Maintenance and Repair of Concrete Structures
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Lecture - 23
Coatings on Concrete Infrastructures

Welcome to this lecture as part of this course on maintenance and repair of concrete structures. Today, we have a guest speaker Mr. S. Ravichandran he is going to talk about coatings for concrete infrastructure and I know Mr. Ravichandran for past eight years and he is an excellent speaker and in fact, he has actually delivered a couple of lectures in my graduate course on the same course but on similar topic on paintings and coatings.

And from him I learned the difference between painting and coating. And I think he will really cover that in todays lecture. And he is a senior manager for technical and development in Protect On he will tell probably what is Protect On. It is not a spelling mistake there and in Berger paints India limited. Welcome sir for this course. I hope we will have a nice lecture today.

Greetings to all those people who have come to attend this lecture we will be talking on a topic under the name coatings for concrete specifically for the industrial infrastructure. We will try to concentrate in this particular lecture.

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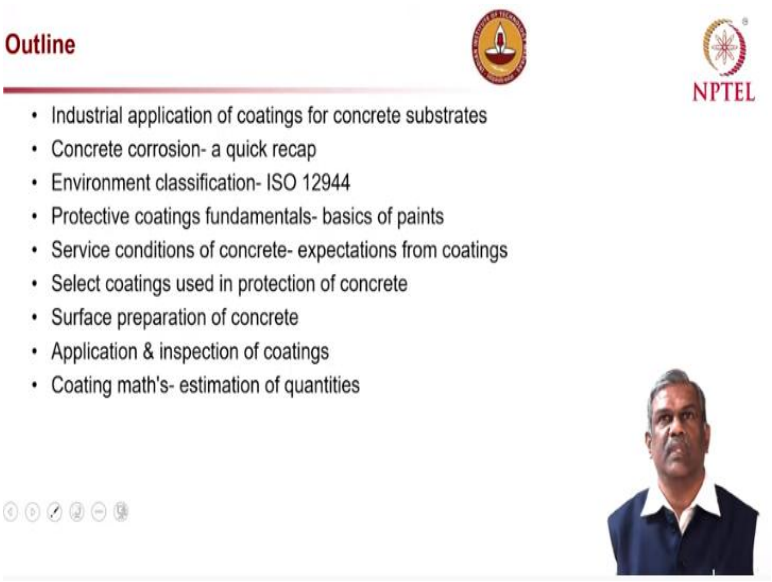

The outline of this course has been explained here on this slide. The industrial application of coatings or concrete substrates there are lot of lectures in detail on concrete corrosion but might be two slides. Just to have a quick recap we will be having the understanding on the environment classification as per the international standard ISO 12944 we will touch on the fundamentals of protective coatings.

It will give you a bird's eye view of various types of coatings that are being used. We try to understand the requirements of the coatings when it comes to the various service conditions of concrete. We will just go on in the same pathway and choose those important coatings which are widely used and most important in protecting concrete surfaces. We will also have a quick understanding on the challenges of application and the requirement of inspection of coatings, coating math if it is possible, we will also try to cover that particular aspect.

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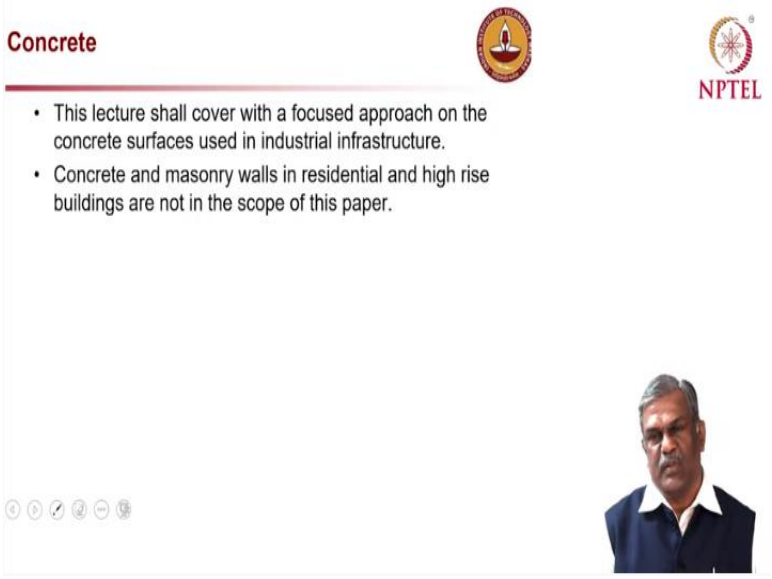

Let us also understand there is going to be more focus on the concrete surfaces in industrial infrastructure which means that this will not cover the paints which are used in houses or any of those high scrapers for building purposes they are totally different and it can be covered on a different occasion.

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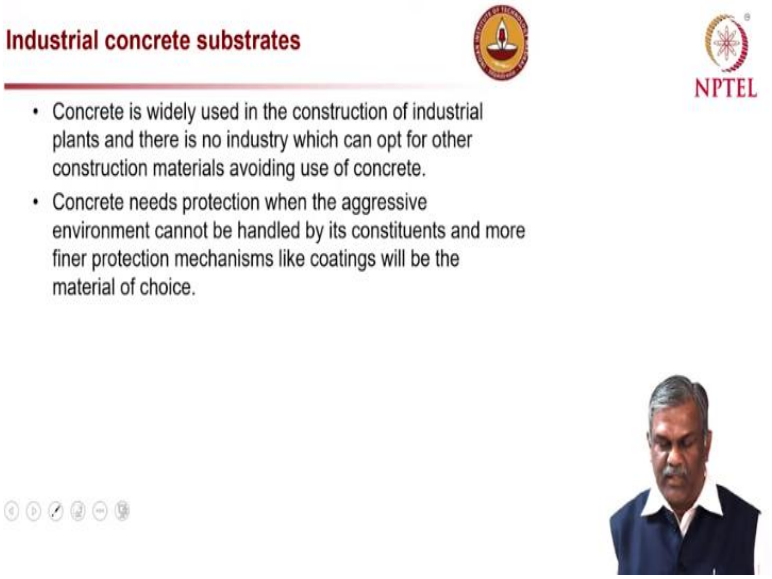

Concrete is widely used in construction. Any industry you cannot do away without the use of concrete or steel and corrosion is not going to spare any of this material and the aggressive environments are going to have a continuous impact on these substrates and hence we need to understand how this works and what can be done to better prevent it.

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When I have a quick look on concrete there is lot of case studies to explain the different mechanisms of concrete corrosion. The one which is there on the top they were trying to remove the weathering coarse. While they were removing it the entire ceiling fell down. This happened in Chennai a few years before and this is one of those important case studies which opens our eyes that corrosion, typically chloride induced pitting corrosion in this particular case was the root cause for the entire collapse of the ceiling. Like that we can keep explaining corrosion.

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But let us get into the topic on how to handle it. Many a times the mindset of corrosion is what is more challenging than the corrosion itself. They are never noticed unless or otherwise it

stops the production and this needs to be changed and I hope this lecture series will help us in creating better awareness in the industrial engineers.

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When you talk about concrete distress it is either a deficiency or damage. When we say deficiency it is like a vitamin deficiency, calcium deficiency like that means something has gone wrong in the system during the time of formation. Damages is typically like you don't go for walking so you are losing all your flexibility it is like that. Damages are because of abuse to the system. So when a concrete structure has not been designed for taking a warehouse it is for drilling purposes and you start loading material there, stacking material there it's going to collapse so it is something like an abuse.

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Let us get into a quick understanding on the differences between a deficiency and the damage. Deficiency as you can easily understand it is by the faulty design, inferior materials and the poor construction practices which are always a challenge for any civil engineer. When you talk about damages it is primarily on the abuse, no doubt a very serious effect due to the environment. The environment also carries a lot of chemical effects probably most of when it is in an industry and the internal stress which are also, we will explain in a different lecture.

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We will just get into the details of understanding it. The various reactions which are going on in the concrete and disturbing the integrity is what will be the topic when we try to

understand on chloride intrusion or carbonation effect or the effect of acid, alkali and sulfates on the concrete

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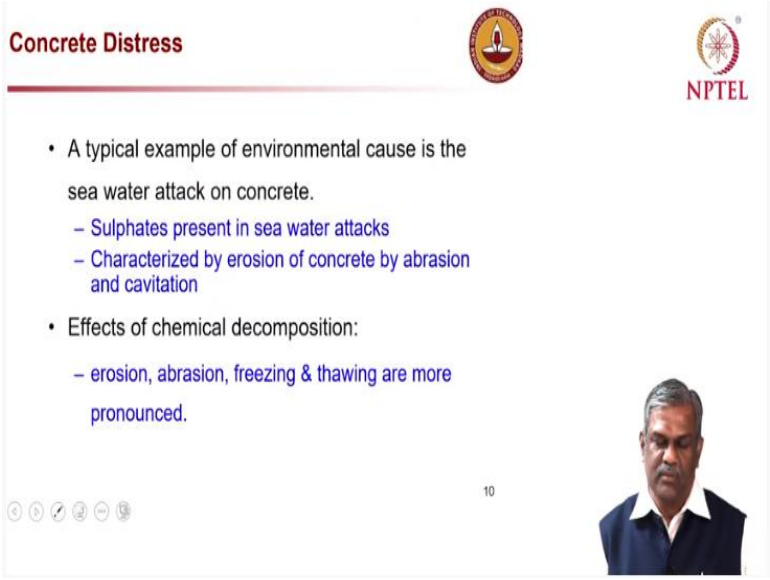

So we just jump into the understanding on how this effect is present and can I have a single study example to know the various effects of concrete?

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Yes there is a chemical decomposition happening when it is coming under different variety of attack. A very clear example is from a pier in the sea which is holding. This is a photograph taken from Pamban bridge (Anna Indra Gandhi Bridge) situated at Rameswaram. So

this particular structure has an effect of atmospheric zone, high-tide zone, the tidal zone, the low tide zone as well as the submerged zone.

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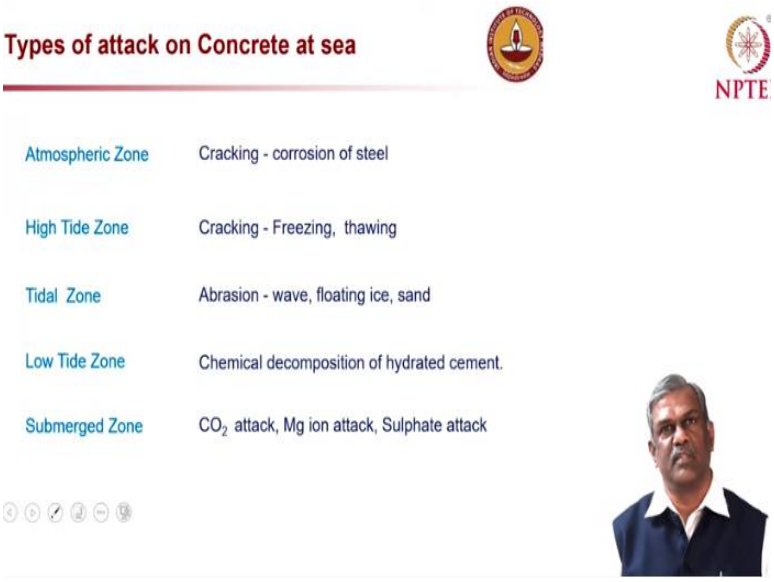

And each of those areas the concrete has been subjected to different types of attacks. Right from the atmospheric zone which is more prone for getting the corrosion of steel happening underneath. You have the high tide zone where you have the freezing and thawing cycles which is more disturbing the concrete. The tidal zone where you have more of abrasion and erosion type of corrosion. The low tide zone where you have the chemical decomposition of hydrated cement. The submerged zone very much affected by the effect of carbon dioxide, magnesium ion and sulphate attacks.

