Building Materials and Construction
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Module - 7
Lecture - 1
Durability of Concrete: Fundamental Concepts, Degradation Processes, Attacks

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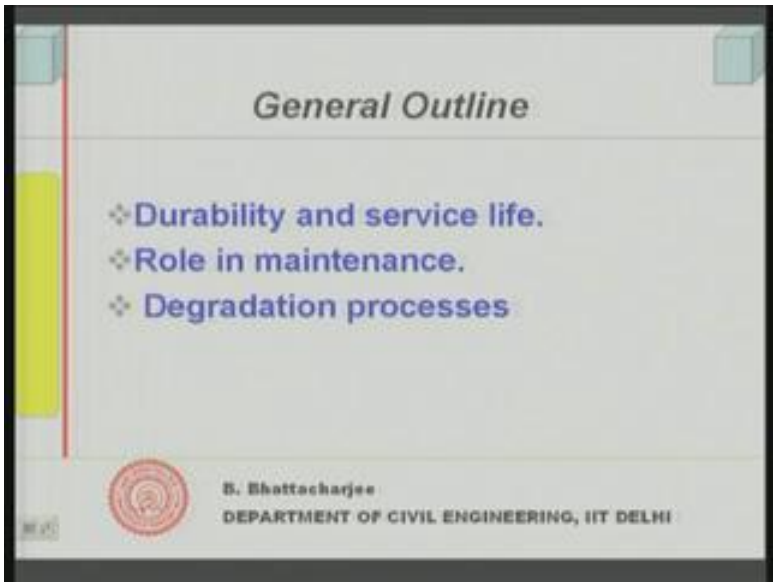

Today is a look in to durability of concrete, so far we look in to spring and then are today look in to some accept of durability concrete, degradation processors and attach in concrete. So, general outline of a discussion will be what you have understood by a durability and service life. Then, whish a look in to roll of maintains and look in to some of the degradation processors.

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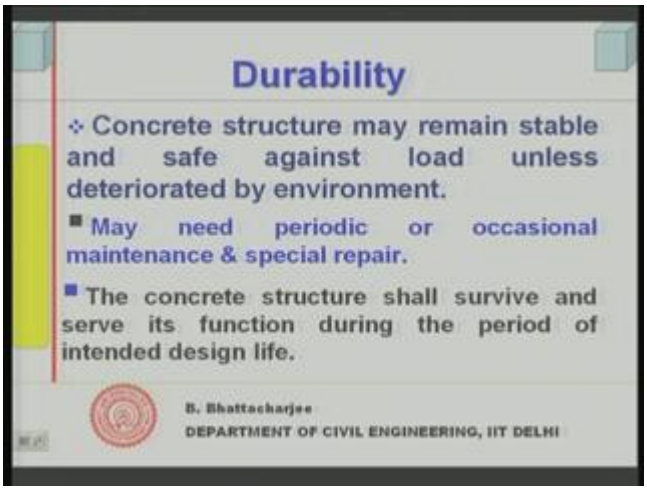

So, let try to define durability you see 1 things so far understood the concrete structure can be remain stable and strength is the factor which actually, decide about whether it will be same shape unstable. Again horizontal you know again horizontal and vertical loading, gravity loading horizontal loading, but this is 1 issue some strong can also be attack by various kind of aggressive, agent present in the parameter.

Durability realize to this choose right, so did duration can take place because of some of the chemical attack from the environment. The concrete structure shall survive and service function during the period of intended design life, issue you try to defend life of the concrete possible. We define intended design life if you remember we talked about life of the structures, which it should have which it should have function. Now, intended design life the driving the life of design whatever is the life conceive, there is called intended design.

So, you take the load that would come during this period of time the maximum load or possible is farfel maximum load the sudden amount of waste that will come 1 during of the time. And due design for that, to sustain such kind f load, but this is intended design life of the structure there can be several. Otherwise of the defining life, service life is normally define with respect to elements.

Now, we can you know define the service life is such a manner that it should service function duration that period of time such bacterially. So, in case for a structure is concern is shall survey. So, remain stable and service function during the period of intended design life and of course, will doing some initial during period of time.

It is not like that you know build a structure whether a building or a bridge that build it and it remain forever without any maintenance, you have do to sudden maintenance. And you do maintenance the structure should survey is function, during that period of intended design life such actual do that job.

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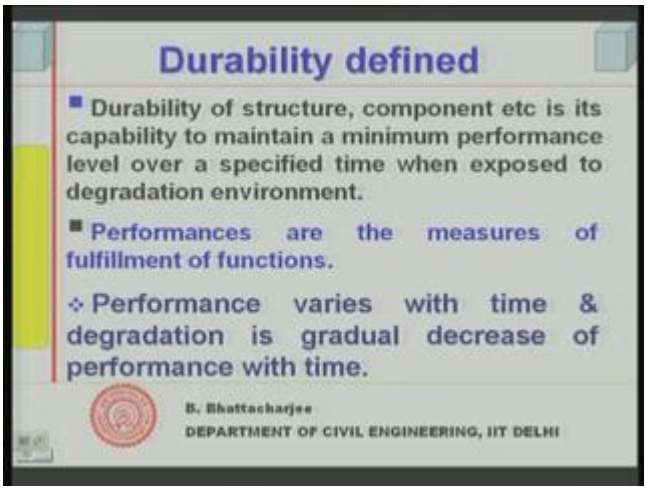

Let formally design the durability; durability of structure, component or you know any material, any produced etcetera can be define as its capability to maintain a minimum performance level over a specified time you know when exposed to degradation environment. So, what is it actually?

Durability related to environment degradation, when you expose the concrete structure to environment it would actually be attacked, by various aggressive argent in the environment. And this would mean it has to survey such attached during intended design like the period. So, durability related to in capability to survey the environment degradation and mention of minimum performance level and during the specified time.

That what you call the durability that an analysis with human being is, you as person can be very strong young person can be very strong, but still can attacked by viruses are you know canceling. So, the remaining healthy is a part related to durability strong person can also fall sick, so that is also attacked by virus are victory whatever it is.

