Concrete Engineering and Technology
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Lecture - 38
Considerations in repair of concrete structures (Part 2 of 2)

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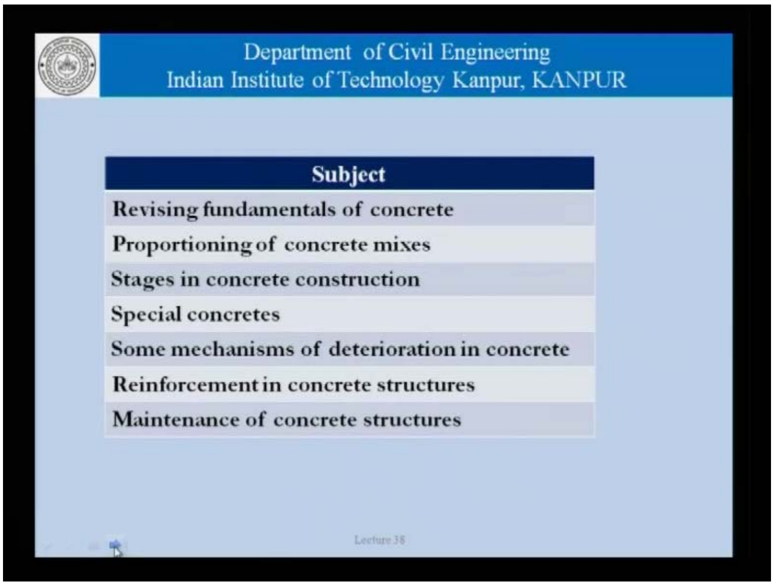

[FL] and welcome back to this module of lectures on concrete engineering and technology. We are trying to revise fundamentals of concrete, proportioning of mixes, stages and concrete construction, issues in quality control, talk about special concretes, some mechanisms of deterioration, reinforcement and concrete structures and maintenance of concrete structures.

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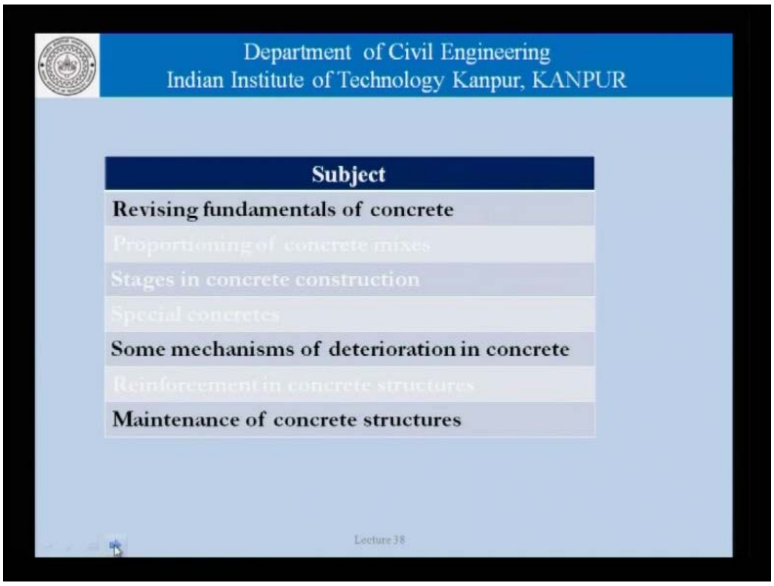

In the last discussion, we were talking about a subject expanse, fundamentals of concrete design in fact the principles of all structural design is matter of at mechanisms of deterioration in concrete and maintenance of structures.

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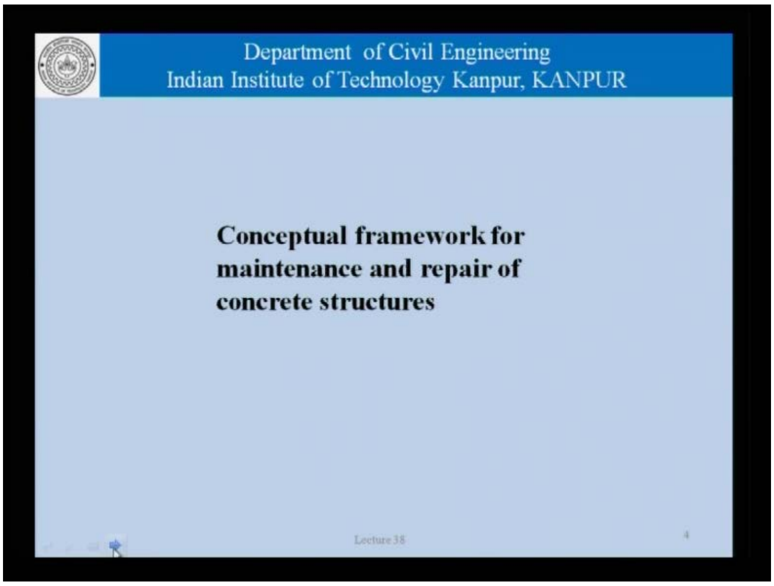

What we were talking about was a conceptual framework for maintenance and repair of concrete structures.

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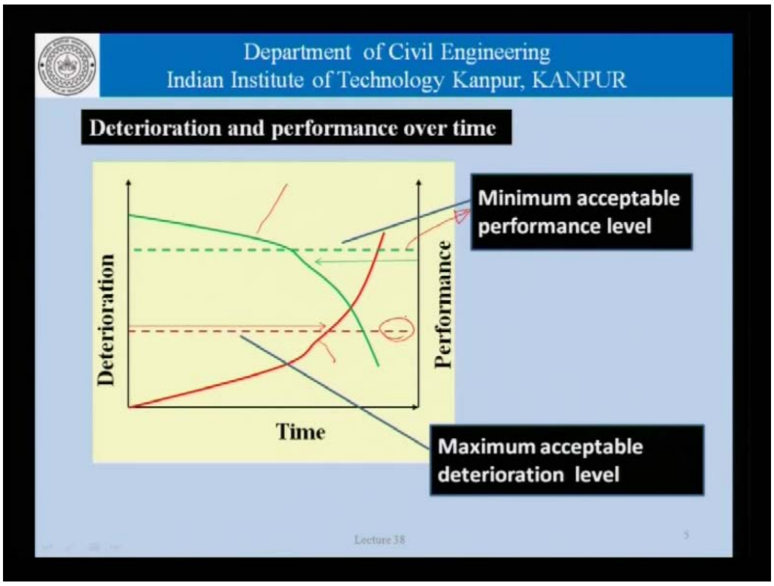

So, recapitulate what we were trying to do, we had studied or looked at deterioration and performance and how they change overtime. So, this here is the variation of deterioration as gradually the structure is in service for along there long in time it deteriorates.

Corresponding to that deterioration the line here shows a change in the performance, initially the structure forms very well and as the structure ages, the performance tends to reduce or degrade taking this changes in mind this green line here is the minimum acceptable level of performance, and this red line here is the maximum acceptable level of deterioration, and depending on how we want to define the concept of service life we can say that the service life is reached once, either the deterioration exceeds the maximum permissible limit or the performance falls below a critical minimum acceptable level.

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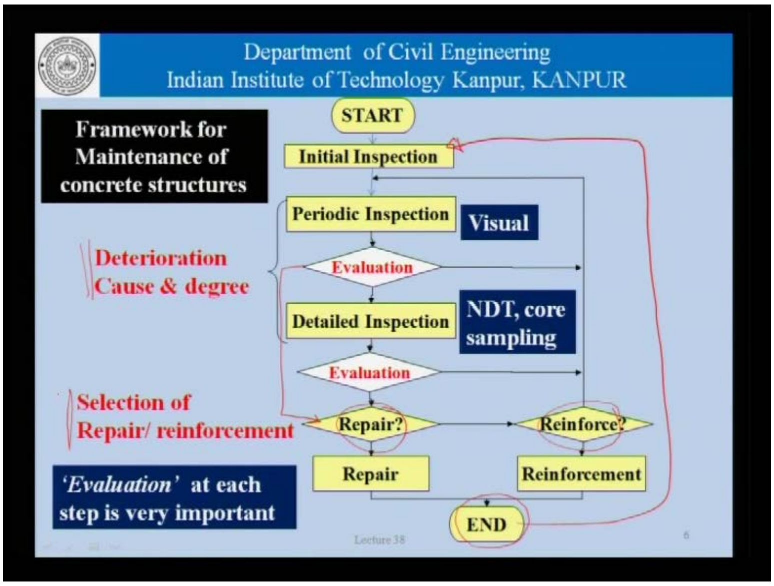

Now, how do we define these levels and what quantitative parameters that is left to us, we could choose parameters such as deflection for performance, we could choose cracking for deterioration chloride penetration for deterioration and so on. And so forth so as a concept this is what we are talked about when we talked about in service maintenance of concrete structures. Extending this concept for the we discussed the issue of inspection which involves determination of the actual state of the structure from the point of view of either deterioration or performance.