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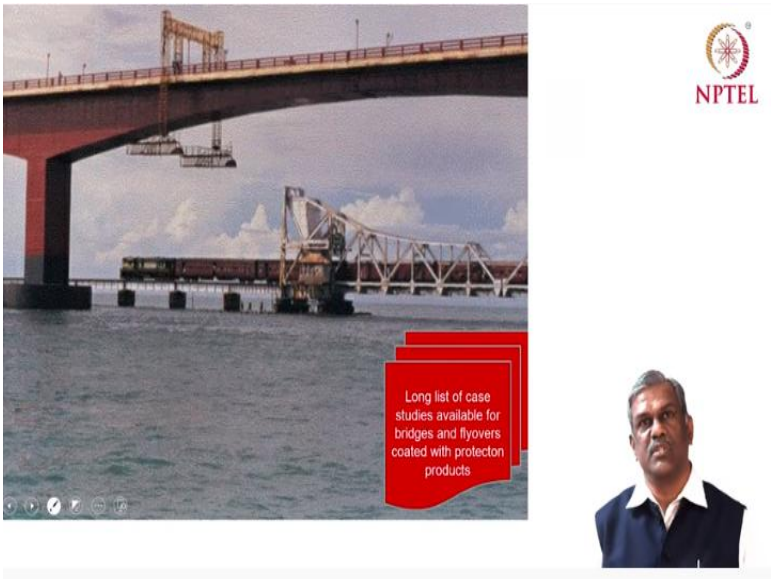

So we have to look at the various options of coating concrete. And this has been a proven system at least to my knowledge it is more than 30 years if I am right. This is a coating which has been done there as per the technology of CCRI of Karaikudi which is a four coated epoxy polyurethane system. The concrete is intact and that is where we get confidence that concrete can be protected with the help of good coatings.

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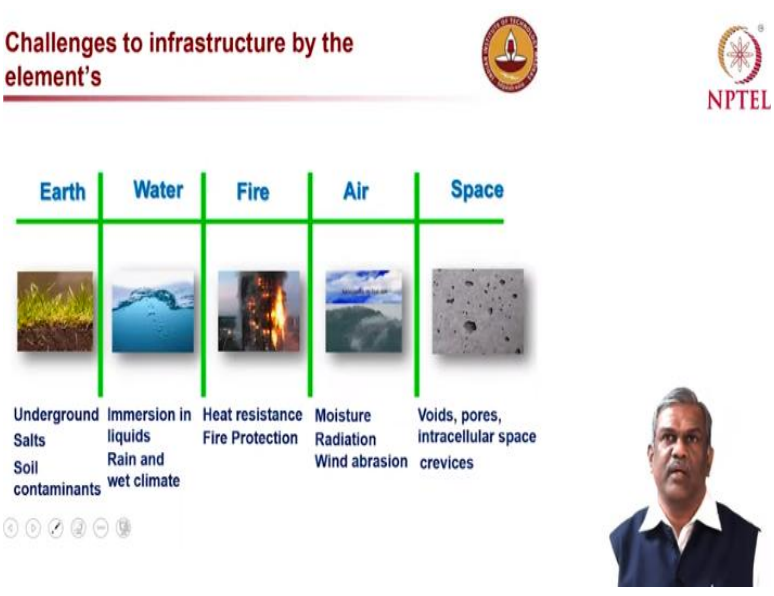

Now when you have an overall picture about the challenges to the infrastructure all these elements have an effect of creating a situation of instability in the concrete. The concrete are being used in variety of areas. If there is going to be an underground pipeline or an underground structure you have the soil contaminants and the salts affecting it. If it is passing through water,

undersea the immersion in liquids and the effect of even rain and wet climate can disturb the concrete.

We all know that the water-cement ratio or the moisture effect on concrete is going to be detrimental to the very integrity of the structure. Fire, we always think that brick lining is going to protect us very greatly, but we are not talking on bricks. We are talking on concrete, concrete if it is going to exceed a particular temperature because of the effect of the fire, then the concrete is also going to buckle up. We are not going to detail too much into this but let us also appreciate that fire is going to be a very severe detrimental factor.

Air, we appreciate with the moisture and the wind abrasion and no doubt the effects of gases which is just coming through the pathway of that including radiation. We are talking about space we understand the problems created by voids, pores and intracellular spaces or crevices.

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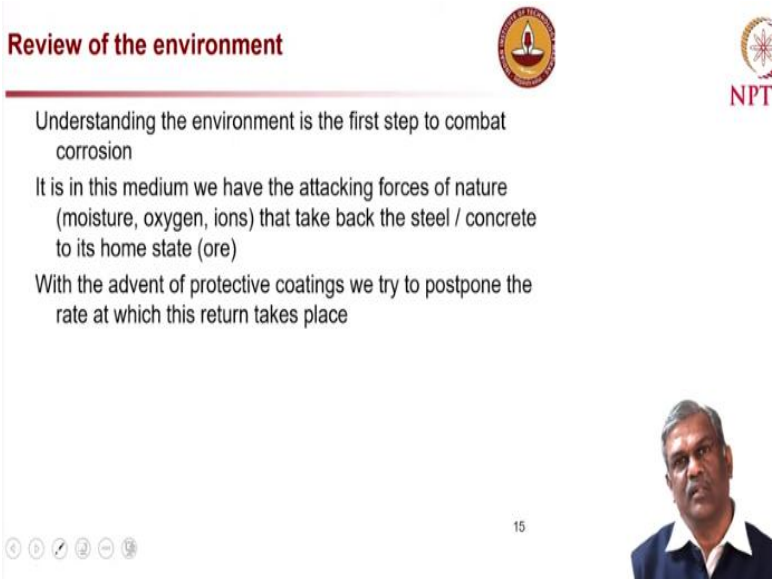

So let us understand the environment in a better way. We try to understand that whenever there is an opportunity of material coming in contact with the environment, they are being taken back to the home state be it steel or be it any material we all turn back to the place where we come from. So that is how it starts.

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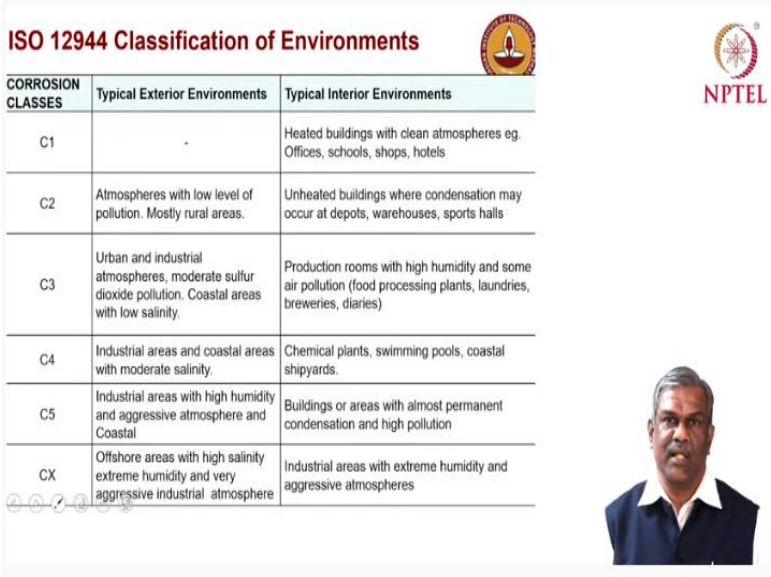

CORROSION CLASSES	Typical Exterior Environments	Typical Interior Environments
C1	-	Heated buildings with clean atmospheres eg. Offices, schools, shops, hotels
C2	Atmospheres with low level of pollution. Mostly rural areas.	Unheated buildings where condensation may occur at depots, warehouses, sports halls
C3	Urban and industrial atmospheres, moderate sulfur dioxide pollution. Coastal areas with low salinity.	Production rooms with high humidity and some air pollution (food processing plants, laundries, breweries, diaries)
C4	Industrial areas and coastal areas with moderate salinity.	Chemical plants, swimming pools, coastal shipyards.
C5	Industrial areas with high humidity and aggressive atmosphere and Coastal	Buildings or areas with almost permanent condensation and high pollution
CX	Offshore areas with high salinity extreme humidity and very aggressive industrial atmosphere	Industrial areas with extreme humidity and aggressive atmospheres

And to put it under the international understanding we follow a typical standard called ISO 12944 this is classification of environments under categories of C1 to CX where you can find that C1 is primarily a dry zone or a heated building. When you talk about C2 we have an opportunity for condensation to take place. You can call it a wet zone as well. And when you talk about C3 we are talking about urban and industrial atmospheres where you have probably even production plants, laundries all these areas and any area which has got low salinity.

When you talk about C4 you enter into a saline zone which is a coastal zone. It can also have a chemical plant close by and where it is C5 it is very much close to a high humid and an aggressive atmosphere, chemical industry or a power plant which is next to the sea. When you are talking about CX you are trying to understand that it is a typical offshore area, the high seas area. So the corrosion rate is going to be different for all these different types.

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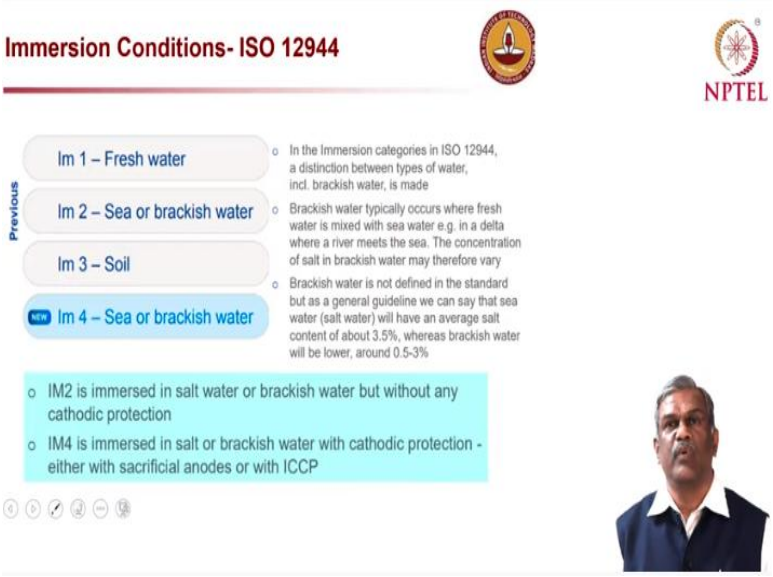

When you talk about immersion conditions, we try to understand immersion under four different categories as per ISO 12944. One is for freshwater, one is for sea or brackish water, 3 is for soil and the recent addition is 4, sea or brackish water which has an opportunity where it is going along with cathodic protection. So, many are not familiar with this brackish water. It is the area where the sea and the river meet so it is a reduced salinity in the particular area.

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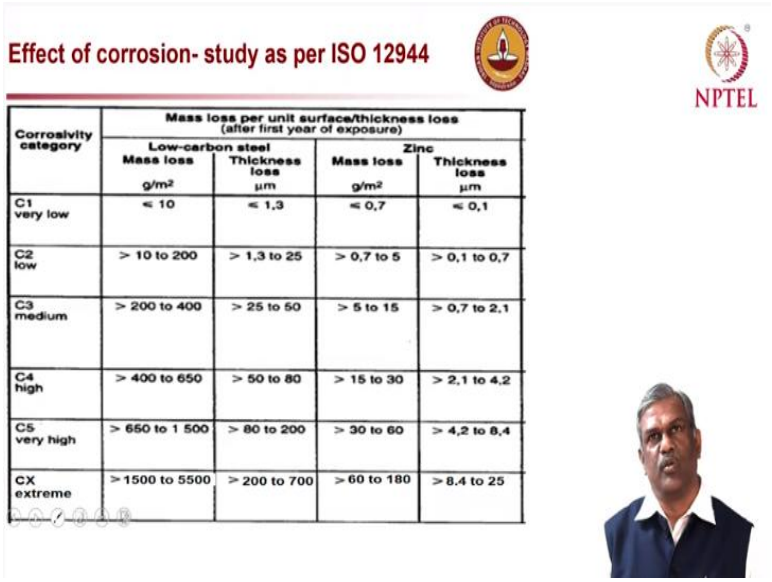

Corrosivity category	Mass loss per unit surface/thickness loss (after first year of exposure)			
	Low-carbon steel		Zinc	
	Mass loss g/m²	Thickness loss µm	Mass loss g/m²	Thickness loss µm
C1 very low	≤ 10	≤ 1,3	≤ 0,7	≤ 0,1
C2 low	> 10 to 200	> 1,3 to 25	> 0,7 to 5	> 0,1 to 0,7
C3 medium	> 200 to 400	> 25 to 50	> 5 to 15	> 0,7 to 2,1
C4 high	> 400 to 650	> 50 to 80	> 15 to 30	> 2,1 to 4,2
C5 very high	> 650 to 1 500	> 80 to 200	> 30 to 60	> 4,2 to 8,4
CX extreme	> 1500 to 5500	> 200 to 700	> 60 to 180	> 8,4 to 25

The effect of corrosion, if I have to understand what happens in all the zones C1 to CX the steel has been taken as a benchmark to understand this. It is being compared with the best of protection which the steel can get that is a zinc coating or the steel. When you expose this particular steel for a year period without coating and with coating the amount of corrosion which

is affecting this particular steel has been identified and tabulated based on the mass loss in grams per square meter or the thickness loss in microns which has been lost.