So, we are talking here we talk of durability, we talk of those kind of expand from the aggressive and agent right. Let us see, now what a performance I being just talking about

various performances. Performances is a major of fulfillment of the function for example, a structure is a suppose to carry the load allow the possible.

Let us say bridge as a mention some earlier bridges suppose to allow to traffic to pass are it safely. And of course, remind standing during the period of it exposure, during the period of intended design life, so performances the measures fulfillment of the function. So, this functions should you know we should performance the function of carrying the traffic, allowing traffic to pass thread this function how is performances.

So, you know how it fulfill this function in design in terms of performance parameter; performance are the measure there the measure try to actually define how it fulfill its functions right. And this performance carry with time for example, load carry capacity of the bridge make it reduced what something like that to environmental. You know the exposure and extant of the ignore of the agent duration of its material and component.

So, performance can be vary where can the various other performances for example, performance can be defines in terms of not only carry the supplely the traffic, but they should be crack. So, you can define the performance as visually as you should look a healthy are you know esthetically you should look present. So, these are also other kind of performances, so performances this performance can vary with time.

For example, at the beginning it may not be showing in the crack in science of any kind of displace, but, with time it may source on science of distance and which man of the expectable. So, performance various with time and degradation is basically gradually decrease of performance with time, so this as sound the definition with reference to durability right. Now understand what is performance we also understand performance where is with time and what is durability.

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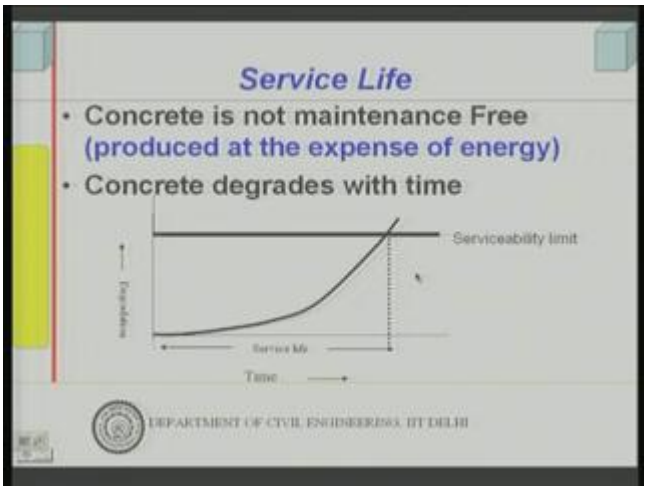

In this contest would like to define service life of elements, let us first just look at philosophically we with is that building of structure material, if you 1 produce there were maintains free, because there are unlike to the maintains free. Because, let us assignment we produce it expanses of energy we heat of raw material when actually m wet some energy in to the material.

So, this not stable conduction would be when it's as dissipated always energy there is no chance of dissipating any further energy actually we use the chemical potential by heating this up. And it will like to dissipate energy as in get a chance. So, symmetry what a dissipating somewhat of energy which you know some reaction is extra thermo we know. So all the material that you produce the expanse of energy, would like to dissipate them therefore, they will tutorial.

So therefore, concrete cannot maintains in concrete cement using some of it locked it energy is dissipated during the hydration reaction, but still there the same amount of energy remaining. So, all together it would like to come to stable say by dissipating al this energy. So, given a chance like a react with environment agent those represent and you know depredated. So, that is why concrete cannot be maintains free we know stiles is start still readily from oxide and rush, so it concrete.

So therefore, 1 has to maintains them 1 as to see that you know it how you how you take up the several problem it will a have tended to we react of degraded, but then we know this degraded behaviors is no problem. Because, you can decide keeping thus in mind, so

it has to by design not by default you can tendency of the degradation may not be control, but rate can be control by various means.

An analysis again is shown so quiet often upon that you can lift of a body of if just relies up keep it up where it is come down. If you some things like some things this you ground like a time you raise a body and lift it up. So, if you just allow just live it in the air it will come down straight away it will live direct fall if you, but in a slope if you, but in a slope when it is come down is must slower rate.

If you is you just flat surface you know built of surface and just hold it there it will never come down. Because, although it is tendency some case are same to come down, but rate are different; first case there are no supporting the rate was maximum quickly come down when there is slope it will come down slowly and when you it, but a platform below it actually never come.

So, rate can be control although we cannot control the potential are the tendency to degrade any way al that is there concrete degrade. So, it time therefore, 1 can take time of what is called service life of concrete element. So, the degreed any initial the degradation level is 0 and in degreed gradually like this and reaches the level which is not expectable to us, when it reach as such level when it not a expectable as when it call as service life.

So, you know service life that life usually concrete element not fellow building concrete element. We are talking of service life of concrete elements and remember once and element which as serviceability limit and infect service life is over whole structure is unlike to clops. What do you go to is, you go to actually repair you repair it and maintain it properly then of course, it will be back to the you know structure is remain.

Decide the structure got enough built in redundancy. So, this is 1 element is 1 column element in a building let us, support in are slide supported in 4 column you cut one column, unless the critical structurally. The other 3 column share the load and, so sun degraded the 1 column is not go to make the building to fan, but it got to implication and maintains.

So, when in extreme cases tended it can fail also, it is not that 1 can sit prided it can fail also tended, but with proper maintains many of the durability problem can be taken care

of, but it got as implication on economic we look in to that. So, divisibility limit or serviceability limit or service tax we define with respect on elements.

Let us, beam a column are slope are something like that kind when the you know defend up on of course, case specific case are in degraded some process also. So, when initially in good conduction when it is reach as define serviceability limit that for example, it could be simply that feasible appearance of feasible cracks and so on. And defend upon degraded some process when reach as the serviceable limit this time we time call as the service life of the element.