So, once the structure is put in service or just before it is put in service there is an initial inspection followed by periodic inspections, and at the end of which we need to carry out an evaluation process, and the side what we want to do, either reinforce this structure or at the end of any stage, we can decide to repair the structure this could be followed by a detailed inspection, which again could lead to a repair or a reinforcement and at the end of the cycle once we if carried out repair or rehabilitation.

We really go back to an initially inspection and see whether, the work that has been carried out is satisfactory, and what is the step or what is the state from which the structure is starting a fresh. While we are talking about this we also talked about the need to understand deterioration and its causes, when we carrying out inspections and they importance of selecting repair and reinforcement measures, when we are carrying out repair and reinforcement.

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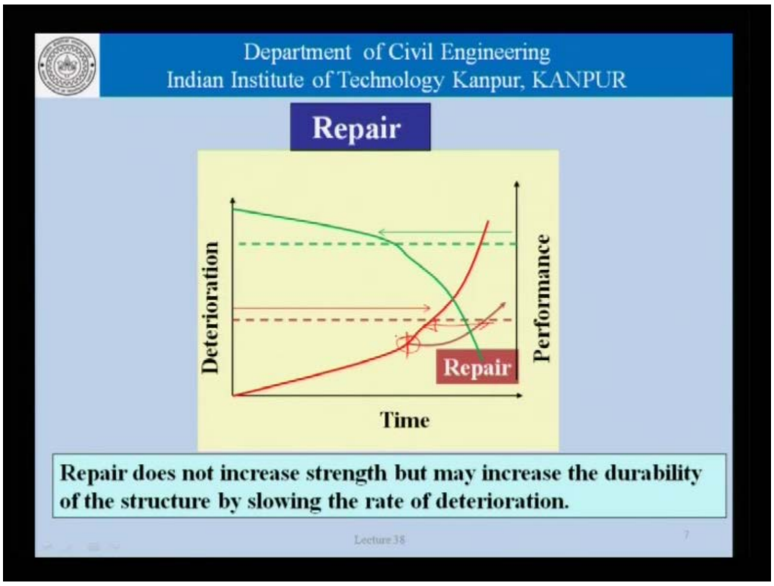

And of course, the issue of evaluation which is really adjustment or decision making processes which is involved at different stages two help us determined the next step, have carrying this forward we try to define the concept of repair in terms of a maintenance action which may not increase or improve the existing state of the structure but, increase the service life that available to a by reducing the rate of deterioration that is occurring at that point in time.

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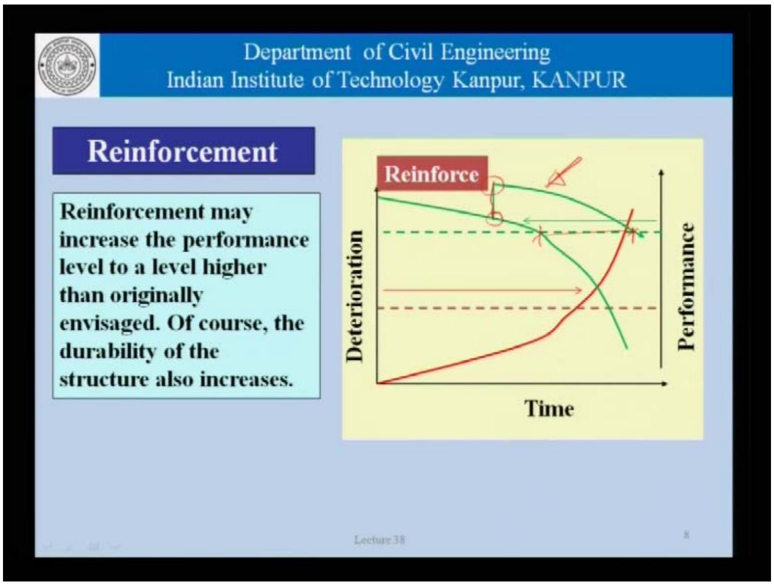

So, if we are intervening a this point in the structure we have increase the service life by reducing the rate of deterioration or rate of further deterioration. Similarly, as far as reinforcement is concerned if we are intervening at this point and time we may actually improve the performance that point and time and how this graph that is the post reinforcement change in the performance goes would depend on the nature and the efficiency of the reinforcement work. So, we have increased the service life from this point to this point because of reinforcement action.

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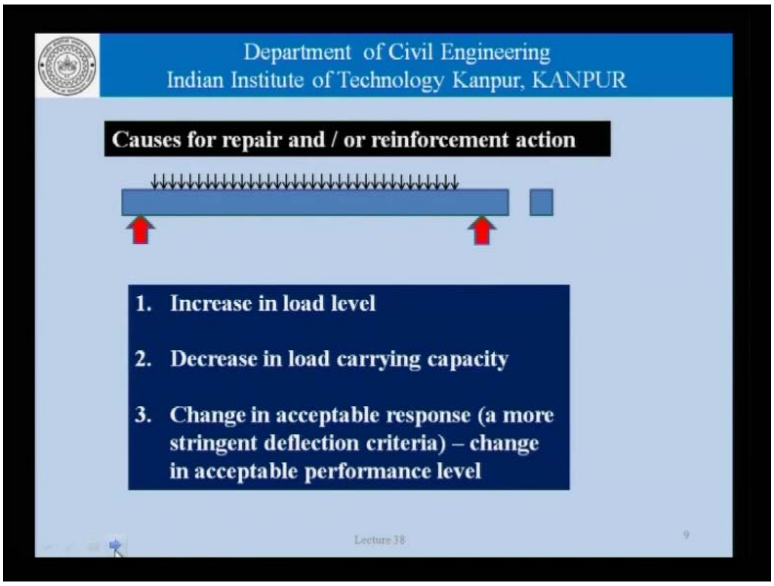

So, this what we are talked about last time, we are discussed is some detail the causes for repair in reinforcement action considering a simply supported being like this one of them could be increasing the load level which in civil engineering structures could arise out of changes in the axle load in the frequency of loads and so on.

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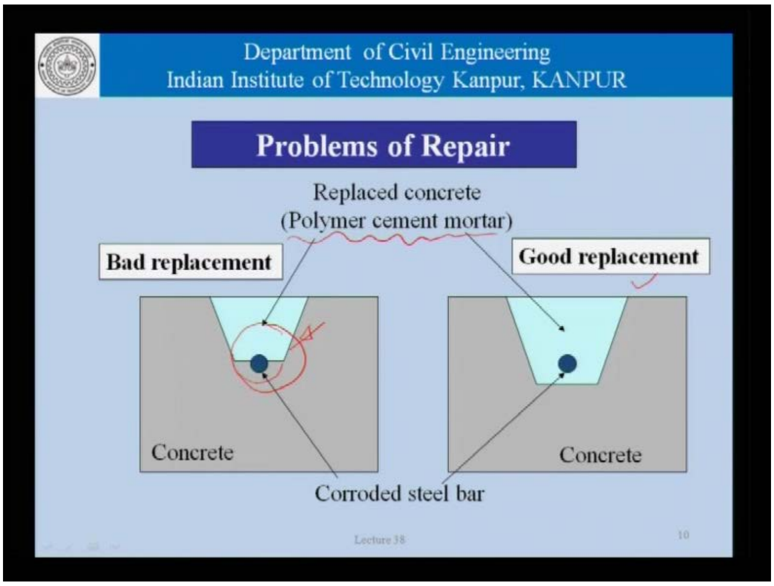

It could be in the decrease the load carrying capacity of the member or the structure which is how the deterioration in properties of the material manifests itself, and there could be changes in the acceptable response or the change in the design criteria acceptable deflection for example, changes in the load factors and so on.