So when you see C1 very low or negligible amount of corrosion takes place in one year of exposure whereas the same when you go towards C5 or CX you are losing 200 microns. In other words in 5 years it is not actually extrapolated that way but for our understanding in 5 years you lose 1 mm thickness of steel. So this is very high and therefore steel is getting protected with zinc and this zinc is actually losing much lesser.

You have only 4 microns to 8 microns loss instead of 200 micron loss of the parent steel itself. So, zinc coating or galvanized zinc which we are very familiar for many structures and pipelines. That has been a preferred choice because of the sacrificial protection which zinc can offer. That is with respect to the steel. So this is the same area where concrete is also getting exposed and we do not have an equivalent table to understand the extent of attack under different atmospheres. Probably this can be one of the studies by our academics.

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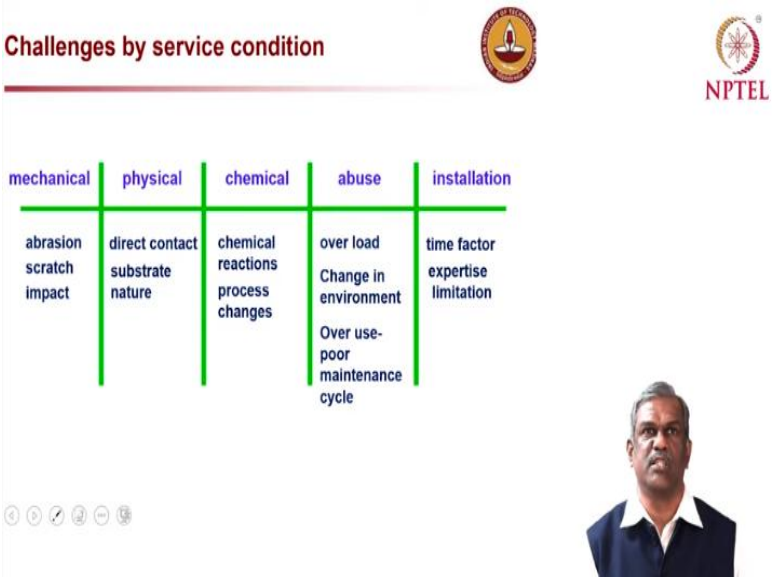

When you are talking about the service conditions which a concrete or any substrate is being subjected to. It can be abrasion resistance which might be required from a coating, a scratch resistance required from a coating. It can have an impact all these are mechanical. Same

way we have a physical contact with the substrate, either it can be a liquid contact, it can be a gaseous contact, and it can be a solid contact with the metal.

And when you talk about chemical the different opportunities where under exposure you have a dry air or oxygen coming in contact or you have moisture coming in contact or you have ions coming in contact with the material for corrosion to take place. Apart from that, we always find abused or even overuse. I would wish to highlight that most of the industries are not giving sufficient attention to this.

Therefore, the maintenance cycle is also skipped which is again increasing the scope for more and more corrosion to take place. When it comes to new projects, we have newer problems like time factors then you have the limitation in the expertise of the people who are actually installing the concrete or installing the coatings for the same.

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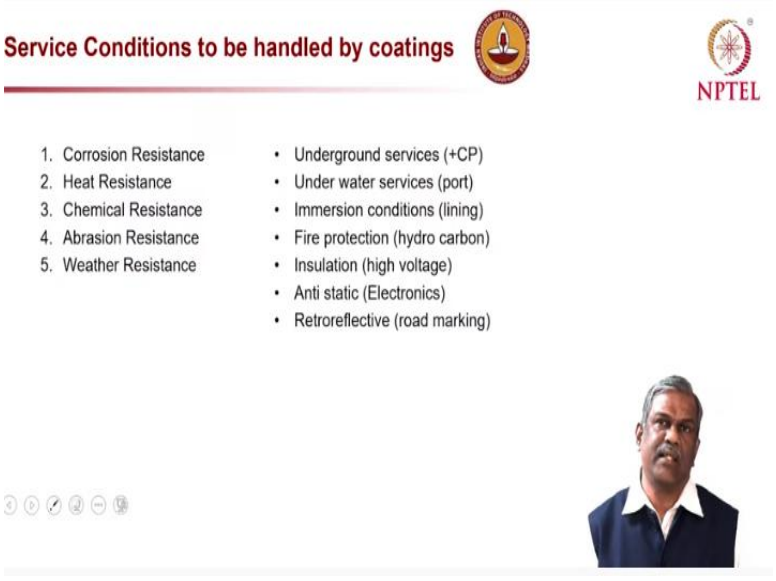

So all these talents have to be addressed and let us have a quick understanding on the difference in this conditions typically which have been highlighted more be it steel or concrete. We try to appreciate the corrosion resistance of the coating, the heat resistance of a coating, the chemical resistance, the abrasion resistance, the weather resistance at least the fires salient features which we need to look upon.

When you are talking about different types of services, we have underground services which can also have cathodic protection systems along with the coatings and you have underwater services in port which are being subjected to a different environment including the animal growth or a plant growth of the Marine organisms. Immersion condition is again an area where you coat a water reservoir here or a water tank.

The inside of the water tank we call them as linings. We have fire protection for most of those civil structures particularly the ones which are supporting the piers, the bullets, the main structures which are there in oil and gas installations from the effect of hydrocarbon fire. We will come to that particular slide to have a better understanding. We have coatings which can insulate from high voltages.

We have coatings which can give anti-static protection in all electronics industry. There is going to be a very high use and then let us not forget whenever we are going in the roads, we have road marking which is guiding us on a safe pathway.

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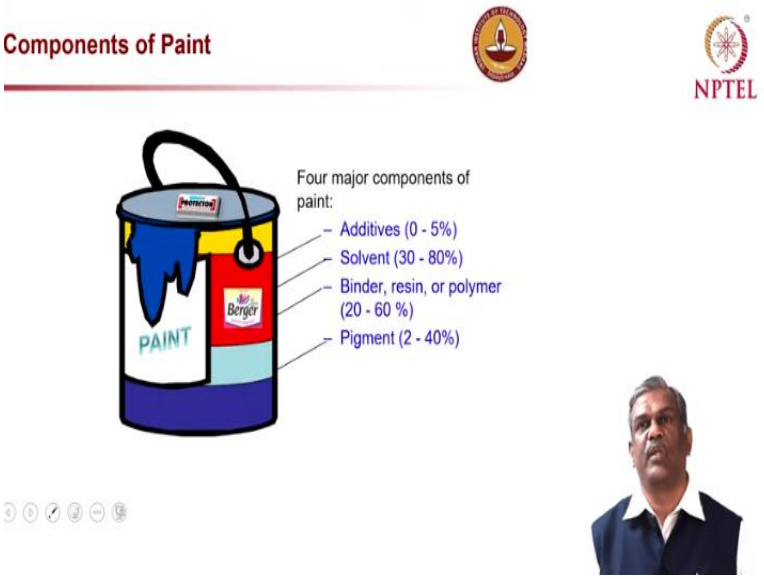

So coatings have a variety of users with respect to protecting concrete. Now for all those people who are quite interested in knowing what are there in paint. Paint is more than color like what I wear is a blue it is not a blue it has got something more than that which is dependent on

the environment. I take protection for granted right? And therefore people only talk about color and the glass which is more of a decorative appeal.

When we are trying to talk about protection, we need to understand a few more words which will help us give better clarity. When you understand these 4 ingredients which are the primary constituents in the paint. You have the binder which is also called as a resin or someone calls it as a polymer that is the most important ingredient. Along with the binder is strength forming that is the pigment and you have a solvent which is used during the manufacturing during the application time which evaporates. Additives are there which gives you the special properties. This is a quick understanding on what paint is.

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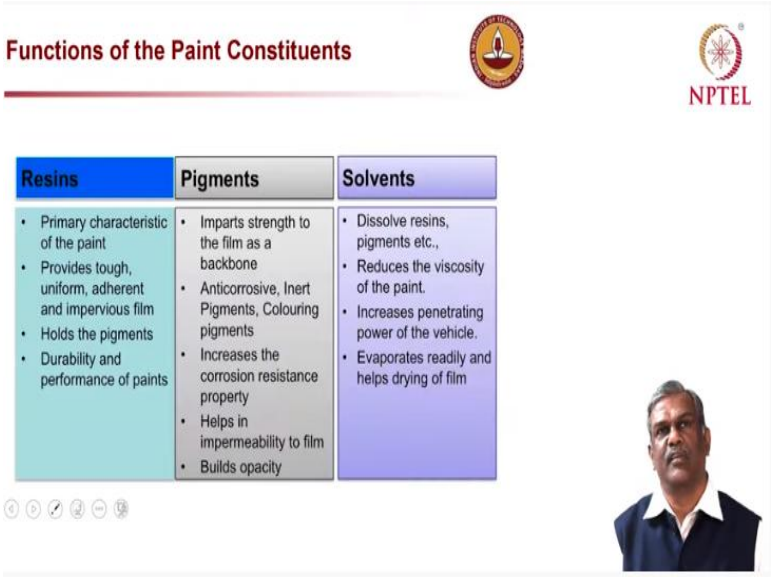

And the resins what they do? The pigments what they do? And the solvents what they do are being explained in this particular slide. Now if I have to go beyond the slide to help you understand what it is if I have to make a body stand, I need the muscle, I need the bone. It is as simple as that. Now the bone here is being correlated with the pigment and the muscle here is being correlated with the resin. If you have either one of them, it does not work. That is why we have a combination of both the resins and then pigment which is imparting you the film properties.

The resins have a classification we will just touch upon that. When you talk about pigments, we have corrosion resistant pigments. We have got what do you call barrier pigments and we have got coloring pigments and on a very high broader classification. Solvents which are there in the film again there are three different types of solvents which are getting processed during the manufacturing and obligation.

One is called a primary diluent the other is secondary diluent and tertiary diluent is what we use in the field which is also called as thinner. The primary diluents function is to dissolve the resin and the secondary diluent is the one which will help in maintaining the stability of the paint to give it a particular viscosity and packing it and dispatching it. So these two are going to be there in the paint and many a time unless or otherwise specified by the manufacturer.

There is no need for you to add any additional solvent and that is not at all mandatory. It is only to improve the kinetics of application that's it. Much said with respect to solvents they are evaporating, be it water, be it any hydrocarbon solvent they have to evaporate out of the film. Then only the film is formed properly. If the solvent has not evaporated properly it leads to problems. It leads to drying problems, it leads to adhesion problems.

It leads to lifting; it can have n number of issues when you are talking about solvents entrapped. So less the solvent the better and the second point, less the solvent it is always more better because we are going more towards a greener environment. So when you are talking about paints, we will have to understand a word called volume solids a word called volatile organic content that would stays back on your substrate.

You can understand it as volume solid which gets out of the main film is all solvents without getting out into the atmosphere and that needs to be controlled. So having a check on the VOC will help you in getting towards a greener environment.

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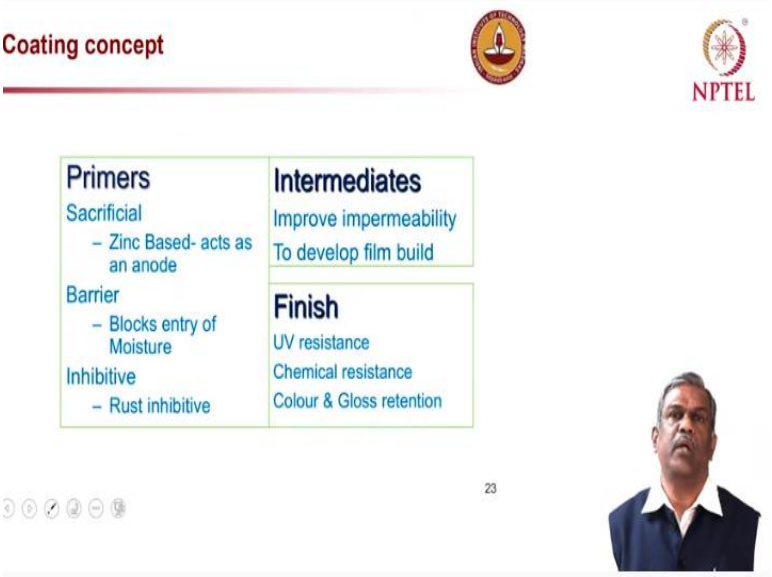

Primers, intermediates, finishers these are the three different types of classification which we commonly come across. Be it a house painting or an industry painting. Each of them has a different role to do. The primers primary function this is stay foot on the substrate and hold onto the substrate getting better adhesion properties. It is also going to give you corrosion resistance properties as well depending upon the requirement. It can also be a sealer to keep closing all your voids and pores.