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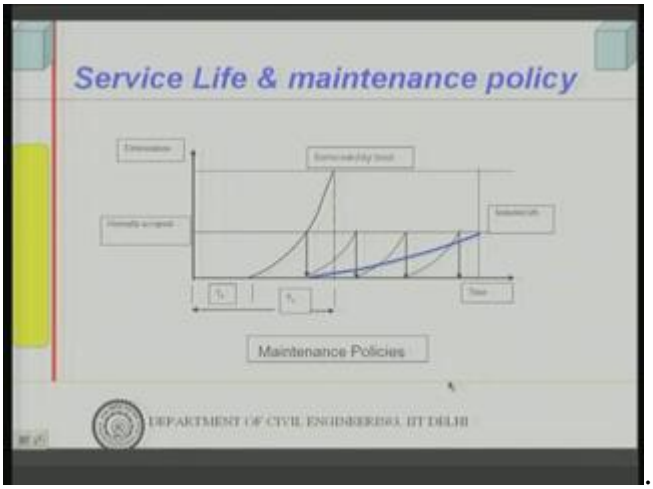

So, this got the relevant durability and 1 would like to design and element for appropriate service life. Right 1 would like to design service life and if you see, what is roll in maintains this diagram shows the roll of service life maintains is you can see, that this is initially there is no degradation 30 period after that possibility degradation start and then it would have range the serviceability limit. But 1 make take a decision generally, when it is normally accepted much before the serviceability limit you might to maintains to back to original conduction.

Then, again it tutorial and then you periodic maintains. So, when you have you know degradation problem concrete structures you might thing in terms of doing it reputability, maintain it reputability doing some repair and re reputability till the indented that design life. So, serious of repair you know this time repair, this time do a repair, this time this

could be one of the manager will decision defending upon economic what is called life cycle cost.

So, every time you would a maintains a cost in cad and this cost can be compare throw what is called life cycle cost analysis. Let us another manager will decision another option could be repair at such a manner, that it reach as you know it follow that path incited of follow this path it reach as follow this path and then last four indented design life.

So, this is service life is related to maintains policy and durability also related to maintains policy. So, 1 can take the policy decision based on durability quality of the material use slate a material which lass for very long white on the beginning it will simple less you know simply last during this period of time. Or you can another material then, which will last for certain period of time tutorage bring it back to original conduction and so on forth.

But both the cases defer, in 1 case initially cost should be high in the case where you have when reputation on the repair the cost initially cost should be low, but maintains cost should be higher. Repair cost should be higher 1 my take a economic decision based on what is called life cycle cost analysis.

Let, the moment economic is not have the business we have try a look in to the durability problem of concrete how durability, how it is relevant. But this is over all relevant of durability maintains policy.

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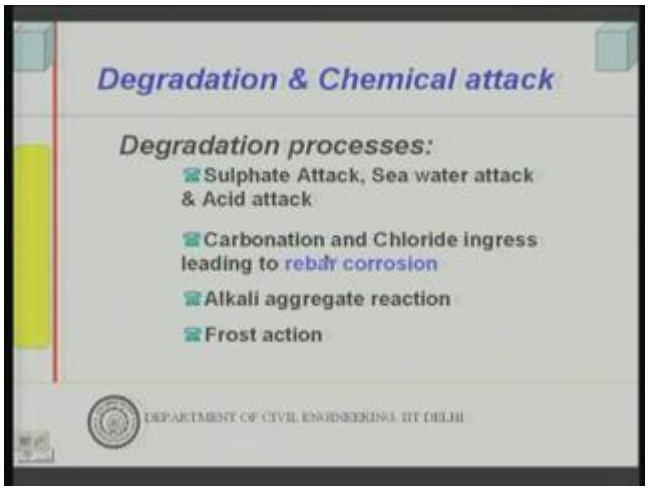

Let us see what is the degradation process and chemical attack that take place in concrete. If you look at the degradation processes discuss all of them 1 by 1. and sulphate attack, then there is sea water attack and see attack. So, concrete attack by sulphate and see that in details sea attack and acid also attack.

Carbonation and chloride these are not realized directly do not affect the concrete, but they effect the enforcement and very major issues effect the enforcement. And enforcement curve as I mention earlier, enforcement normally we use the still you know well of iron craven and steal on various form.

Now, this steal is again produce with expanse of the energy; iron nature is available as iron oxide, iron pirate, you know sulphate oxide from magnetite, hammertoe, whatever there the overseer. Therefore, iron effect in a effect state in never available in nature; in although in steel it is also in some combine for may be in a sea are some other combine, but effect as a high tendency to react to this Oxygen and Hydroxide.

Because, we again a produce from the over the produce from the steel with expanse of energy. So, this have a tendency to actually go back to establish state and therefore, iron in still oxidizes are get cordite. So, every ever cordite actually calculation and chloride in the all the not they not dangers, they are not really a durability problem concrete for say.

But concrete is really use plain concrete most of the time use them as in force concrete or priest the concrete and either case the common enforcing are rebar material is steel the steel corrosion. So, this is another durability problem and in look in to the this also. Then, there are other durability problem has Alkali aggregate reaction and talk of first excellent concrete this is a physical one other are chemical.

Some other degradation process are chemical, some of those are chemical, but they all It all takes place due to with expose of environmental and you know aggressive agent coming from the environment some for other. So, physical this then the can be some other physical also and that is how you know that degradation process. We will discuss the first to toady and the Alkali aggregated reaction will discuss in the next lecture.

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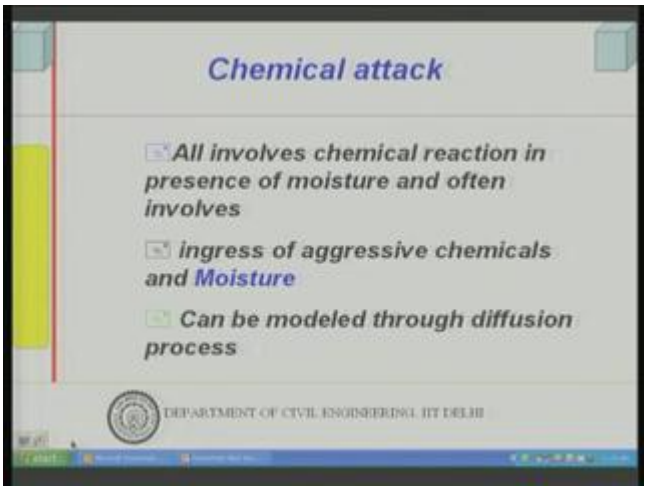

So, let us look at the sulphate attack first let before at understand 1 thing that, all of this degraded some process their physical or chemical generally chemical 1 involve presence of moisture. And also involves of aggressive of chemical and moisture of outside, they can be modeled various diffusion process, but at the moment.