We are talks about some problems in repair, we are talked about a bad repair in which case we had seen that the repair material for example, polymer cement mortar is placed in s structural like this without removing all the concrete from behind the deteriorated reinforcement bar, which is what this done here as good replacement and a replacement of this nature or repair action of this nature does not necessarily mean that the a structure will not corrode in the future. So, corrosion or such problem could manifest itself very quickly after the repair work has been carried out, if the work is not done properly.

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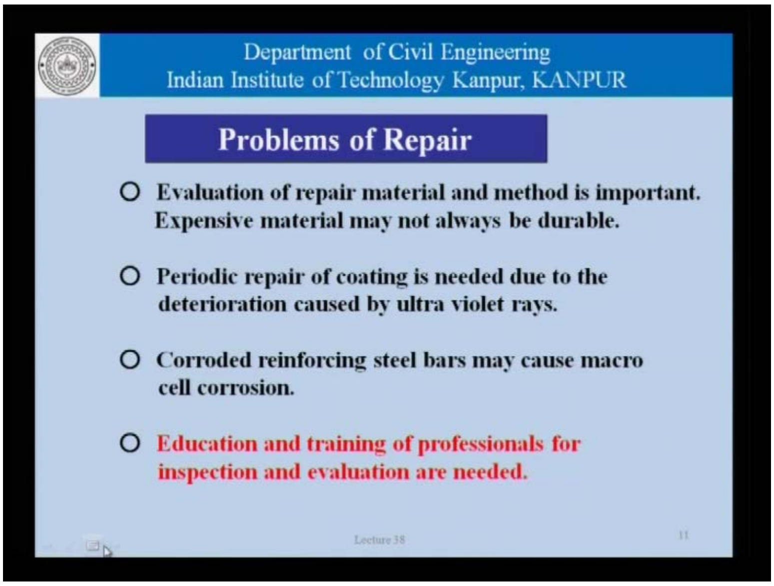

We are talked about the need to evaluate repair material and the method it is not necessarily that expansive materials are always more durable. We are talked about periodic repair of coatings because those coatings could be deteriorated or could lose their effectiveness on account of deterioration by exposure to ultra violet rays in cases of corrosion.

We have to be careful about macro cell corrosion being initiated, and we have talked about macro cell corrosion going to talking about deterioration in concrete structures on account of reinforcement corrosion, and the need for education and training of professional for inspection and evaluation of concrete structures, which is a professional job just cannot be done on in [adobe] manner.

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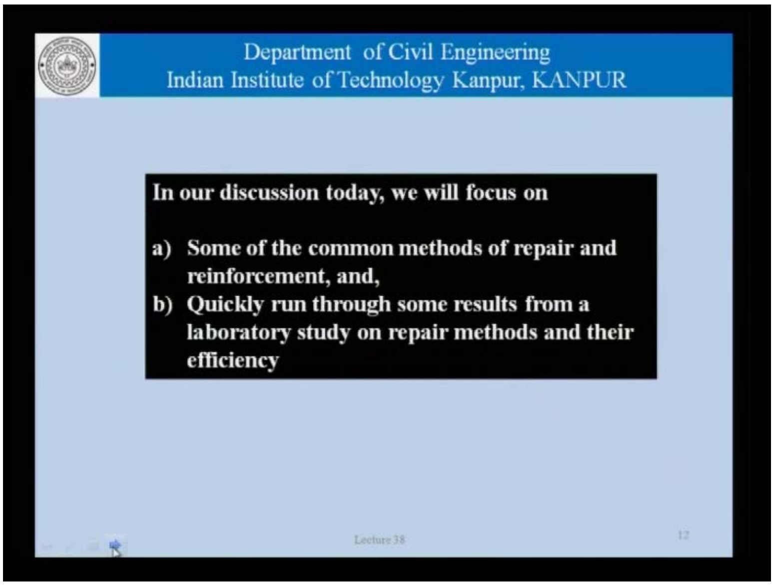

So, now coming to what we will talk about today, we will really focus on some of the common methods of repair and reinforcement and we will quickly run through some results from a laboratory study on repair methods in their efficiency.

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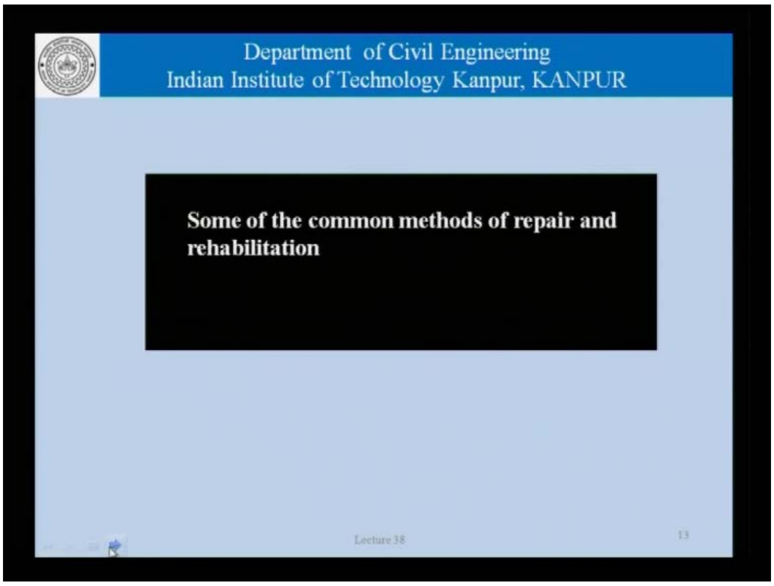

Now, coming to some of the common methods of repair and rehabitation, the discussion here is more in terms of introducing the repair methods rather than going into the details of each of these methods, and I would like the listeners and students who are interested in this subject to actually go through the net and some of the variable literature.

Which describes each of these process is in much greater detail and that perhaps not required, when we are talking about the general principles of repair in reinforcement of concrete structures that two within a framework of operational maintenance and so on.

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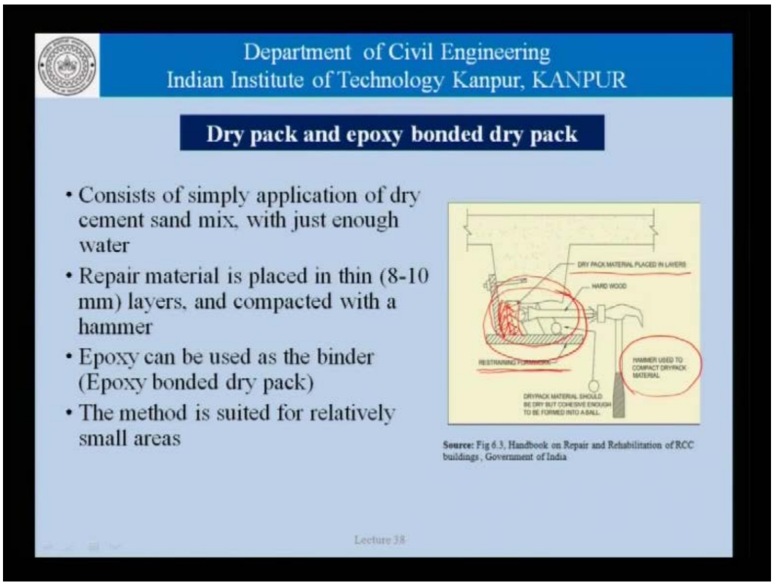

Now, coming to the first such method that we talk about is the try pack and epoxy bonded dry pack. Now, what is done here is that we have a situation here or a portion of the structure here which needs to be repair so what we put in place is a restraining formwork and we try to pack the repair material in layers.