It can also be filler which can be filling up the blue holes or a requirement on dense in the case of steel. So there are various products which are combined and under the terminology of primer which can either be as a first coat and then subsequently as additions to that. And subsequently the primer is the one which is going to be next to the substrate. We come to the word intermediate or in the case of floor coatings we call it an underlay.

So these are products which have more of film build which is primarily to stop the penetration of oxygen or moisture or any of these gases or other way around. It gives you more stability to the entire film which means giving strength to the film in the case of floor coatings. When you are talking about finished paints it is primarily to take care of the external service conditions be it ultraviolet radiation in some situations and be it in the property of showing up the color, showing up the class giving you the required color retention and glass retention are part of the resin characteristics but showing the color is part of the finished paints property.

And in some situations, we may have extreme conditions of chemical attack, spillage of chemicals or in contact with chemicals or with respect to temperatures in certain cases so all these are different types of resins and different types of pigments are getting added to give you the desired properties.

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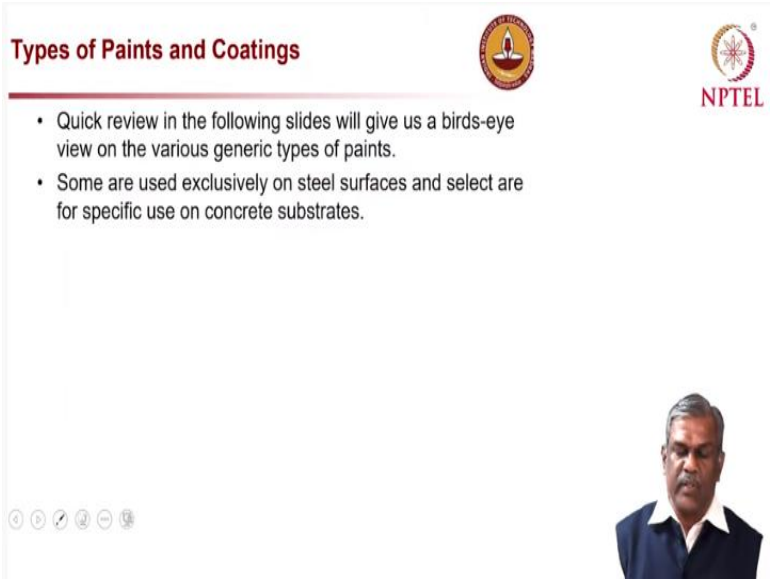

A Quick review of the following slides will give us a bird's eye view and we are just getting into a few of those very simple and very important classifications which will be used by a civil engineer as well to understand some of the paints which are being used by them in metal structures.

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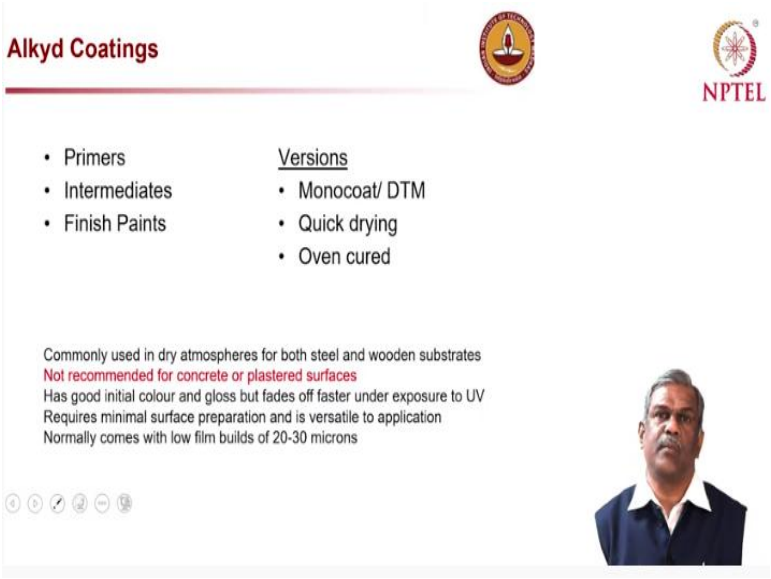

Now, when you talk about Alkyd let us not forget to read the red line there. It is typically not a product for concrete, but this is a versatile coating. This is a paint which you have seen in your houses also for your grill gates for your doors and windows. This is same paint which has been widely used to a large extent in your railway coach exteriors as well. Of late we have been modifying that from simple alkyds 5 coat systems to 3 coat epoxy polyurethane systems in the case of railways as well.

But this has been a work horse for decades to decades for more than 80- 90 years. I would say that for close to 100 years probably alkyds have been ruling the market in a very big way. The latest versions are reducing the number of coats. So we call it as a Monocoat or a direct to metal coat and you have quick drying versions which is helping us because normally Alkyd take more than 4 to 5 hours for even a touch dry.

So the quick dry versions are now in play. And these Alkyds are also taken for Oven curing is also called as baking or stoving. So that the production time can be reduced and imparting a very good film. These Alkyds are on a typical thickness of 20 to 30 micron just to have a quick understanding of what is this 20 to 30 micron. The plastic bags which you carry or nowadays we are not supposed to carry in a vegetable market.

That film is 20 microns or your hair for that matter is around 20 to 25 microns. That is how thin a coating is and this can be measured with the help of thickness gauges called dry film thickness gauge.

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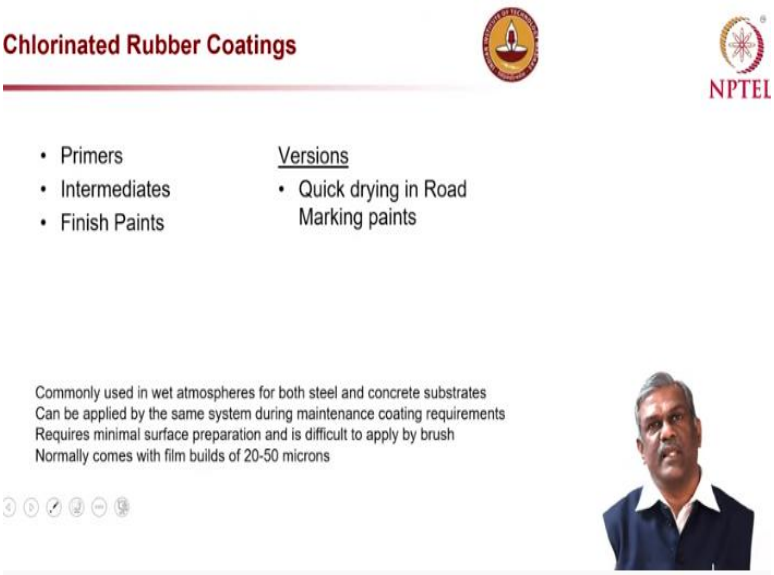

We are talking about the next resin variety called chlorinated rubber coatings. These coatings also have primers, intermediates and finishes and these are better suitable in the case of C2 like environment where you have a wet condition, wet atmosphere coming in play. The latest version of one of this product has been used as a quick drying version in lane marking. So this can be applied on concrete as well.

I would say that the product which has occupied the major area when it comes to concrete that is epoxy this Epoxy coating are available as primers, intermediate and finish. The number of versions depends upon the reactions which are there and this is again let me say when I say reaction, I have to help you understand with one more point. The earlier two products they are all single pack products.

You just open the container and start using them put your brush start applying them. That is how simple it is but when it comes to Epoxies it is a two pack product. You have a base, you have a hardener or someone calls it as part A and someone calls it as part B, someone calls part

B also as an accelerator. So, every paint has got a mixing ratio in the first place. So this mixing ratio has to be maintained with all due respects.

If not, the reaction is not going to complete. As per our design requirements these reactions are called the polymerization. Epoxies are a wonder product. Let me tell you it is very good for different situations and different epoxy combinations are available to handle different types of conditions. Now let me tell what are all the different types of conditions, epoxies can be used underwater?

Epoxies again it is not a single word epoxy and single product. Please have a check on that particular usage of word. When we say a particular service condition, we have to refer to the technical data sheet of the paint manufacturer. Look at the performance data sheets and then come to a conclusion whether it is workable or not or better call the technical service people to have clarity on the coating system which can be followed.

So now let us quickly go through. It can be used for underground. It can be used above ground, it can be used in the mid sea, it can be used in offshore areas, it can be used in refineries, it can be used in chemical plants, and it can be used in nuclear plants wherever you want. This particular product will have an opportunity to show its presence. Here again we have a product which has been reduced the number of coats.

Instead of primer, intermediate and finish we have got direct to metal which is called a Monocoat system which will exhibit both the primer and finished properties there are properties we just call as surface tolerant. Now the word is something, very simple in English but very difficult in technical. The reason being we need to understand one more point of epoxies. Wherever an epoxy coating is getting applied on a metal, the metal should be free of contaminants and the contaminants start from the mill.

That is the mill scale, the rust, the paint, the salt, the dust, the debris you can have quite a large number of all this oil, grease, water. Nothing should be there when we are applying an epoxy painting and if this is getting compromised, the performance of this epoxy is going to be

compromised in a very large extent. That is why maintenance team was always finding it difficult because they were not able to remove the old paint.

They were not able to remove effectively the rust, so they are finding it quite difficult to use epoxies. And they also did not know because of compatibility reasons. They have not been in a position to understand. Was it vinyl paint earlier? Was it chloro paint earlier? Now I have to go for vinyl or chloro which is also difficult. They have no clue on what coating was there on a substrate.

In these areas this epoxy was developed as a surface tolerant product. It was a massive coating, which had more than 90% solids and it used to give you 100 micron thickness in a single coat. And that is why it is maintenance engineers dream coating. It can be applied on steel; it can be applied on concrete as well. Further developments on surface tolerant coatings were addition of glass flake as a pigment.

So you have glass flake coatings, which are again epoxies built at a thickness of 200 to 500 microns in a single coat applied by brush or by spray. It can take very harsh environments. Now the challenge was I have different material in metal. Say for example, I have a steel, mild steel, I have stainless steel, I have cast iron, I might have aluminum, I might have various materials in my construction and every time I have to look for which primer is going to be difficult.

So we have developed an epoxy, which is called as a universal primer. So this universal primer, can we apply it on different substrates? We have different epoxies for immersion conditions. That is in direct contact with the liquid or gas. In another situation you have got coatings which are required under the insulation they are no doubt floor coatings as well, so coatings in epoxies can be applied anywhere from 20 microns to more than a millimeter. So, the range in which the epoxy paints are available are quite huge and it is very interesting to get into the details.

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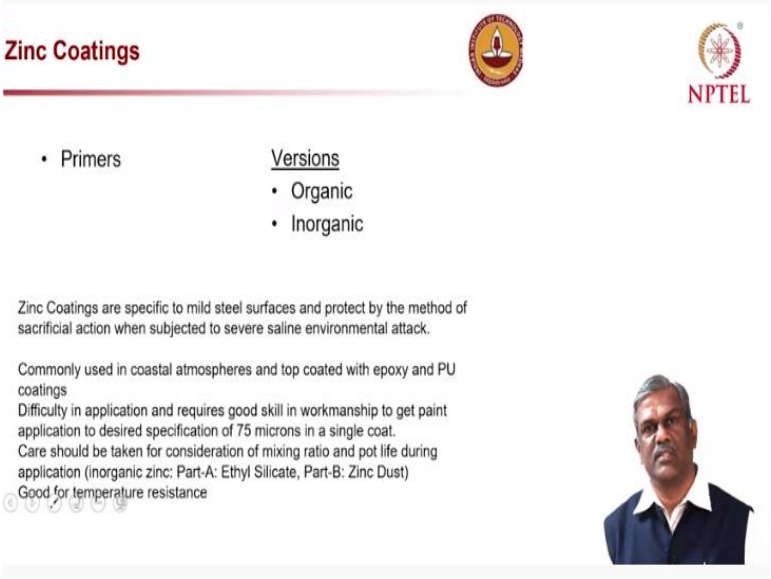

Whenever we talk about coating, I cannot miss this particular product called zinc coatings. We are primarily looking at the sacrificial protection of zinc. Therefore, you are getting it applied on steel substrates wherever you have an opportunity that the steel has to perform for a longer period or in a marine zone or any primer which has to work at 400 degree temperatures as well.