So, we are not interested in the models, but I want to actually high light is the fact that it is the moisture it is the very important and inverse of the aggressive chemical which is also important. So, 2 issues are important the moisture interest and aggressive chemical preset of moisture or water in webworm or liquid form thus most important and it has enter in to the concrete.

So, we will discuss more and in to it later on when you discuss general issues, but less can right now in to chemical attack. If even case of physical frustration in it is again water in guess which is important. So, either physical or chemical role by roll if moisture is very very important in case of due to durability of concrete.

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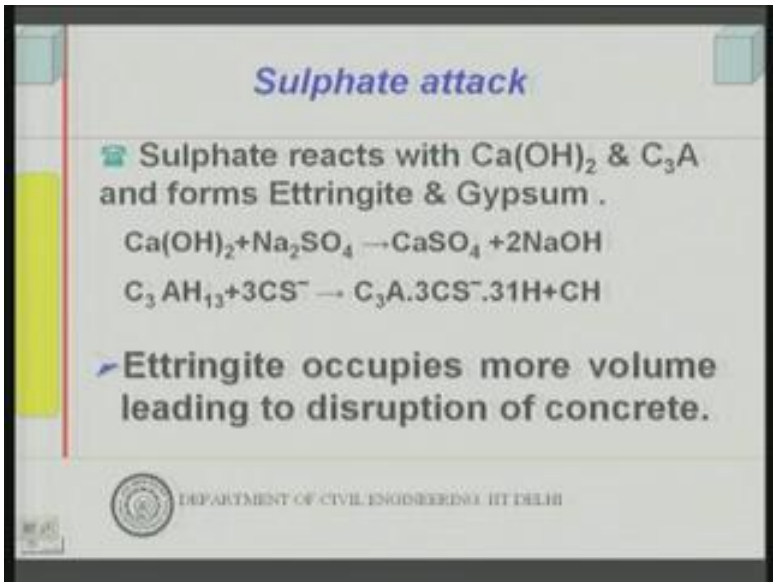

Let look in to some those attacks like sulphate attack, if we remember we added to gypsum to cement in case of you know during is grinding process. And why this is, because to control the setting and when you discuss hydration of cement to set. So, it is the c3 a quickly with gypsum and form it enjoyed a compound it enjoyed therefore, c3 a react to gypsum calcium sulphate forming it Ettringite.

Now, this reaction in the soft past are concrete you know in case of before setting concrete is not a problem at all. Because, in plastic concrete if inject which occupy more volume then the it know it is a reactance that is c3 a gypsum does not create any problem in concrete. Because, this expansion can be accommodate by the plastic concrete because it is the plastic state something a push a material state.

So, it simply the loud a moment its plastics paste in a plastics state can accommodate that at in set reaction that the C3A reaction with gypsum forming it enjoyed. But supposing this is happening in a later date that is, when concrete as harden cement is hydrated concrete harden in to a sallied mass.

The C3 inside they concrete that is the C3 a hydrate present you know, tri calcium eliminate hydrate present in a concrete. Now it react is gypsum or calcium sulphate, forming same it Ettringite and on to you know it Ettringite like to occupy the more volume it will every tendency to occupy more volume. So, what it you do actually exact presser in to the concrete.

So, gypsum reaction in the plastic concrete it control setting, but in the long time it can course expansive presser within the concrete and cross cracking that what a essence of sulphate attack. Let us, see slight more the chemical reaction aspect of it. So, sulphate react it calcium hydroxide and C3A and forms Ettringite and gypsum you see how it is let say the statement something like this.

Sulphate present let us, the sodium sulphate it will react to calcium hydroxide present in the concrete as a result of hydration of cement. We said that, C3 as and C2 as react with what a forming Ch sell structure also calcium hydroxide sodium sulphate react with calcium hydroxide and then this form calcium sulphate and then sodium hydroxide. So, sodium hydroxide permission takes place sodium sulphate.

So, whether the sulphate in sodium sulphate from, in potassium sulphate form, quickly reaction calcium hydroxide from in calcium sulphate, now this calcium sulphate you know remember this calcium sulphate in the return in cement chemistry of revalidated form as this. This CS bar is nothing but you remember you use to you said that, SO3 can written as S bar.

Therefore, when I write C,C is nothing but CaO. So, CS bar is noting, but CaSo4. So, this is calcium sulphate this is same 1 same produce calcium sulphate and this is reacting with try calcium eliminate hydrate this rise to this salt which is called din. So, C3A dot 3CS by you know just set of plus the water which was present forming calcium hydroxide again. This is this give rise to Ettringite to permission the volume expending.

So, you know which occupies more volume this is at Ettringite and it can occupy more volume original volume of the reaction, where something like things like this it 1 to occupy more volume and you have surrounding material all over the place.

So, it will exact presser one two surrounding material and eventually cracking of those surrounding material. That is the cement paste, surrounding cement paste eventually cracking of this. So, it Ettringite occupies more volume leading to disruption of concrete you know there cracking, paling of concrete, concrete will come out that is what is the sulphate attack.

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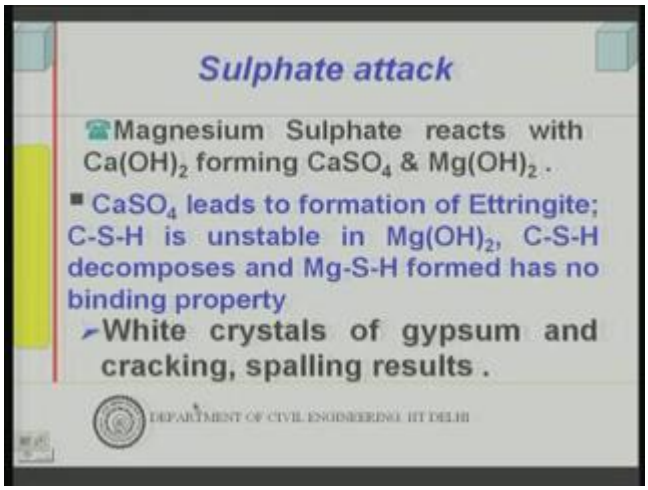

So, if the concrete is expose sulphate environment this will can resulting this where off. So, say containing sodium sulphate, potassium sulphate this can resulting sulphate attack. There can be several other situations where sulphate you know all present and sulphate attack could be there. Now let us, to be the another case sulphate 1 specific sulphate, that is magnesium sulphate is the 1 this reacts with calcium hydroxide from 1 calcium sulphate and magnesium hydroxide.