So, we put this layer first followed by another layer after that and so on, and this compaction is carried out using a hammer so that is the manual method for placing compacting and ensuring that this part of concrete, which had been removed or which had to be removed on account of some reason is now replaced by another material.

Now this material could consist of a cement sand mix which is basically cement mortar. We just enough mortar, so it is basically a very dry mix because the compaction that we are doing is with the hammer and that we can obviously do only if the mixes dry and as we said the repair material is placed in thin layers, and compacted with the hammer instead of a cement based binder. We could also use a epoxy based binder in which case what we would call this method is epoxy bonded dry pack and the method is obviously suitable only for small areas, and susceptible to changes in the quality of the work done depending on the work man involved because all the operation is are is strictly manual the mixing perhaps the compaction is completely manual and so on.

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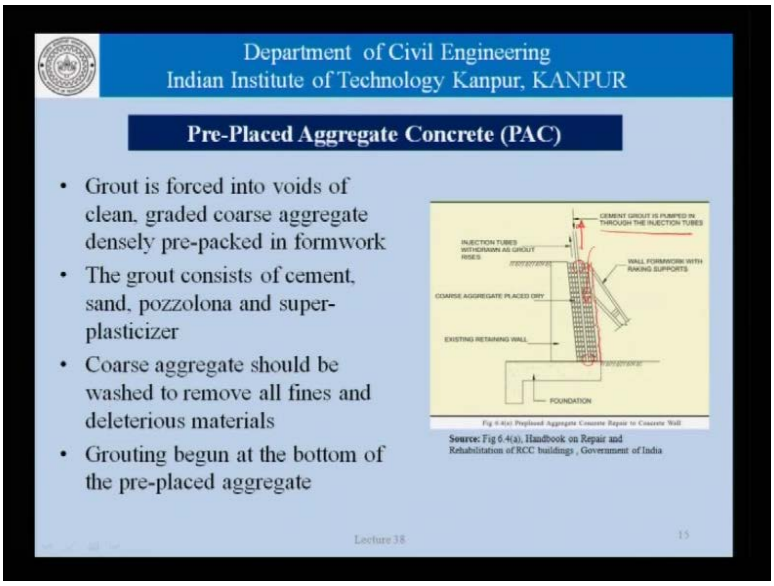

Coming to the next method, we have preplaced aggregate concrete. Now, this is another method where of formwork first as shown here pack this space with gap gridded course aggregate compact the aggregates and finally, inject cement grout through pipes or tubes which are going to the right to the bottom and gradually with draw the pipes as the grout rises in the pre placed aggregate.

The advantage of this method compare to using simply concrete to begin with would be that we do not really need to compact the concrete it can be done in sections where concrete cannot be placed and compacted.

So, we can use course aggregate fill that space with course aggregate and add the grout later on there are basic differences between pre placed aggregate concrete and normal concrete. The way pre placed aggregate concrete has been done as you know would involve aggregate to aggregate contact which is not necessarily true when we are talking about normal concrete construction.

Similarly, the tradition of aggregates that is used should be such that it facility its or allows the movement of cement graphs, we need to engineer the properties or determine the properties of the grout that will be suitable for a particular application depending upon the maximum particle size and the particle size distribution which would essentially control the void geometry of the compacted cores aggregates.

So, grout is force into voids of clean graded course aggregate densely pre packed in form work it consists of cement sand pozzolona and supper plasticizer course aggregate should be a washed to remove all fines and deterious materials and grouting begins at the bottom of pre placed aggregate. Obviously, we cannot start the placing and grout at the top and hope that the grout will simply flow down its better to start from the bottom and then go up gradually.

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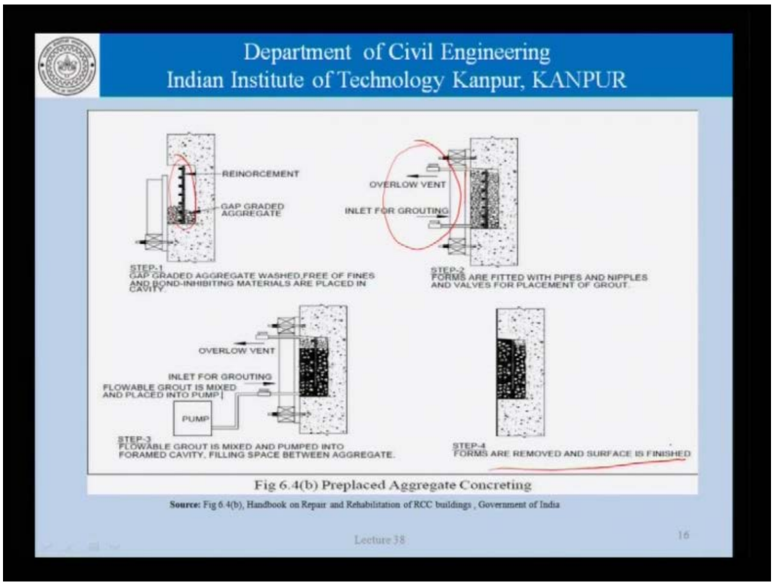

These are some more pictures from preplaced aggregate concreting operation. The first step is to fix the formwork, and they did aggregate washed free of fines bonding materials placed in the cavity. We could use reinforcement here if you want followed by form of fitted with pipes and nipples and valves for placement of the grout.

So, all these paraphernalia is added with this system, we can close the system completely which we cannot do when we are trying to place concrete in the cavity like this is step three, would be flow able grout is mixed and pumped into the cavity formed feeling space between the aggregate. So of course, we have to have a vent through which the air is allowed to escape and finally, the form the removed and the surface is finished.

So, much for the pre placed aggregate concrete operation we can imagine that an actual placement of pre placed aggregate concrete would be a lot more complicated, and the quality control even more so because we need to understand the void geometry, we are need to understand the void configuration for a given mix of aggregates and we need to choose and appropriate grout from the point of view of viscosity this aggregation bleeding strength and so on.

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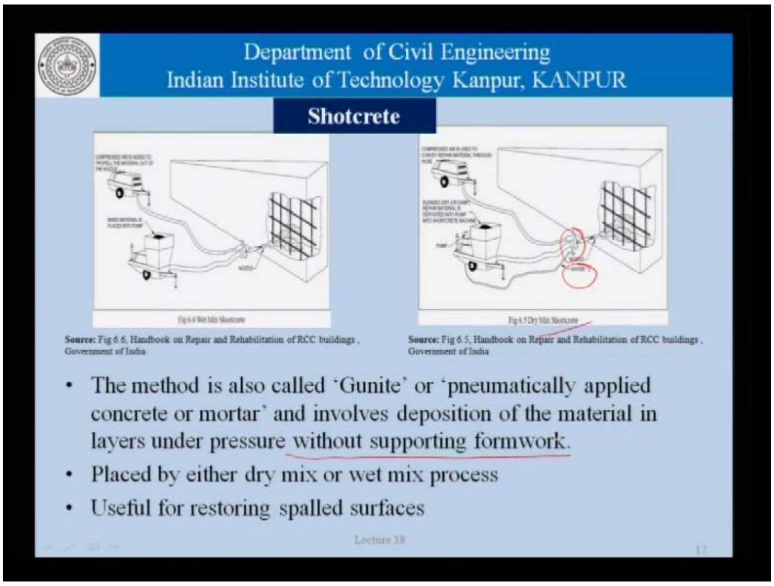

Continuing our discussion with methods of with pair shotcrete is another candidate and we have talked about it earlier, when we are talking about special concrete were could be wet concrete mixes wet mix shotcrete and dry mix shotcrete in the dry mix shotcrete the water is added just before the material is shotcreted on to the surface.

And, the method is called also guniting or pneumatically applied concrete or mortar as it involves deposition of material in layers, under pressure without supporting formwork, and this part limits its applications. Of course, is a require material as a repair method is a very powerful method because material can be deposited in layers.