This is the only primer that can take both corrosion resistance and heat resistance when applied properly at 75 micron thickness in a single coat. There are two versions of it. One is called organic other is called inorganic. I am referring to the inorganic portion, which is also called as cold galvanizing. The organic version is putting zinc dust in an epoxy resin and that is called epoxy zinc rich primer that can be brush applied whereas inorganic zinc cannot be brush applied it has to be spray applied.

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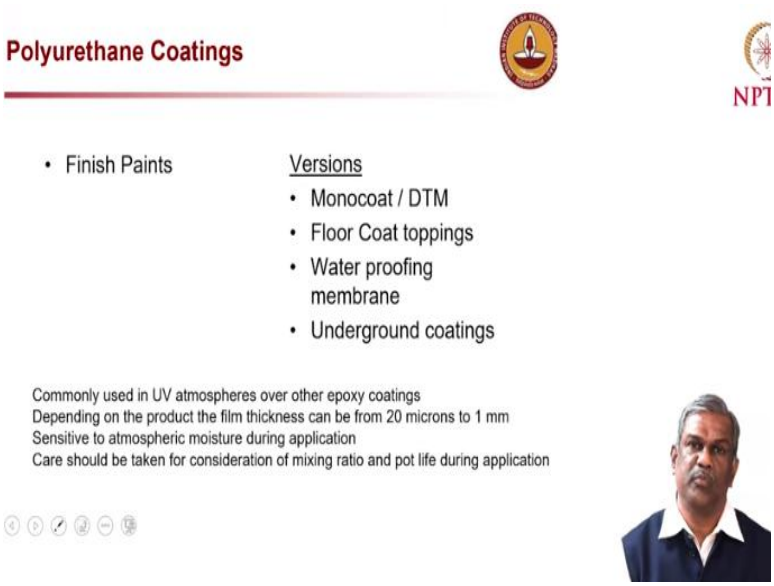

Now, polyurethane we have heard this name very frequently, it is used on wood, it is used on concrete, it is used on mild steel, the primary function of this polyurethane is based on the resin in which it has been cooked, it is an aliphatic resin or an aromatic resin. If it is aliphatic, then it is more to do with UV radiation resistance. If it is aromatic, it can offer you a chemical resistance.

Here again, you have the various toppings and floor coatings as well as you can use it on concrete as thick waterproofing membranes, you can use it in protecting the underground structures, underground bullets and on pipelines as well. So on any of the epoxy primers polyurethanes are used as topcoat. It gives you better color and glass retentions.

Further developments on polyurethanes are poly siloxanes and the latest generations are in the same line for giving you a better color better glass is fluoro polymers which can give you protection, for more than 40 to 50 years life that is very interesting. Polyurethanes normally give you around 3 to 5 years at that thickness.

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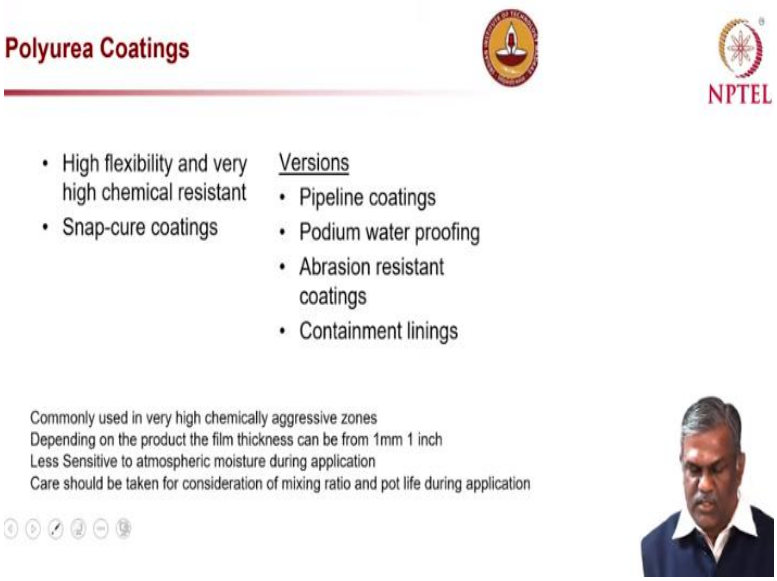

When polyurethane was born, polyurea was also born at the same time in the lab, but polyurethane became famous and polyurea was not so famous. The reason being the difficulty in getting polyurea application. Polyurethanes are typically a product which is a reaction of an isocyanate and the polyol whereas here in poly urea, it is a reaction of an amine with a polyol and therefore these products are very tough. It has got fantastic flexibility, good chemical resistance. It is also called as snap cure coatings, I have a few slides to show you where it can be used.

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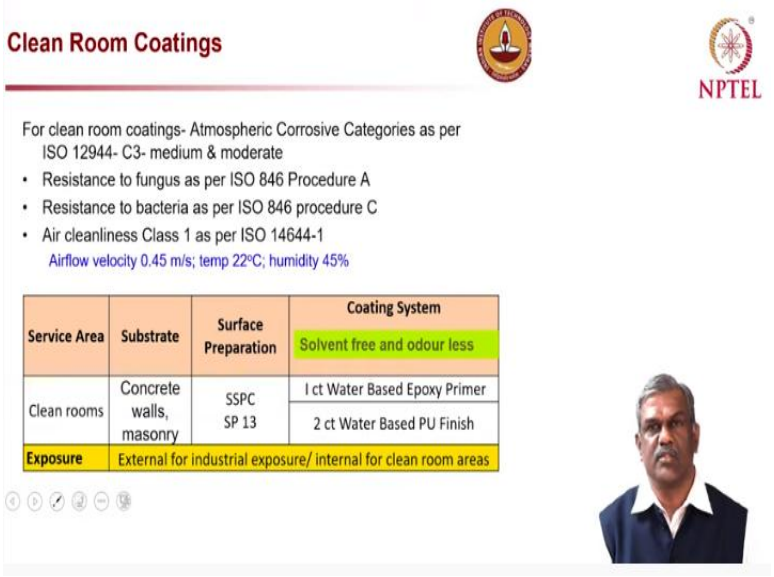

And that is a very interesting product. Now, talking about clean room coatings. I am just now getting into some of those service conditions based expressions of coatings. This is also

having a system wherein you have a water based epoxy primer and top coated with a polyurethane. This particular product is used in hospitals, is used in pharmaceuticals or even concrete as well as on plastered surfaces.

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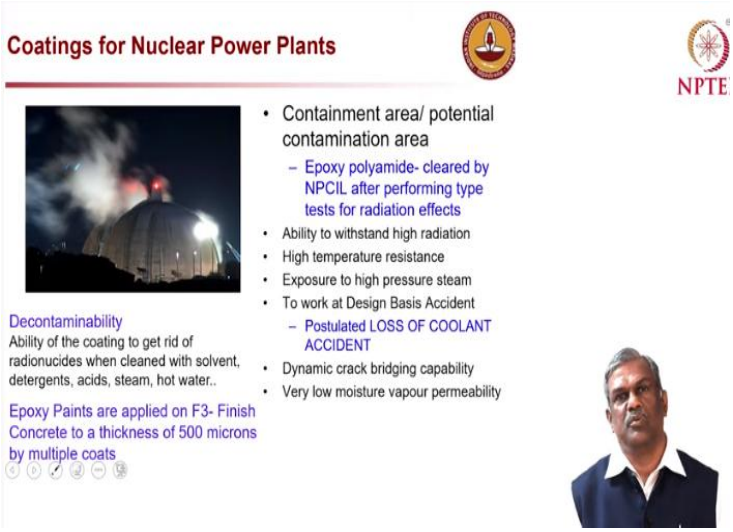

Epoxies are one of the major items used in nuclear power plants. Without epoxies, you will not be in a position to complete the construction of a nuclear power plant. That much is what epoxies can do for the country. What is the place where epoxies are used? Be it steel or concrete? I said epoxies have a role to play right from the cooling water structure, which gets into the inner lining of that to the containment area.

So, epoxies are playing a major role, the walls, the ceilings, the floors, the structures everywhere. Epoxies are used widely in the nuclear plant. The epoxy which is used here is not the normal epoxy. It is subjected to a variety of tests by the government NPCIL and then they accept a particular coating, whether it is able to take care of the radiation resistance, the ability to withstand the radiation. That is the most important requirement. Secondly, can it bridge cracks? That is also a very important requirement.

So nuclear plants have a typical painting system and we are not detailing too much into that. We only require a good concrete, moisture free F3 finish and then you start applying epoxy in multiple coats.

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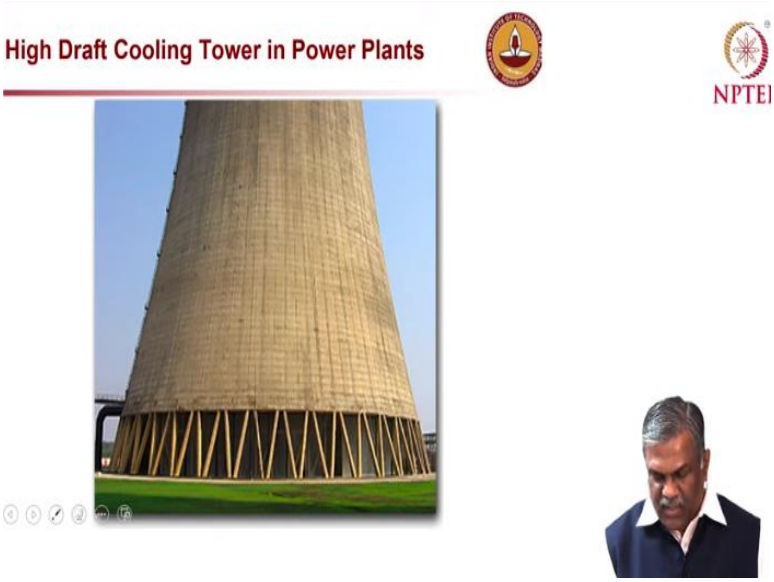

The second important area is in thermal power plants where you have a high draft cooling tower. Water continuously keeps falling inside at a high temperature of 35 or 40 degrees and it has to be cooled down before consumption.

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This water is continuously in contact with the concrete structure. So water and temperature are not going to go well with concrete and you might have lot of issues with respect to the penetration of water, utilization of the concrete and the corrosion happening there. So we require a coating to apply when the concrete is dry. That is fine many coatings are there. But epoxies are not to be applied when there is a wet substrate, when there is a substrate that is contaminated with oil or grease.

So when you are looking into these conditions, no coatings are workable in this type of structures during maintenance painting, I cannot do 100% shut down of the plant to start painting. Therefore, we have to improvise on the qualities of this particular products, drying capabilities. Even when there is a presence of water, even when there is a high level of moisture, even when there is a substrate contaminated with water. This product can we apply it dry spray.

This is the same product which can be used not only on concrete but the neighboring steel structures as well because it has given around 300 microns fantastic salt spray test of 2000 hours.

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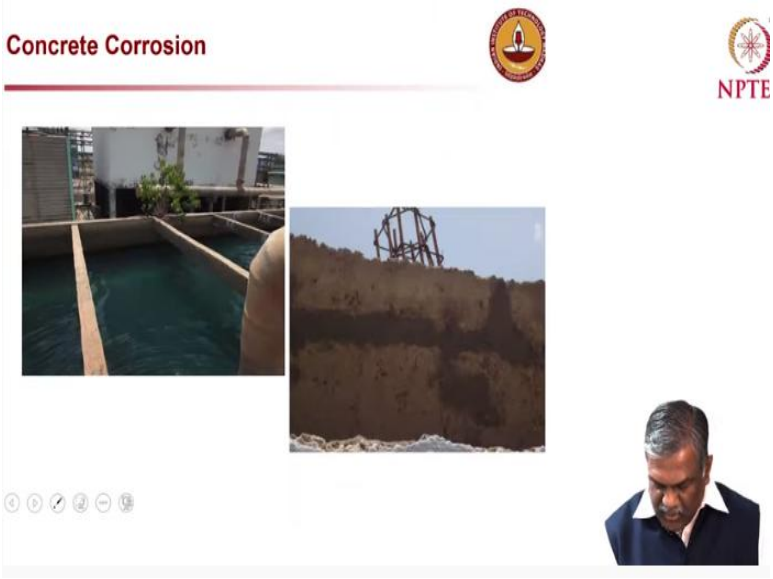

Concrete corrosion well known to us.