So, calcium hydroxide concentration reduces and in it form it same gypsum which form then again that form Ettringite write calcium sulphate would lead to formation of Ettringite. And magnesium hydroxide which is present, it case other kind of problem CSH jell talked about the cementing material in cement hydrate that would cementing material in cement hydrate.

So, that is unstable in then environment of magnesium hydroxide in calcium hydroxide environment it is stable. But it is magnesium hydroxide environment in unstable and in it so happens when you have magnesium sulphate present it converse all the calcium hydroxide to magnesium hydroxide. This Ettringite decomposes in magnesium hydroxide environment, resulting in formation magnesium silicate hydrate in long on.

So, this important this is in unstable in magnesium hydroxide environment and finally, this is from and this is got no cementing property. So, cement in present of magnesium hydroxide the cement hydrate in not only a ettringite permission in take place, but at in same time it can also extract it can be extort the C H S structure for the binning property of the cement will be lass.

So, it will be simply you know even know dangerous magnesium sulphate is more dangerous than others. What are the symptoms? The actually see white crystals when gypsum such sulphate at takes place and you have; obviously, cracking, spalling etcetera. Sulphate attack finally, result cracking and spailing of concrete and permission of gypsum power, white gypsum crystal line power you will be see.

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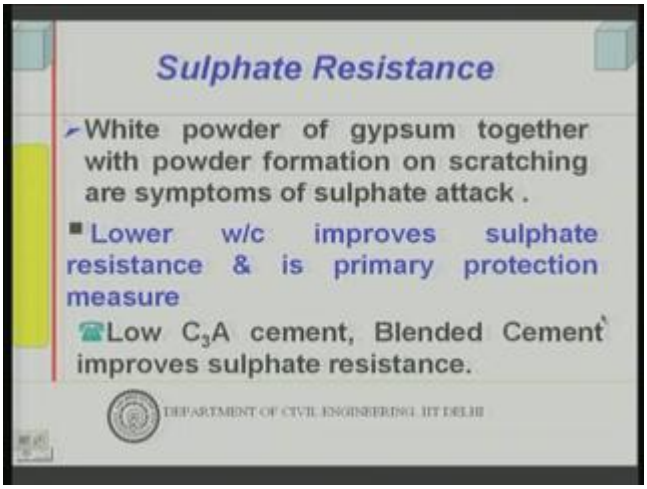

So, white power of gypsum together power permission you know crash. If you crash it for example, cashing simple crashing the surface you will this is surface you crash it find lot of material comes out this is a concrete surface. Let us, say this is a concrete surface this is concrete surface you know and column and vertical surface you crash it little bit you will find just power comes out.

So, this is then white crystal of calcium hydroxide is usually present, so this is a symptom of surface attack. So, it can happen in many places how to protect; obviously, low water cement improves the sulphate in, because I said that penetration is required whatever to penetrated because reaction in take place in solution from. Then, sodium sulphates in solution look in to concrete.

So, if you have water low water cement ratio even have less porosity and therefore, it can improve the sulphate resistance. So, that the primary protection measure, but something more important which cases reaction with the sulphate it is a C3A. So therefore, C3A cement high C3A cement would have higher sulphate attack tendency to sulphate attack, less resistance again sulphate attack.

But low C3A cement will show better resistance to sulphate attack and blended cement improves sulphate resistance right. Blended cement means, we said that and also any blended cement, because it is reduce down the C3A and lower down the C3A by dilation effect. So, you know it will reduce down the C3 accounted if you are using the some percentage of blending material blending other material.

Obviously, reducing profession C3 reduce some of them make it in formable, very informal relative more in formable as cement hydrate to observer. So, earlier discussion with respect to cement therefore, it is improve the sulphate resister.

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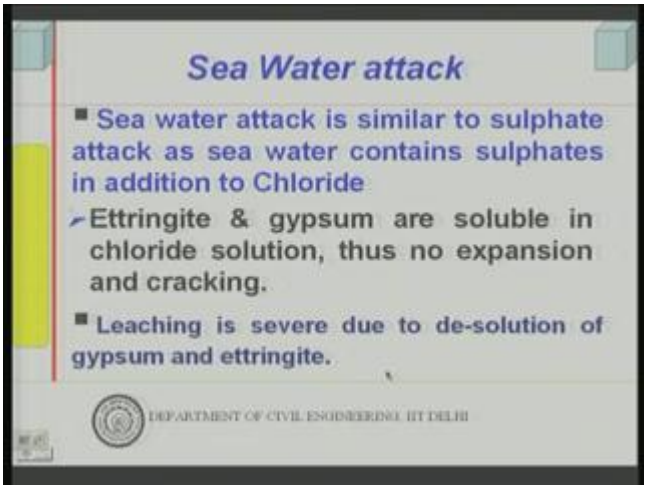

Let see to the next sector: Sea Water attack .So, what Sea Water contains? Sea Water contains sulphates as well as chlorides. So calcium sulphate , sodium sulphate present in to sea water at in attention in what sodium chlorides etcetera. So, chloride and sulphate both at both are present.

So, now same sulphate means it will form it Ettringite and of course, calcium sulphate permission will take place. But the expansion and cracking does in result the reason is it Ettringite gypsum are soluble. There are soluble, this as soluble in chloride solution thus no expansion and cracking. Since there are soluble Ettringite soluble moments it is found in a more soluble in chloride solution in Sea water.