It can be done by the dry or the wet mix process and the method is particularly useful for restoring spalled surfaces if we have a surface we are the concrete is really fall enough then shotcrete and organiting or placing concrete under pressure is a very viable alternative this is quite different from having to place the concrete manually in that area.

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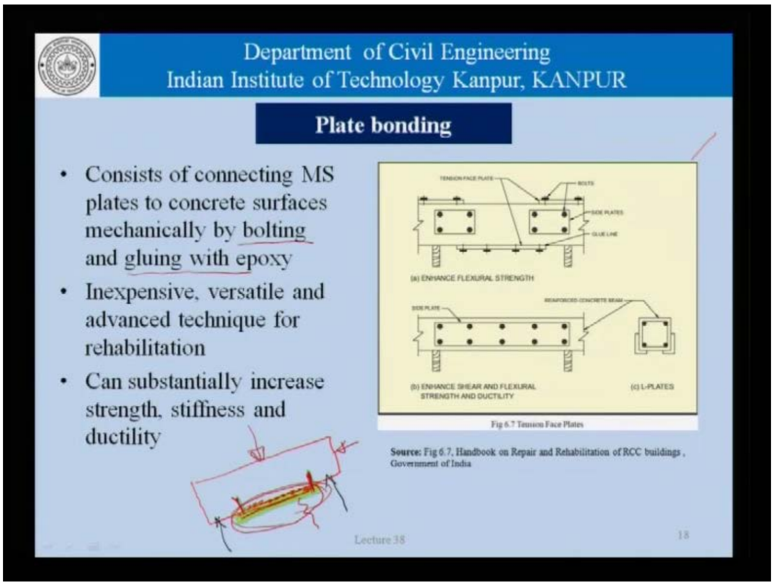

Now, let us talk about another method which is quite different and that is played bonding, now this consist of connecting mile steel plates to concrete surfaces mechanically by bolting or glowing with the epoxy as we can see here in this picture fixing a plates on the concrete surface would enhance the flexure strength and the plates can be held imposition by either bolting them to the concrete or fixing them using an epoxy.

So, what primarily is being done is that we have what we have in this method is that if we have a concrete beam which has deteriorated, what we want to fix is mile steel plate here and then if you apply load on this beam this plate takes all the tension. So, this increases the load carrying capacity of the repaired beam now what has to be ensured in this process is that this plate is properly held into position either by glowing at the concrete surface or by appropriately encoring the plate into existing concrete and that is what is mean by saying bolting or glowing with epoxy and we have a steel plate which has been placed here for the tensile face we can place these plates even on the shear faces and so on.

This is an in expansive versatile in advanced technique for rehabilitation except that we should know how to design this method we should know what is the kind of plate to be used what is the size of the plate what is the size of the bolls or what is the kind of epoxy or glue which is to be used at the surface in order to ensure monolithic structural action but, it can substantial increased strength is stiffness and ductility of the repaired structure, we could even use l plates if we want to use in a beam or column.

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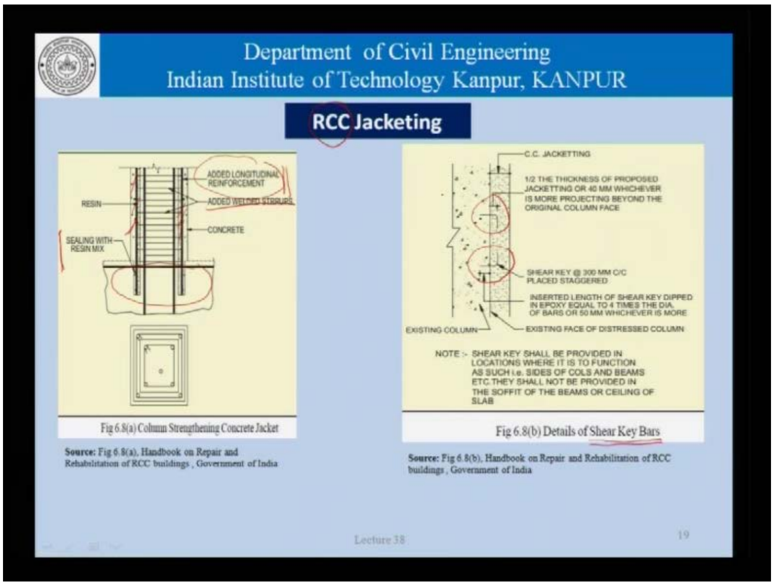

Now, let us talk about jacketing jacketing really means in existing concrete around which fresh concrete is flexed. So, that is a concrete jacket we call it RCC jacket means reinforce cement concrete jacket is placed around in concrete, which could have deteriorated in which case it could be a repair action without an intension to increase the load carrying capacity or the performance of that column or the structural remember or it could even be a reinforcement step where we want to actually increase the cross section of that particular structural remember.

So, what is being done is that we add strrups which are welded we add longitudinal reinforcement and this longitudinal reinforcement is anchored in the existing concrete somehow with a rayson mix and we finally, concrete the outside surface and this can be done either by normal concreting that is placing the formwork and poring the concrete compacting it and so on or it could be done by shotcreting or it could be done by pre placed aggregate concrete the idea being that there is reinforcement outside an existing structure and a concrete covers that we increase the cross sectional area or keeping the cross sectional area the same and so on.

When, we are doing jacketing we need to be especially careful about the need to provide shear key bars and these shear key bars are bats like this which are provided to ensure that the newly added material that is the jacket at concrete becomes monolithic with the existing concrete.

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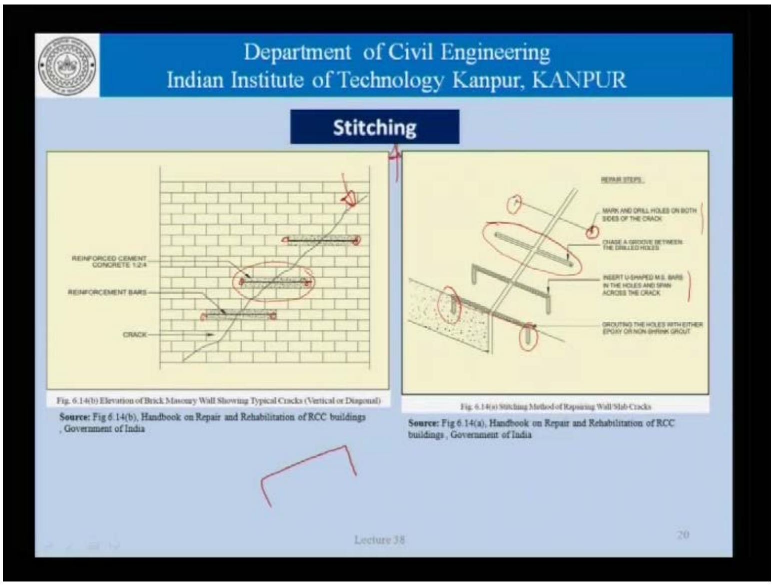

Now, let us talk about stitching suppose we have a crack like this in a structure one of the options available to repair this crack or prevent this crack from spreading either lengthening or increasing in width would be to stich it. Now, how do we stich it remark and drill holes and both sides of the crack that is here and here across the crack chase a grove between the drilled holes; so we make a chase or a grove around the across this crack like this insert a u shape m s bar in the wholes that expanse the crack and grout this on either side and fill the chase.

So, what is happened is that this crack now has these u shaped clips or m s bars which are spanning the crack now as the crack tries to move it has to cause failure of these clips before the crack and move, so effectively these m s roads or clips serve to erased any crack growth because is steel is not easy to feel it is not so easy to apply enough stress on the steel to fail is steel is a fairly high strength material as far as filling of these groves is concerned we could do it with mortar we could do it with concrete we could do it with the epoxy concrete whatever, we want.