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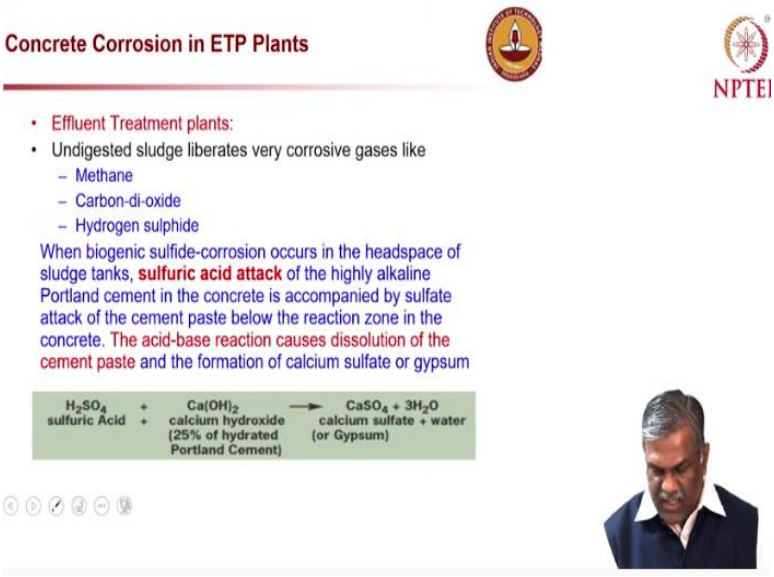

We try to understand the corrosion in effluent treatment plants.

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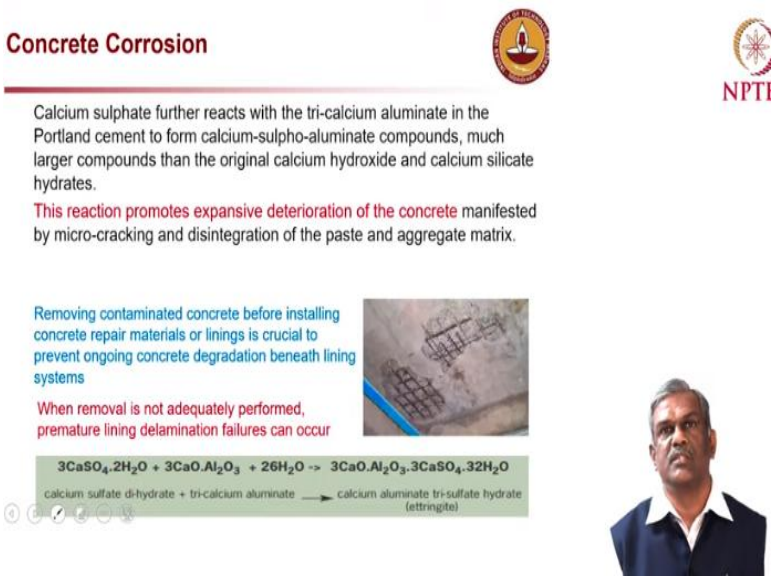

Where the conditions are more severe and aggressive?

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Coatings that are used in effluent treatment plants. These are special epoxies these are again products which can be applied on mild steel as well as on concrete surfaces. The thickness of each coat is 500 microns and you can apply minimum of two coats under these situations. These products have a reduced pot life, means after mixing the two parts, part A and part B, the paint has to be applied within a specific time and that is called the pot life

If paints are applied within that it will have an opportunity to spread evenly. It will be in a position to cure well and give you the desired performance exceeding the pot life whatever material, we have mixed moves to rubbish it cannot be used.

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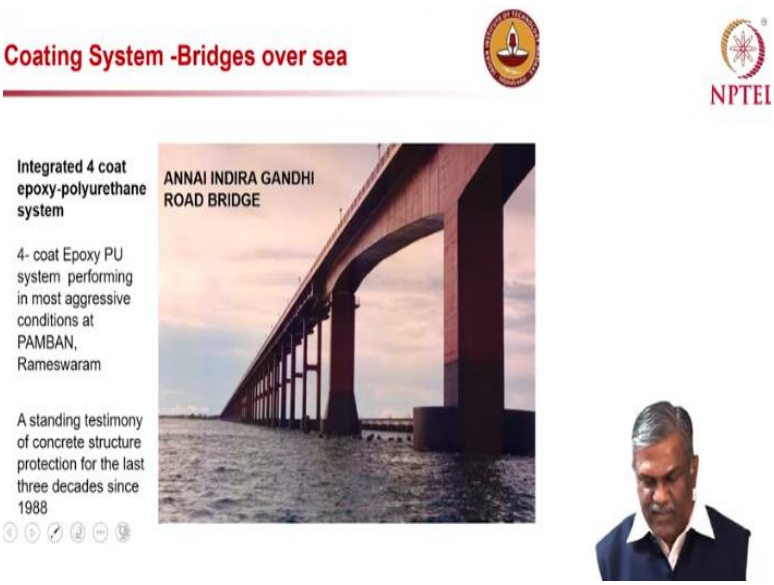

This is the title slide I can call, the best of the coatings. We learned coatings from this particular area in a better way.

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Anti-carbonation, we know the effects of carbonation on concrete, chloride intrusions on concrete and we require protection of all those piers which have been constructed as flyovers and road over bridges. Anti-carbonation coatings are available both as water based product as well as solvent based product. The thicknesses of these coatings are around 150 microns as a total system. These products can be applied by brush, by rollers or by spray and it is quite easy to apply with a normal surface preparation and what is normal and abnormal. We will try to look at it at the end of this lecture.

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Pipelines are used in irrigation projects. We are also taking water from far away sources. The pipes are having a cement mortar lining and the latest development is to give you a coating inside cement or steel pipelines to carry the water. They are tested and they are approved as food grade pipelines, food grade epoxy coatings.

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Vitamin coatings are also used in coating on the external pipelines or this can also be taken as internal pipeline coating. Coating thickness, per coat it is around 200 microns. You can take 2 or more coats not a problem. And this particular product is also tested by the international body WRAS who accepted as a food grade coating.

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What is WRAS? It is a Water Regulation Advisory Scheme. It is a body of UK and from the body of US you have US FDA. All these have regulations to certify that the coatings can be in contact with food and water.

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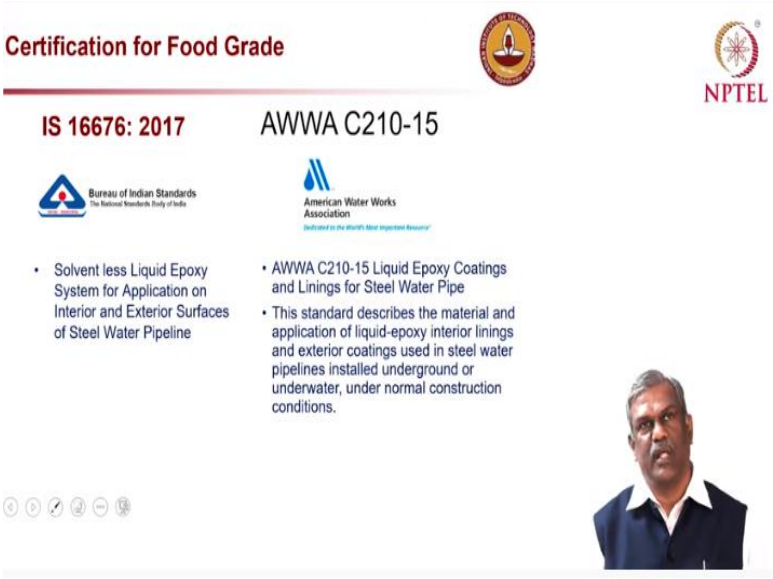

AWWA is American Water Works Association. They also have a standard to accept liquid epoxy coatings and linings for steel water pipes. The latest of the Indian standards is IS 16676 which talks about the same product, solventless liquid epoxy for application on water pipes.

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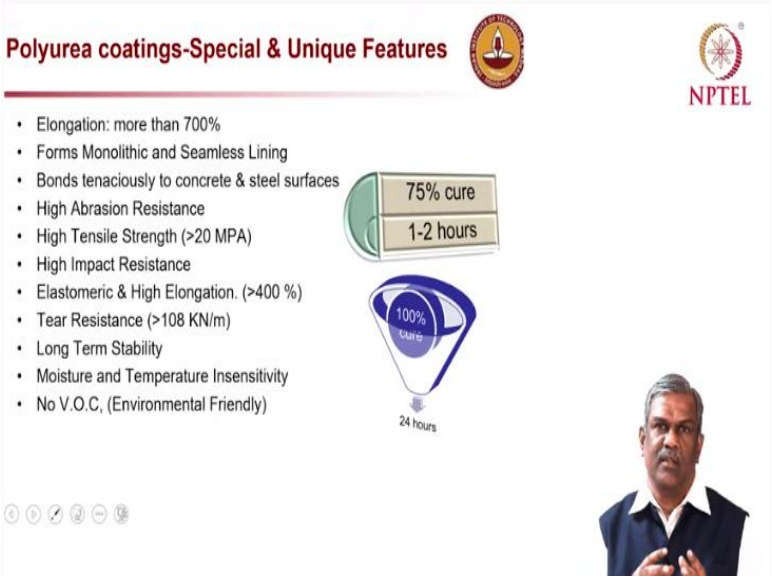

Polyurea is a wonder product as we said it was born along with the polyurethanes. What is this wonder about? The wonder is, it is a snap cure. What does it mean? You have a part A and part B of this material; you mix it 15 seconds. It is already set. So the technology of application of polyurea is the one which took nearly 60 years for the product to come into the market.

This particular product has fantastic elongation property and in comparison to normal polyurethane. It is a seamless lining, which means there are no joints, there is no stitching. It offers excellent abrasion resistance. It offers very good impact resistance, elastomeric property and higher elongation more than 400%. It has got excellent Tear resistance property and reduced VOC which means it is environment friendly.

The entire coating gets cured in 24 hours one can start applying and start walking on top of it. And that is the speed in which you can have a return to service. These are the unique features of polyurea.

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Polyurea application can be in the area of canal management wherein the concrete construction joints can be totally sealed. Polyureas can be applied in few inches as well. It can be totally sealed so that water loss in the pathway of transportation through these canals and open canals can be reduced to a negligible level. Pipelines are coated and it is also an excellent waterproofing material. So for deck waterproofing, podium waterproofing, this is an ideal choice.

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When you are talking about concrete floors, we have different problems in concrete. We all know that steel can be welded one above the other but concrete cannot be welded. You cannot

have two concretes to become a homogeneous layer. So we have a lot of issues. When there is a wear and tear, we typically call it as erosion and are due to this high abrasion on the left side.

When you are able to see this particular portion this is a parking lot, you are able to see those rods getting exposed to lot of cracks which can happen in concrete and any touch-up area. All these areas are not going to stay for a longer time. The wear and tear is much higher here. This is a typical case of assets and chemicals. This is an industrial plant you have a lot of concrete and this is another interesting area to observe.

This area is not an epoxy for floor coating and this portion you will find a very good epoxy as a floor coating member. Not all epoxies are suitable as a floor coating. Now, what does that floor coating do? It is able to resist the cracking. It is able to help you in better cleaning. It is able to give you better abrasion resistance, chemical resistance and many other service conditions we will try to touch upon with respect to floor coatings.