So therefore, there is now expansion and cracking it has dissolved it has dissolved right. But what happens this will resulting leaching, it will dissolved it get dissolved, which form is dissolved calcium sulphate which is called a dissolved. Therefore, this will get

leached out this will get dissolved and you know taken everybody the sea water. So, leaching can take place and it can be severe.

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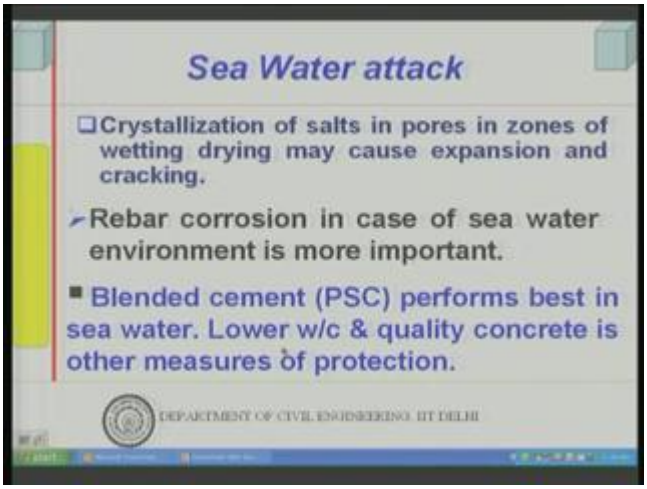

So, de solution Ettringite and gypsum are case severe leaching case problem because leaching case problem. Because, more sea was penetrate and therefore, it is a kind of you know non liner effect leaching other sea water penetrate leaching and so on so forth. So, where there the wetting and drying the zones, where the wetting and drying place crystallization of salts can take place in the force at found.

Because, now there is leaching there as sufficient leaching and law force and original, if there are force there will be now more force. If it in the wet and wetting and drying zones that is between in the highest water level on the lowest water title water level. In sea they what will happen, some the salt in get inside pole and what are the. And crystallization of salt can actually exact presser on to the concrete structure.

So, this may case expanse crystallization of the salt within the pore expansion and therefore, cracking. This happen between in a way zone were wetting and drying, where take place and not of course, completely serve much situation. But more importantly rain enforcement take place, because we said the chloride do not attack concrete for say, but chloride actually initiate corrosion process are steel in concrete.

So, if the concrete become pour as more chloride can penetrate and reach to the river level and it can initiate river corrosion process. So, initiation of river corrosion is possible and thus more dangerous right. So, this is importance sulphate it issues a discuss

rivers corrosion will come to this little bit later. How can be improve you know resistance second you know sea water?

Blended cement sulphate resisting cement really do not help much here, because sulphate things here can prevent the sulphate attack. Attack again when as sulphate persistency water, but it has another side effect is you does not help again in chloride, rather it reduces what more as chloride binding capacity of the concrete. Because it is C3A which can bind some the chloride chemically and would not allow reaction in the chloride to proceeds initiating enforcement corrosion.

So, when you reduce from the C3A in sulphate resisting cement this is not very helpful chloride attack chloride interest and river corrosion due to chloride. Therefore, sulphate resisting cement is not a good solution as a sea water is consign. So, sea water attack 1 can it can resisted by port slape cement this performance best in sea water. And obviously, lower water cement ration is lower quality concrete is other measure of production. In fact, to see this time and again lower water cement ratio and quality concrete is the more important future as for as durability as concern. So, this will discuss in more details some time later on.

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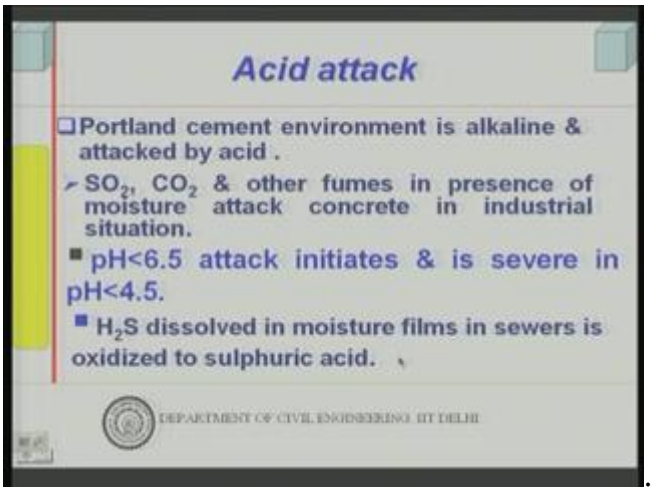

Let us see a acid attack Portland cement is alkaline and therefore, will be attack by acids, because any alkaline material is attacked by acids. So, sulphur dioxide and carbon dioxide and other fumes in presence of moisture attack concrete this is case in industrial

situation. Because, sulphur dioxide and carbon dioxide they can react with water forming sulfuric acid or carbonic you know then of course, sulfuric acid when it get oxides.

So, carbon dioxide react with water forming, carbonic acid, etcetera etcetera. And they can attack the alkaline material in concrete namely calcium hydroxide, sodium hydroxide etcetera sodium potassium hydroxide and you know industrial situation may other fumes are there fumes attack the concrete. Below pH 6.5 attack usually initiates and severe in below 4.5. Now, this result in what? This result in result in actually removal of lot of material from the concrete.

Because, it is attack in those material will be you know the leaching lot of action would be seen lot of material will take up of. 1 special case is H2S in the s shiver line this when it dissolved in master film since ours and then oxides from sulfuric acid, when shiver at the point of a low water level to high water level. So, you can have again talked to sulfuric acid which form due to solution of H2S in the master films and then further oxides of the product.