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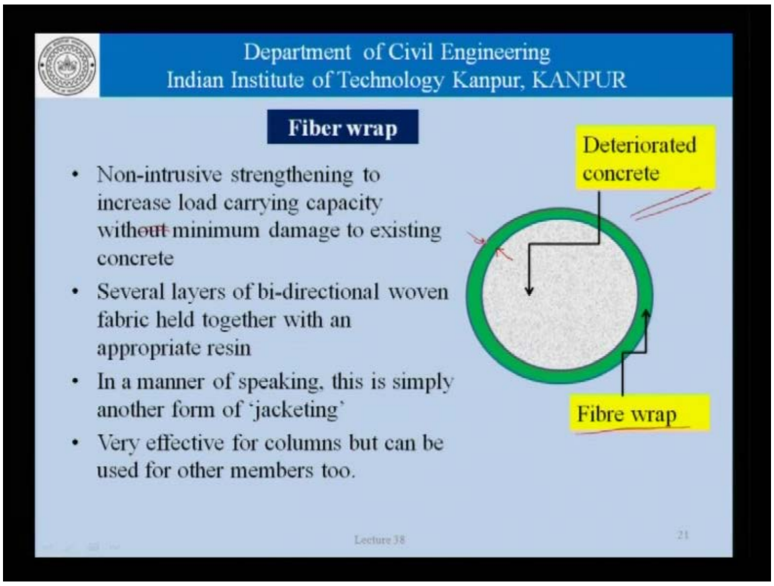

Now, let us talk about of fiber rap now fiber rap is basically another form of jacketing where the deteriorated concrete here is raped with fiber. So, it is non-intrusive strengthening to increase the load carrying capacity with minimum damage to existing concrete several layers of bidirectional woven material of woven fabric is held together within appropriate resin.

So, it is not a single material here or it is not a single layer of fiber it is several layers of bidirectional fibers woven and held together within appropriate resin and in a manner of speaking as I said it is just on the form of jacketing so instead of a reinforce concrete jacket we are placing a FRP jacket on a deteriorated concrete member its very effective as far as column is concerned.

But, it can also use for other members you will recall that we had some discussion on use of the FRP materials for repair and these strengthen in of concrete members or deteriorated concrete members when we were talking about the applications of fiber reinforced plastics in civil engineering construction.

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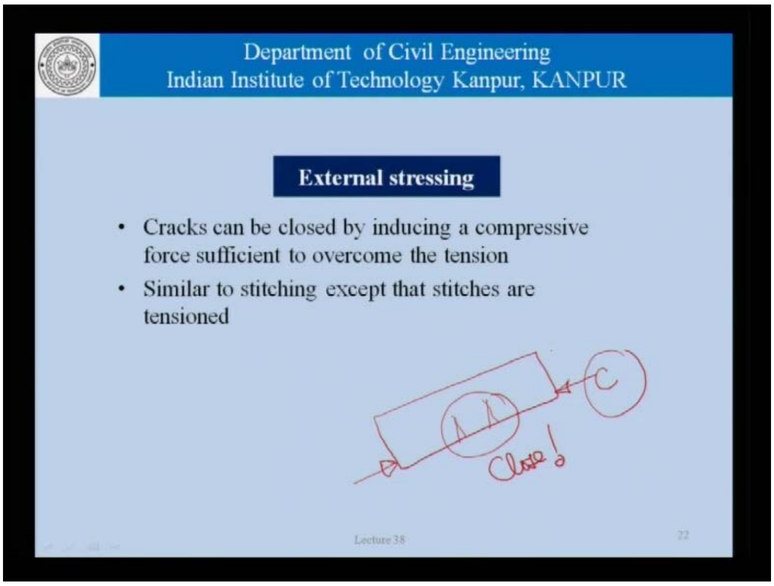

And now, coming to perhaps the last basic method for repair of concrete structures that we are talking about today, we come to external stressing. Now, what is external stressing? we must remember the cracks in concrete can be closed by inducing a compressive force which is sufficient to overcome the tension which is cause the cracks to basically, if we have a concrete member with cracks like this, if we apply a sufficient compression on the concrete as shown the chances are that we will be able to close these cracks.

And once we are able to close these cracks half a four battle as far as reducing the rates of deterioration has been one because these cracks are not only melodies from this structural point of view themselves. But, also provide easy ingress to deleterious materials such as carbon dioxide and air water may be chlorides into the concrete and that accelerates the deterioration process.

If we are able to close these cracks we are at least be able to slow down ingress of these materials into concrete, and how can we induce this kind of compression is what we get when we externally is stress or this what is called external pre stressing, out cable pre stressing. Now, without getting into the details of this output cable pre stressing because if talked about a little because we have talked about at earlier in this cores.

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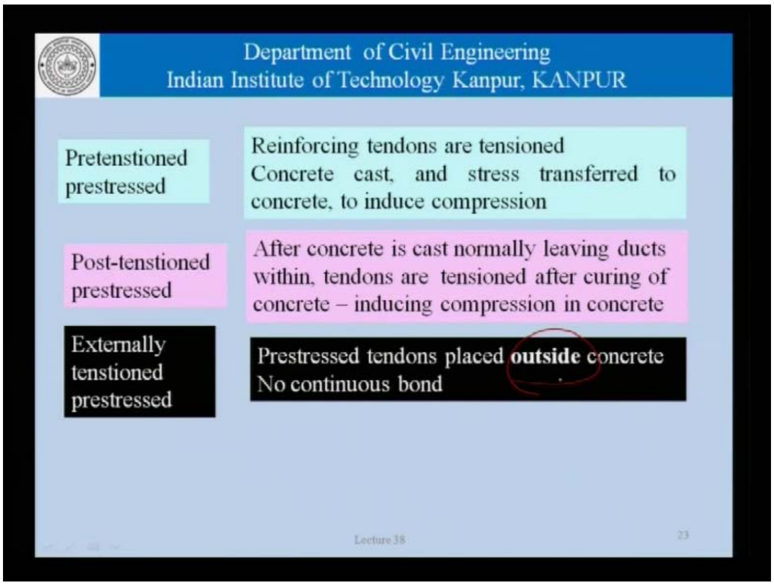

We will just recall pre tension pre stressing, where reinforcing tendons are tensioned in stage one concrete is caused and allowed to harden and then this stresses transferred to concrete to induce compression. As contrast to post tensioned pre stressed systems where concrete is cast normally leaving ducts with then tendons or placed within these ducts and tension and after curing of concrete, and once the tension is removed using appropriate anchors at the ends the concrete is placed and compression.

Externally tension pre stressed which is often interest to us now in these kind of externally tension pre stress systems which are often interest from point of view of repair in rehabilitation of structures is a system, where pre stressing tendons are placed outside the concrete and there is no continues bond. Once these tendons are outside of course, they have they merit that any problems in terms of maintenance can be actually monitored at the points of anchorages points of supports the tension in these tendons and so on.

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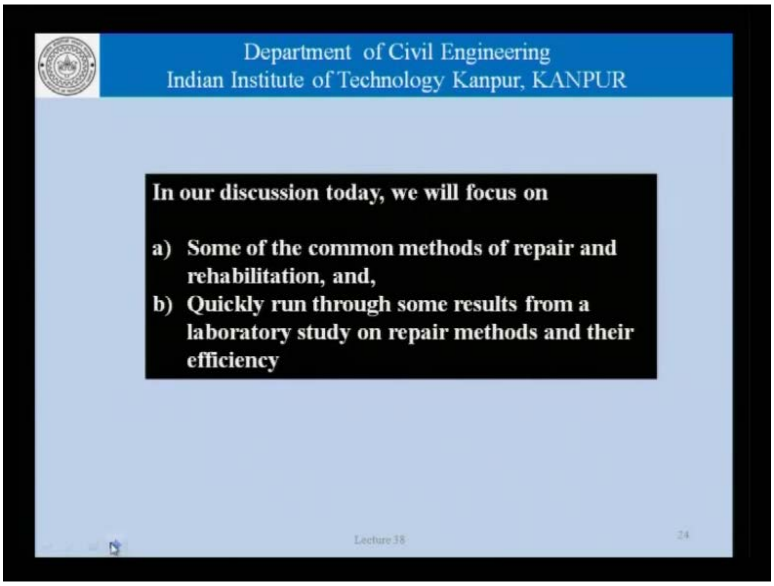

So, what we had said at the outside today that we will focus on some of the common methods of require in rehabilitation and that something which we have now completed having gone through a verity of methods which are used or can be used in concrete structures apart from simple method a part from simple methods such as impregnation of cracks application of coating pleasing and over lay and so on.