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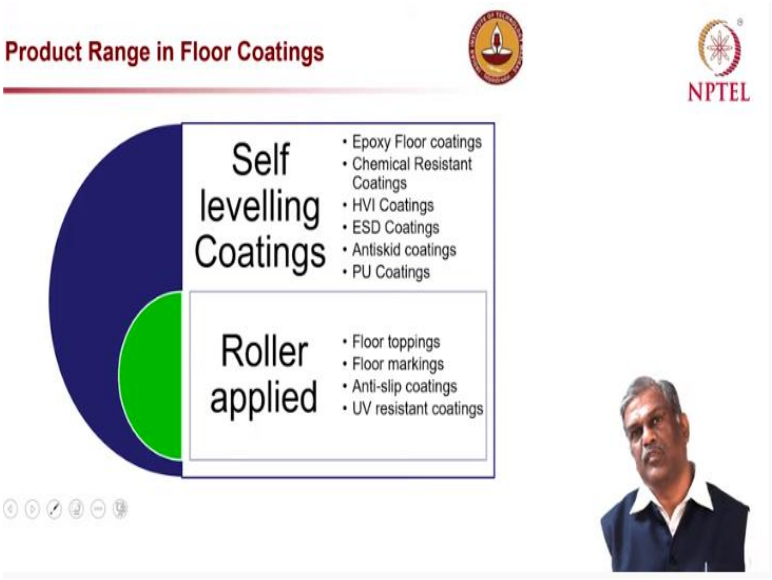

Typically to have a broader understanding, they are self-leveling which means that you apply the material and it is able to maintain a same dry film thickness across, provided we are able to spread it to all the corners to the desired areas which it has to cover. Roller applied means you are able to use a roller and apply the particular material at a defined thickness, so they are also called as floor toppings.

You can use it as marking for lanes and some of those UV resistant coatings which are applied over normal self-leveling coatings are roller applied to give you a specific service condition property.

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Floor coatings have crack resistance, chemical resistance. We have understood this in an overall manner. We have a few examples shown here one is for a heavy duty flooring where huge material of 18 tons plus are being taken here you have a deck coatings for car parking. Here you have high voltage insulation, acid resistance this is for battery rooms. We know how much a battery can spoil a floor. So this particular coating is an epoxy Novolac which is suitable for such harsh environments of chemical attacks. We also got thermal shock resistant coatings.

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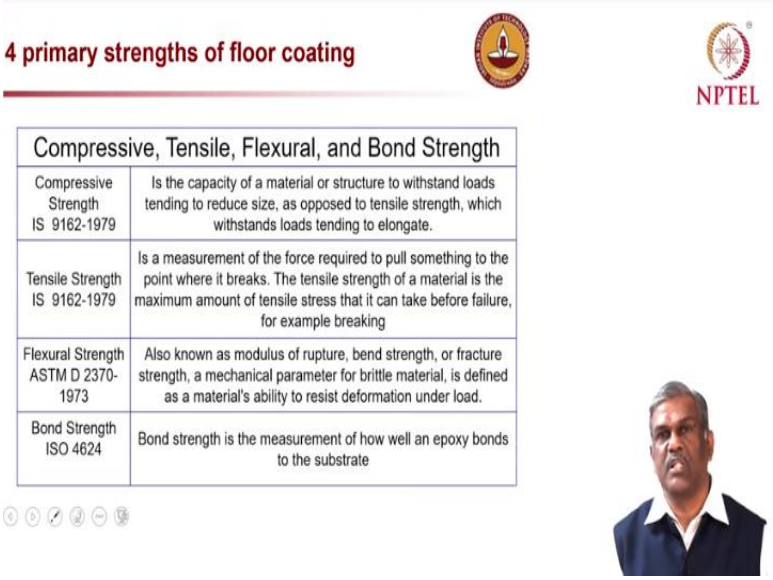

So there is wide range of coatings available for floors. But whenever we talk about a floor coating, we try to understand on the 4 fundamental parameters, the floor coating if it has to protect the concrete, the floor coating has to be stronger than the concrete. So when you are looking at concrete strength of M20 or M40 means I should not have a coating of the same strength it should be better than that.

So the compressive strength of the coating are normally around 60, which means that it has the power to protect it very well. We have other requirements like the tensile strength, the ability for the coating to take care of the tensile forces, which is coming and acting due to the expansion and contraction requirements of the concrete. More flexural resistance is required when you have a vehicle and it is trying to turn around.

We try to understand the tear resistance; we try to understand the flexural strength of the particular coating, which is going to give you the better performance height of all the coating has to stay there on the substrate. So you require a very good bonding therefore the bond strength is being tested. So there is a Dolly which will be fixed in the lab. We try to pull the Dolly out and we will check whether the coating comes away from the concrete or the concrete along with the coating comes off.

In many a case, the coating is so strong that the concrete gets turn off, but not the coating bond with the concrete. So these are the 4 fundamental properties which we try to check when we are looking at the floor coatings.

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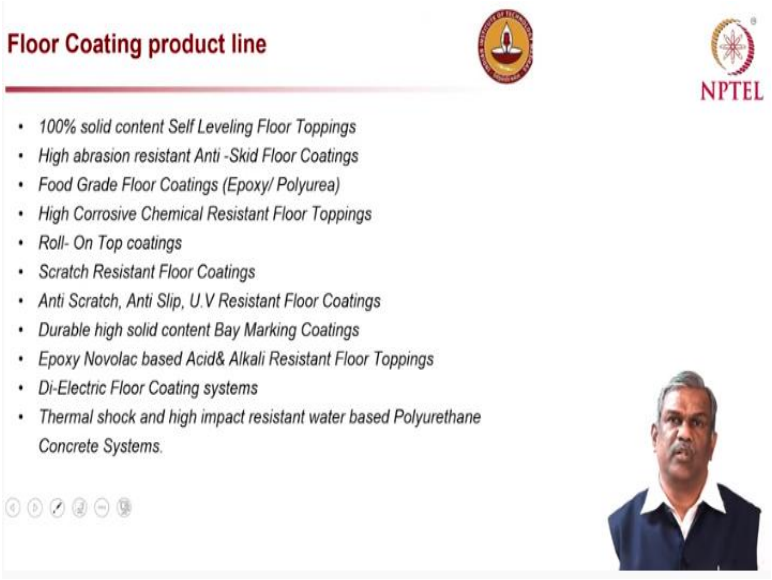

You have a huge range of performance requirements for floor coatings.

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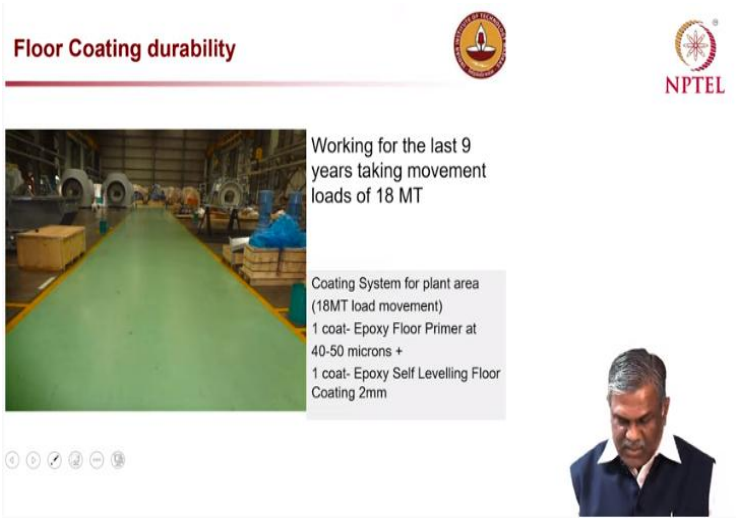

A quick understanding on how much life floor coating can offer. And this is a typical case where I have seen, for 9 years this has been performing and still doing very well without any maintenance other than cleaning it well. This was applied at around 2 millimeters thickness, I recollect it is a VDF floor.

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Now, condition for coating during application is a topic which we need to understand in detail. Surface preparation requirements, the mixing of coating requirements, application of coatings, the various methodologies which are there. What is the importance of drying and curing and none of them can be taken as all. Many a time, we are not getting involved with the person who is actually installing the coating.

If the people as a mason, if he is going to play havoc then that the structure goes for a toss. Same way if the painter is not aware of the product, which he is handling the coating goes for a toss. So the performance is more dependent in these situations. With the effective implementation of the application, there are a lot of influences to the coating characteristics, the film curing characteristics due to the temperature, the temperature of the air, the temperature on the substrate.

We also have to understand on the dewpoint temperature when there is going to be condensation or possibility of condensation occurring on the substrate, the epoxies are going to have different problems called amine blush. So this is not going to help you with a better film characteristic. So we need to monitor all these particular requirements, right from relative humidity to the wind velocity whenever we are doing a spray application. So we have many requirements in this particular area.

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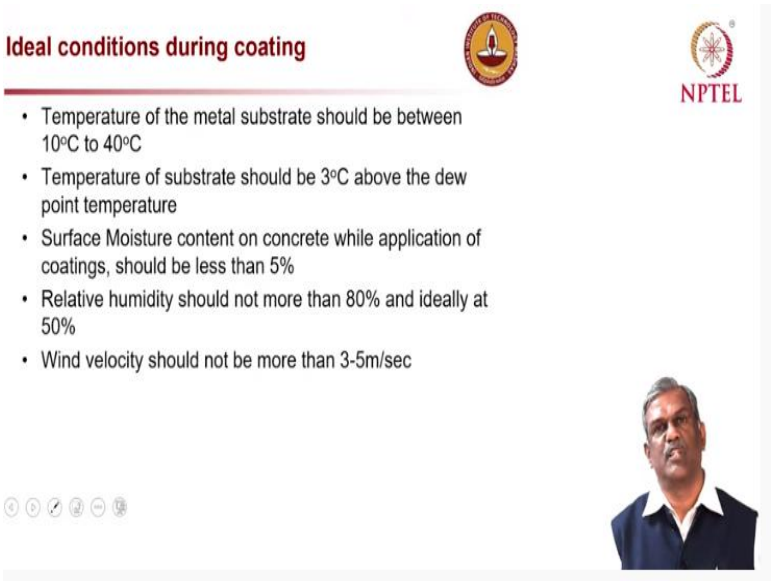

The coating of steel, the coating of concrete, we have to fine tune the understanding and ensure that it is implemented well. The temperature of the substrate is also being monitored because most of the coatings have solvent which is having an opportunity to release its solvents based on the temperature on the substrate. The temperature of the substrate is very cool, the solvent stays back. It is not able to find an opportunity to move out.

Same way when the humidity is much higher, there is no opportunity for the solvent to go out. So, understanding the temperature of the substrate, understanding the humidity percentage in the air and understanding the opportunity of dewpoint and condensation to occur. All these are very critical factors when we are talking about application of coatings.

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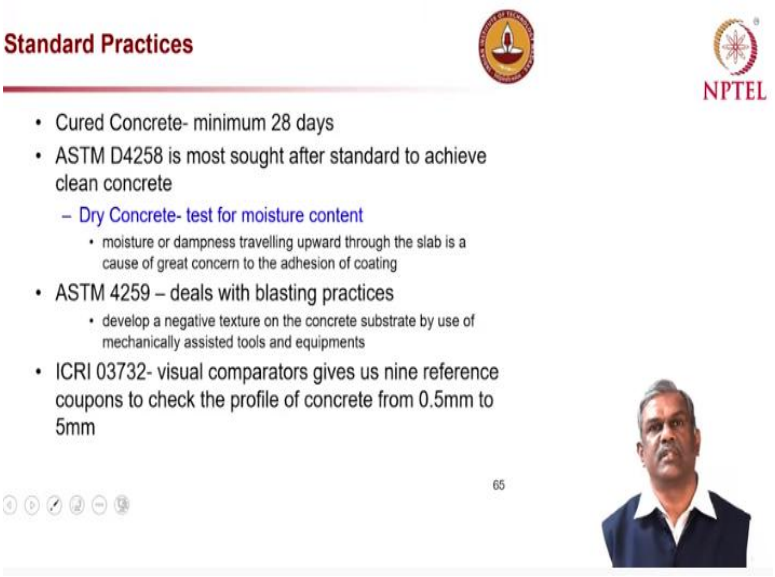

The standard practices we understand on the cure of concrete, we have to understand the concrete has to be ideally dry, clean and sound and you also need to understand the profile of the concrete and you have the practices of ICRI 03732 they are visual comparators. I think I have a slide to show you how it looks and how it is being used.