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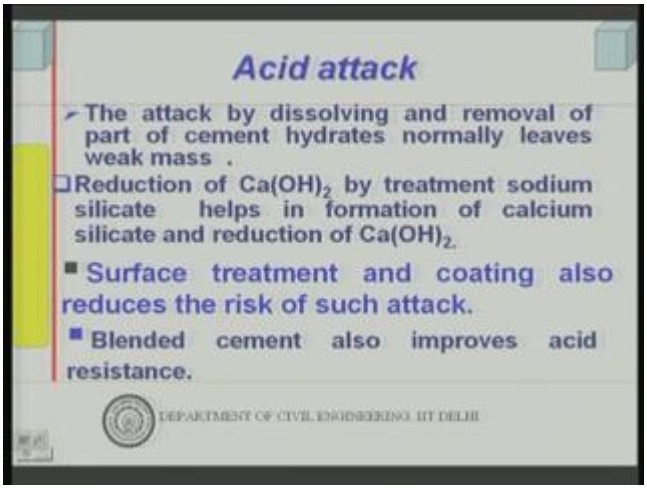

This attack what to does, is to dissolve and removal of part of the cement hydrates normally leaves weak mass that what it is you know. Because, it is should actually attack can I material in concrete and remove those salt, those inform and leaves finally, weak mass.

So, that is the result of acid attack highly prevent, when reduce of calcium hydroxide if in case in some case treatment which sodium silicate calcium formation of you know

called silicate water glass. Sodium silicate treatment of sodium silicate helps in formation of calcium silicate reduction of calcium hydroxide. So, you can actually use sodium silicate and form calcium silicate within the force if required and that in a acidic environment.

If we say is the concrete is like due to be in acidic environment, you treat the concrete wise sodium silicate or what is called water glass and this will actually form helps in formation of calcium silicate and reduction of calcium hydroxide. But other solution should be obviously, as I set low water cement ratio is very much there, it could be there and also quality concrete right.

So, this could be thing blended cement they will be also other important means of production as usual see. So, something else we can do some case in specific case where high acceded that is actually emissions thing there is a possible to high acidic attack. Environment is highly take, you will have to surface statement is quoting and various kind of surface.

To statement may be quoting lining, statement they where it is of treatment for available for surface you can give some quoting are short of rendering thick plaster of lot of things. And there are other kind of surface statement 1 can provide may be a between as proxy such material and they can actually provide production again acid attack.

So, I said blended cement you know it will also improve the resistance again said it acid attack. Because, the blended cement would can consume good lot of calcium attack. So, there by acid attack can be reducing by it also make improver, so this is can produced again acid attack.

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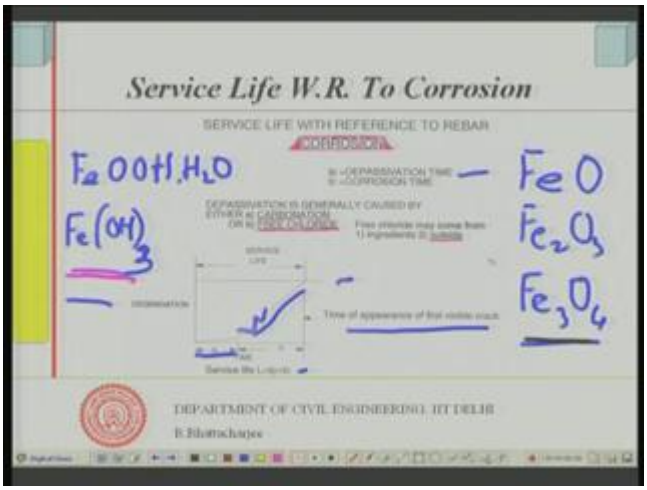

Let us now to the phenomena service life with respect to corrosion W. R corrosion next can be attack is river corrosion. And we define it slightly different manner then, we have defined earlier for general you know definition of service life. Here will see, we define service life in to segments first is relatively less loop portion then a repeat loop portion.

So, when a normally cover concrete is support to provide production to the rain enforcement bar, by not exposing to the environment. Therefore, you know steel is put it in to the environment mass to especially mass in oxygen available environment are marshal oxygen is available corrosion procedure. But then cover concrete in force concrete is suppose to that produce to the rain for cement bar.

Now, if the cover concrete is self innovate didvoriate are allows something to come in such that, the production it was providing is not a available any more then corrosion install. Then, it such way are the 2 faces: first face is actually concrete itself is decorating is the same that it was production it was able to provide the rain enforcement its that capability is lost. And 1 that is lost actual corrosion start which also could possible non you know short of varying like this.

But to a approximate it is the liner line this is 1 short of notional understanding. So, service life with respect to with corrosion is 2 faces: the first face were concrete production provide by the concrete will be last that we call as Deblesivation period time. You know this is we call as this preservation time then, second period we call as corrosion time during that period.

Since the production is lass now, the corrosion will start and corrosion will continent. So, corrosion time some total of service life is the dp plus you know dp plus dp plus some total gives the service life. So, this is what you see is the some total of this 2 with respect to corrosion you know service life what is the serviceability limit we define?.

Serviceability limit is define as the crack first peaceably crack that is observed in the surface on the concrete So, this line represent appearance of first feasible crack now, how does the production given by concrete is loss? Well how does first 1 when look in to how does concrete provides the production? As a mention to earlier steel of the iron in steel has tendency to come to establish state.

So, it will get oxidize it will have the tendency to oxidize and this tendency will cannot introduce. But what can we reduce, the reduce from the rate at it will can oxides and this can accrue when peek of the concrete is high this is 1 issues. Second aspect is, this this production is provided by formation of some oxide here; power the steel. You know the oxidation we cannot stop, but all oxide of again all dangerous are no detrimental from the point of view of is performance.

So, you know you can still perform even some oxide of form so along as the oxide those the form iron oxide which the form ever the steel bodies do not consume. And not a very fast rode or does not occupy large volume, along it occupy less volume does not occupy large volume compare to original volume in the steel it will not exactly any presser as use we will see later on in one of the those slides you know action of blasting.

So, when it exact the product occupy large volume compare to the original volume to steel it will exact presser to concrete and concrete. But it is does not occupy large volume in otherwise, density of the produce of lasting in nearly are same are closing to density of the steel itself then it is not a problem this is 1 issues and second issues try should slow.

So, iron oxides a FeO Fe2 O3 Fe3 O4 this oxides form oxide is black crossed. And this black color and not so dangerous, because they do not occupy large volume compare to the steel. But if a produce like this is form, if I may write it in on other way as Fe OH3 this is called red trust. This occupies 3 to 4times, you know it is occupy 3 to 4 time more volume in the original steel is called ret trust is a black rest, this red rust.

