truck which is used for transporting the bitumen. So, this will help you to maintain the temperature of the bitumen as I told you, the working temperature of the bitumen is very critical. So, you have to maintain it at temperature similarly, even your ready mix concrete trucks you can go for insulated RMC trucks particularly in the cold weather countries in order to maintain the working temperature.

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So, another important thing the same way you can say that your heat and wind will affect the concrete performance. So, that is what we discussed in the earlier slide also, if your concrete is going to be exposed a very high temperature and you can see that it will result in the evaporation of water from the concrete. So, even during the process of making of concrete, it may result in evaporation, if it results in the evaporation, it will affect the workability of your concrete.

So, in those high temperature places, you should have a provision to protect the concrete from the high temperature even during the process of making of concrete and similarly, after the concrete is made, if it is subjected to a very high temperature. So, what happens it will result in loss of water from within the concrete to outside environment. So, that may result in a shrinkage cracking of concrete it is called as plastic shrinkage cracking.

So, in those cases, we should have some facility to protect the concrete from high temperature or high wind velocity even a higher wind velocity may result in the loss of water from the concrete. So, that may result in cracking of concrete so, in those places you should also facility to protect the concrete during the making of concrete and even after the concrete is made.