We will not gone into the details of these methods, we will not gone into the design of these methods and that something which is very very important. One can imagine that each of these methods has a structural implications, when we are talking about of fiber rap, when we are talking of RC jacketing, when we are talking of m s plate bonding get tend to alter this structural behavior of the members and therefore the structure.

So, any such method the use what kind what time what nature and so on must be decided by a structural engineer or in consultation with structural engineer, who should s s the implications of carrying out this maintenance action on the behavior of the structure.

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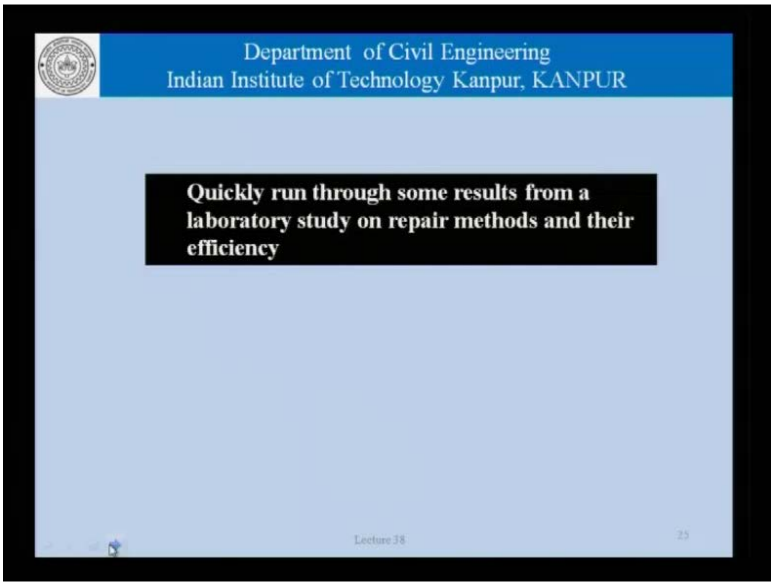

Now, having said all that lets quickly run through some results from laboratory studies on repair methods in their efficiency which will give you an idea as to what is the kind of work that needs to be carried out from an engineering point of view to better understand the different materials and their efficiency as far as repairing and reinforcement of concrete structures is concerned.

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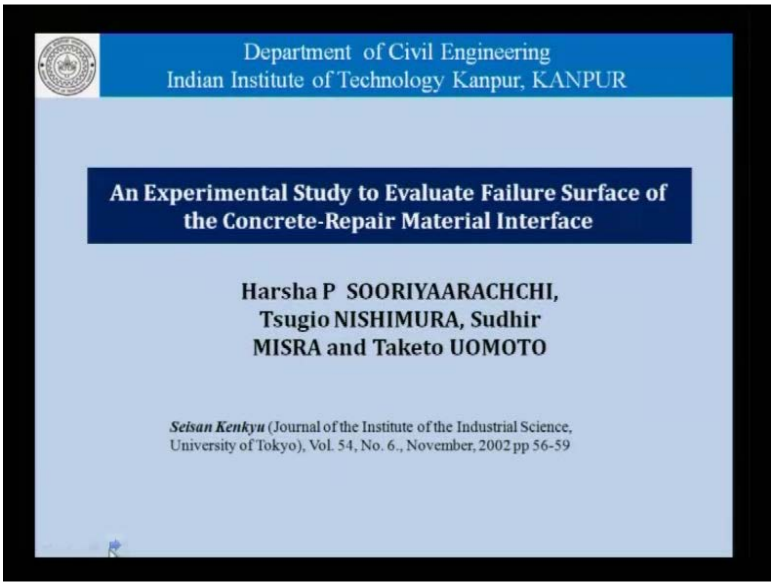

What we will talk about is two studies the first one is an experimental study to evaluate failures of surface of the concrete repair material interface and this study was published is sank think you which is a general of the institute of industrial science university of Tokyo, some time ago now if you look at are reinforced concrete beam with a repair as shown here.

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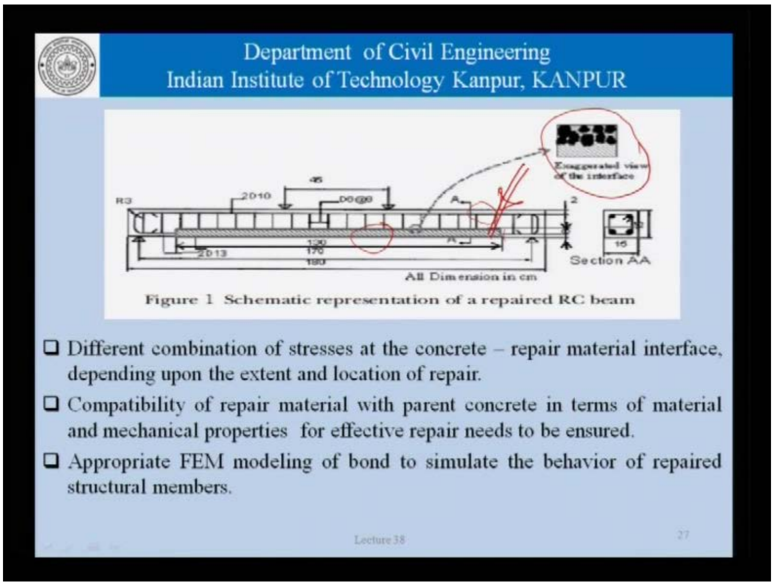

What we understand is that the behavior of this beam after it has in repair would change depending upon factors such as the location of the repair whether it is from the top face that the compression the void it shown or the bottom face which is the tension face the location of the repair, whether it is in mid span or closed to the supports the depth of repair and so on.

Apart from all that it will obviously depend on how they would concrete and the repaired surface bonds that is the interface of the old surface in the new surface so as a part of the study with discussion really in this in this research work was focused on an understanding of the interface and different combination of stress of concrete can be expected depending on the extent on location of repair in this portion here we would expect a certain state of stress if the repair was being at carried out at this point we would expect another point kind of stress and so on.

So, really need to understand how the interface behaves under the action of different stresses so compact ability of repair materials with the parent concrete in terms of material and mechanical properties for effective repair needs to be ensured and of course, once we have the basic properties with us determined experimentally we could use final element methods or any such program to simulate or analytically examine would behavior of the repaired concrete beam.

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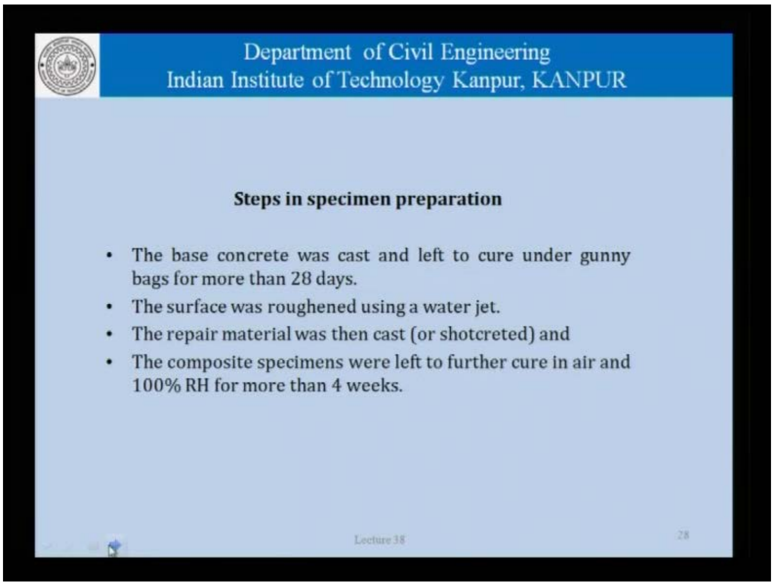

Now, as far as the steps in the specimen preparation is concerned there is base concrete which is cast and left to cure under gunny bags for 28 days the surfaces rough end using a water jet repair martials caused or shotcreted with the composite specimen being left further cure in layer for another 4 to 7 weeks.