So, red rest occupy more volume than the original steel and this is dangerous is not dangerous, because dose not dangerous more volume. Now, the original steel does not exact presser on to the concrete. So, if this forming I am not really worry and this coating when it is forming it actually know as de perseverate the steel; resulting in deduction of corrosion rate.

So, inner in sudden environment still de perseverated when peek of the concrete of high concrete surrounding are the material in the force surrounding the steel bar when speech is high then, it cannot depreserved. In some such situation black rush, but is lower speech red surf form.

So, it get speculative can black rush in form and if some means if you know ph of the concrete force solution ph of let us, say water around the steel bar is lower down when red rest formidable start. That we call props call depreciation passive film formation Fe 3 of 4 etcetera balk rash for fuci film when it is break and down depreciation. So, depreciation take place at 2 are ph now concrete normally will be high ph.

Because, calcium hydroxide is a sodium and potassium hydroxide are also will be there they mention a high ph concrete. But which time, if the carbon dioxide from the atmosphere you know common relax with the react with the calcium hydroxide present in a concrete forming calcium carbonate that process is to redaction into ph.

And you know the process is carbonation, because we know the carbonation in the contest of linkage and also in the context non to of testing look at in more detail. This corrosion can reduce on the ph of concrete and other agene we can accelerate the carbonation process depreciate this breakdown the pace film, of pace layer of black rest is called is chlorite free chlorite water saleable chlorite. So, this 2 agene can actually breakdown it can actually lower down the preservation or breakdown the perseverate of concrete depreciation.

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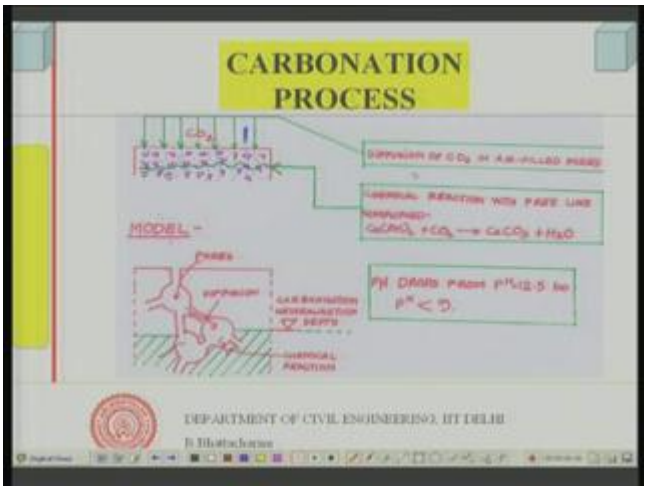

And then corrosion let see, the carbonation process if we see the carbonation process carbon dioxide at the atmosphere you know enter in to the concrete as you see, throw the diagram carbon dioxide can enter throw the concrete. So, carbon dioxide actually diffuse. through the air fill force and then the chemical reaction with the you know with the lien calcium hydroxide present in concrete text place.

Now, why does the line come from transform the hydration of cement we know that C3 as and C2 as when it to x with water it form to line. So, this line reaction carbon dioxide of that atmosphere, but this all happens in the person of water. If there is no water reaction will not precede and from calcium carbonate and again water and this process call as carbonation.

So, this chemical reaction we call as carbonation and this carbonation result in formation of calcium carbonate, calcium hydroxide in to calcium carbonate. This knows voluminous, this does not occupy more volume this does not occupy more volume. So, does not cracking a of the concrete infect if forms a hard mass. So, if the carbonation front as reach up to this it will form a hard mass up to this.

So, carbon dioxide for it wise for surface first the surface concrete will get carbonate; that means, calcium carbonate calcium hydroxide at the surface will get come border into calcium hydroxide of surface will get calcium carbonate. Once lot of carbon dioxide will inform, carbon dioxide actually diffuse throw the layer of carbon dioxide and then carbon dioxide you know reaction will precede below that layer of carbon dioxide, calcium carbonate.

So, carbonation front as we call it precede within from surface to inside of the concrete and this is where up to this actually carbonation front now reach. There which reaction continuous of course, we are intermediate reaction because normally there are a sodium hydroxide reacting with the carbon dioxide from a sodium carbonate then reacting with etcetera.

But final product is like this and this cause redaction ph of the concrete, because in it can when it consume all the hydroxide present in the concrete or all the alkaline material in the concrete ph of the concrete will come down. And this process last down the ph and passive film, which was there if the when the page will become below 9 passive film can get actually depreciative.

So, ph of the force initially was around dual 0.5 in concrete and even high 12.7 and 12.8 very close to 13 right when it is comes down. So, right what you know in the force these workers actually carbonation workers, what are the essential requirement water must be present here. Because, reaction process in water of course, present of carbon dioxide is must and carbon dioxide is must in the air present of both water and air is must.

So therefore, this reaction precede when this force are actually mass force where as master as surfaces, but air is available you know air is available both air is not fully if it is fully saturated total wet concrete then combination will not precedes. And if it is carbonation will be precede, so that is the carbonation process of this reduces on the ph.

Now, in the next class we shall look in to continue from in the first up all carbonation to chlorite interest and liver corrosion. Now, how you know can you stop this carbonation process actually the permeability of the concrete in the surface is most important. If you concrete is important in formable then in formable in corrosion you know carbonation process cannot procures. It has to be partially saturated nor fully saturated, so inferable concrete is very important and of course, alkanet is very important.

So, this is a actually reduce on the carbonation process remember the carbonation process for say not a problem. It can causes on error in understate testing, but harm a hard mass is a strong mass. And again it can actually cause alignment of string case in some cases, but does not crate in any problem otherwise, but it is can lead to process of correction in station.

Now let me, summarize just here today because the process would continues will discuss the carbonation process it production. Then, look in to chlorite interest an interest of chlorite interest and river corrosion process together alkaline aggregate reaction and protestation in the next process. Now, overall summarize the whole process together in the next class.

So, what you have look toady look in to what you mean by durability definitions of service life, then we look in to what are the possible process throe actually corrosion may know titration of concrete text place. Some processes you have try look in to the rest of the process then we look in the next class.

Thank you.