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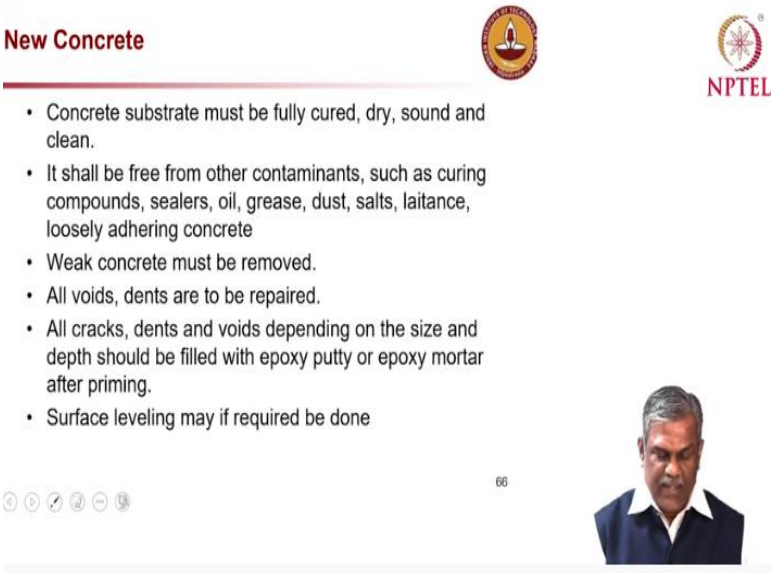

When it is new concrete, we have to ensure that the concrete is cured well before we touch with coatings. Ensure that there is a curing compound and sealers do not have oil contamination leftover on the concrete. There should not be any dust, salt or laitance or loosely adhering particles on the concrete. It has to be removed and then we will have to work on the

cracks, dents voids, blowholes and it has to be filled with proper putty. And then we work further.

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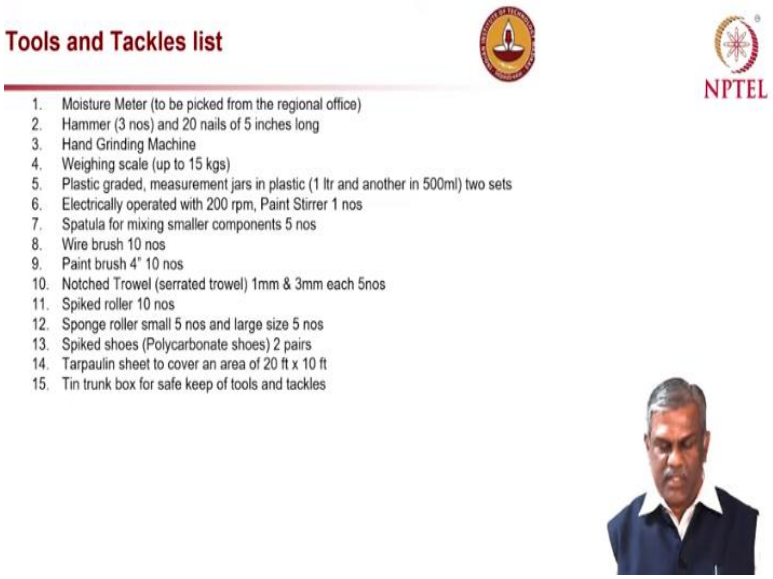

The tools and tackles list have been listed which can be kept as a quick reference wherever you get into a coating project.

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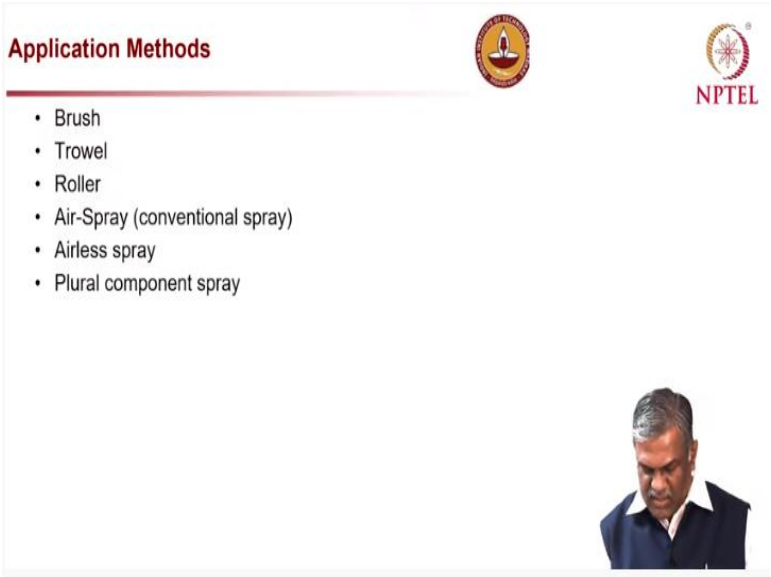

The different methods of applications.

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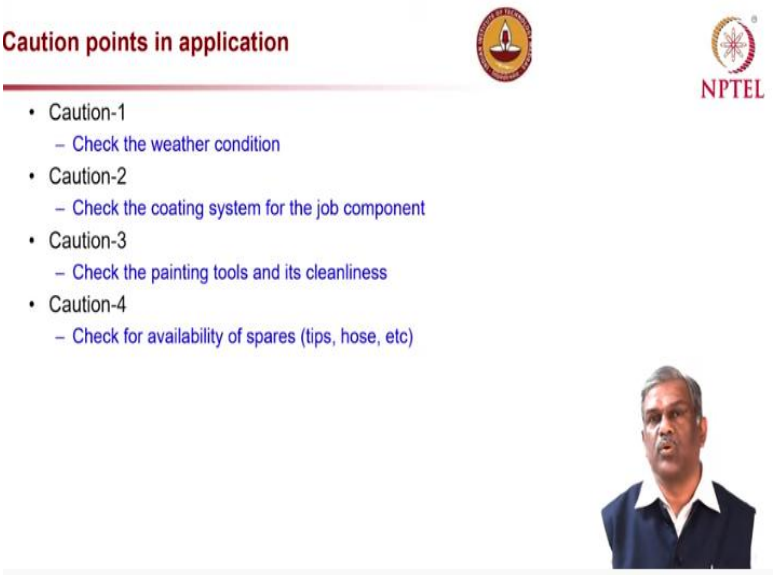

We will try to touch upon the importance of the caution areas. That is the weather condition as we told a bit earlier. Then we should know what coating system is there for that respect of job, which has been taken? Tools which are required? What is the cleanliness we have to adapt? And whether we have the spares, when it comes to tips or hoses in the case of spray.

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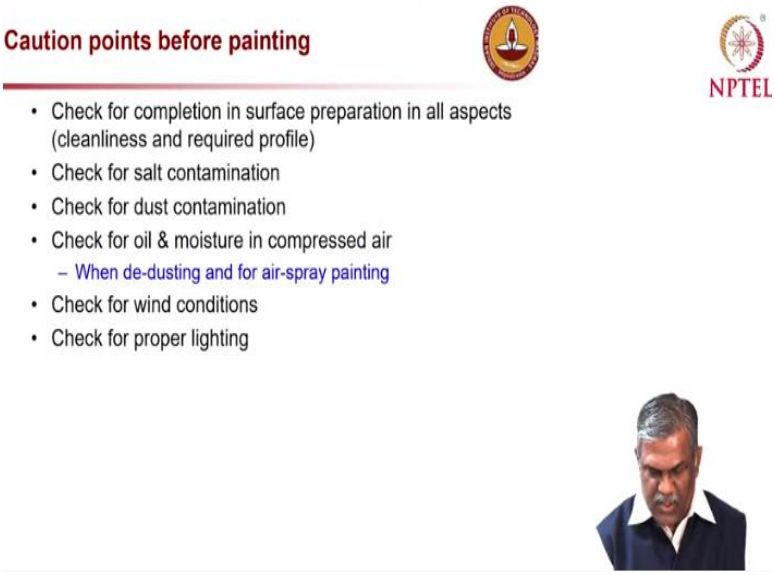

We are talking about the contamination, if salt is there, dust is there, debris is there, oil is there this is going to have effect. So we have to have a check for all these different contaminations before we start the painting. It also includes proper lighting. If lighting is not sufficient, probably coating cannot happen without any holidays.

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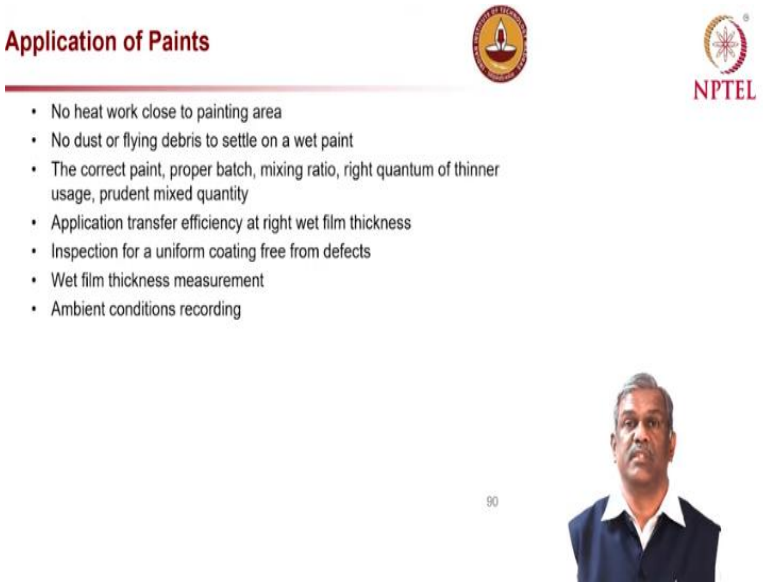

It can lead to holidays means there is going to be a small area which has been left without painting, which can allow the ingress of the corrosive ingredients which can go like oxygen or moisture or chemicals and start attacking the substrate. So paint has to be applied free of holidays, free of pinholes, free of bubbles and it has to be uniform in thickness. And this is what we look for in good painting.

Whenever it is in an epoxy or any other paint, solvent based paint, please do remember that they are hazardous material. No air is left without understanding the smell of paint in that particular vicinity. So you know that painting is going on there, so whenever there is a painting activity going on. Do not create a spark opportunity; there should not be any welding activity close to the painting yard. This is very important it can cause accidents.

So when you are talking about the transfer efficiency or the right film thickness, this is very important area. When you are saying that I wanted a coating of say 500 microns then you have to check on the volume solid content and then arrive at the required wet film thickness to achieve the dry film thickness of the paint. Then if you are able to maintain the required wet film thickness, you can be rest assured that the paint will be giving you the desired dry film thickness.

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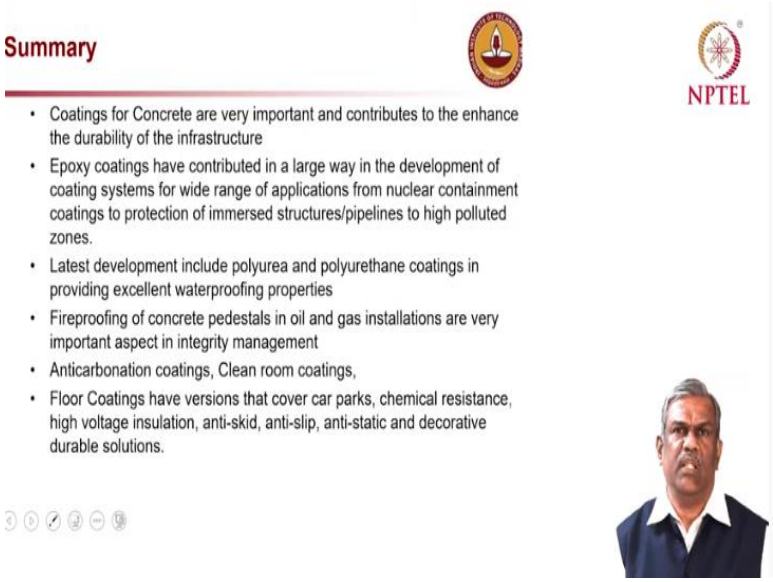

So I think we have covered all the topics. This is only to give you a single summary appreciation of what went in this lecture we have to primarily summarize saying that coatings for concrete are very important and mandatory. It enhances the durability of the structure, epoxy coatings are in wide use. The latest developments in protecting concrete are with Polyureas and polyurethanes as well. Fireproofing of concrete pedestals in oil and gas installations are very important aspect in integrity management. We have Anti carbonation coatings, clean room coatings. We have coatings for a variety of purposes including pipeline coatings.