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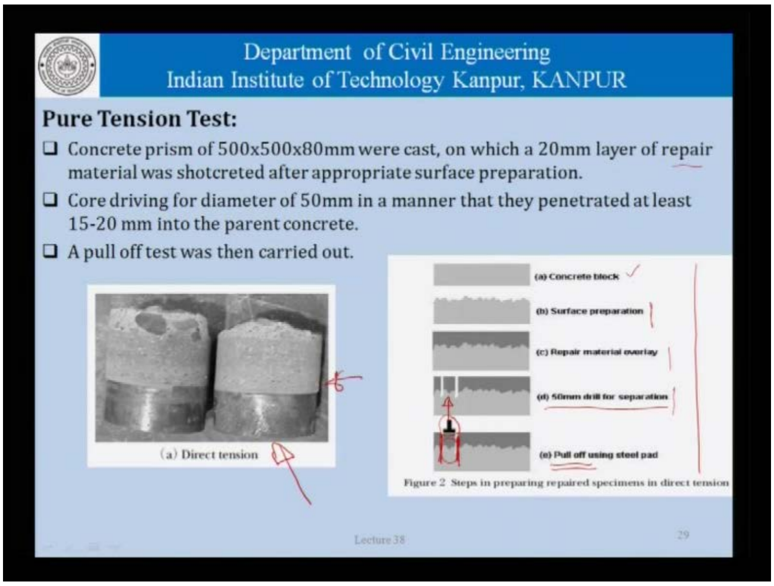

And in this case different test was carried out for the pore tension test this here outlines the basic process casting the concrete block of 500 by 500 by 80, on which a certain layer of 20 mm of repair material is to be placed, the surface preparation is carried out repair material is overlaid, and are drill is used to create a specimen which is shown here, and then we carry out a full of tests a full of tests really means fixing up fixture on the surface and trying to pull it of trying to ensure their by failure in this small neighborhood, whether the failure occurs within the repair material or at the interface or in the concrete. So, now in order to do that this depth that we make as far as the coring is concerned is fairly important and this here shows of fairly specimen.

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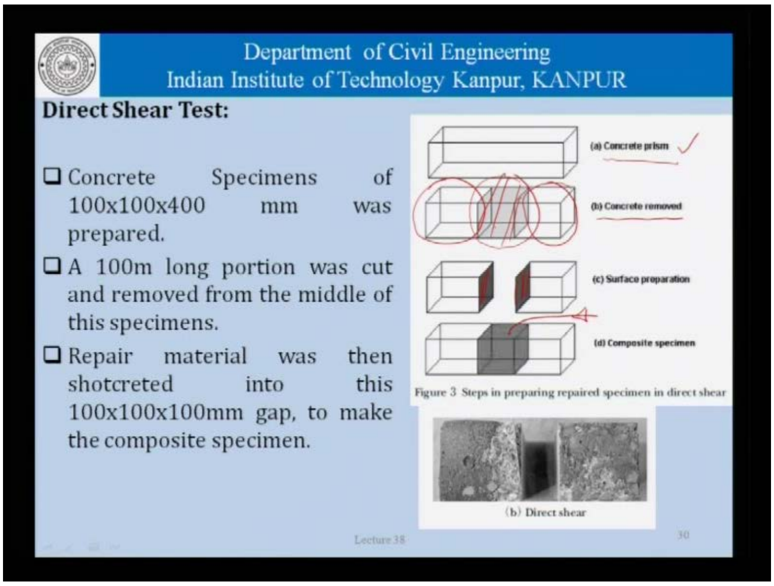

As far as direct shear test is concerned a concrete resin is cast the concretes from the middle is removed and we and we can we carryout in a appropriate excise, as far as the surface of the concrete is concerned cast the repair material here, and then finally, subject this specimen to shear

It should be remembered that this process of casting the concrete prism and then removing the concrete is not the same as casting this block of concrete and this block of concrete first and then placing this repair material within the reason for that is that in case we cast the concrete and then just place the reinforcing material, and then place the repair material within the block.

We would not be doing any surface preparation of the concrete the concrete at the surface would not be really the same as the concrete that we would get of the removing the concrete which is originally cast. So, these are some fine differences or points that one must remember when we are doing in a experimental work, we must try to simulate the actual or the field conditions to the extent is possible.

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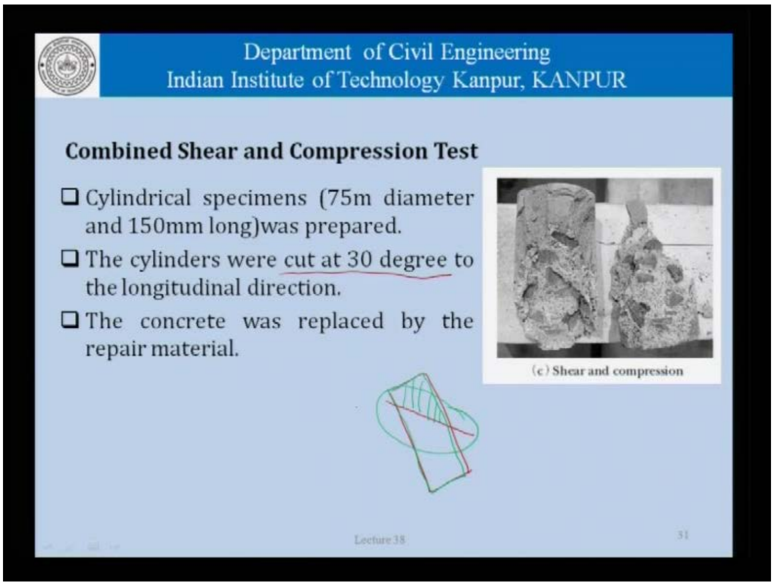

When it comes to combined shear and compression test a cylindrical specimen 75 millimeters in diameter in 150 mm long was prepared the cylinders were cut at a slope of 30 degrees to the longitudinal after whatever surface preparation has to be done the cylinders were recast using the repair material. So, we cast the cylinder here remove part of this cylinder and then fill this part with the repair material and test this composite cylinder and see what happens at the interface as far as failure is concerned.

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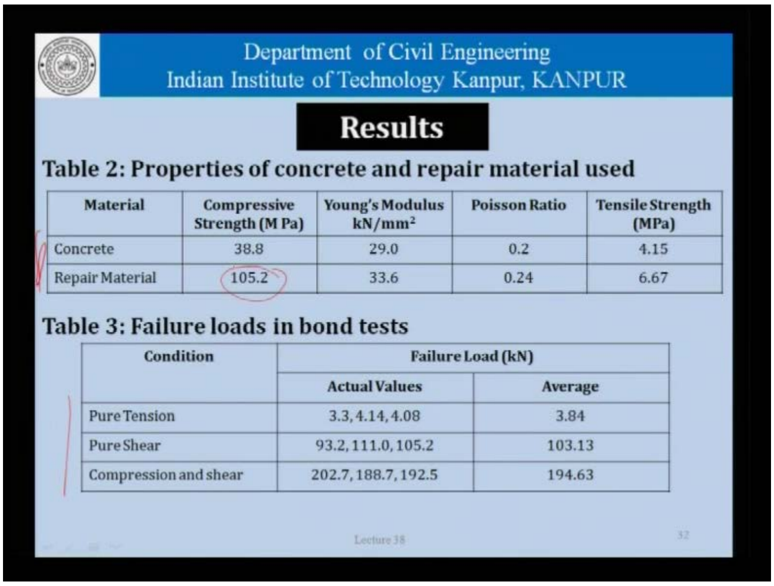

These are some of the results which have been obtained from the pure tension pure shear compression and shear values for different surface preparations the values are different and of course, these are the results for the compressive strength young's modulus poisson ratio and the consult strengths of the individual concrete and the repair material.

So, we can see that the compressive strength of the repair material per say is much higher than that of concrete. But young's modulus the poisson's ratio on the tensile strengths parameter not so much a part.

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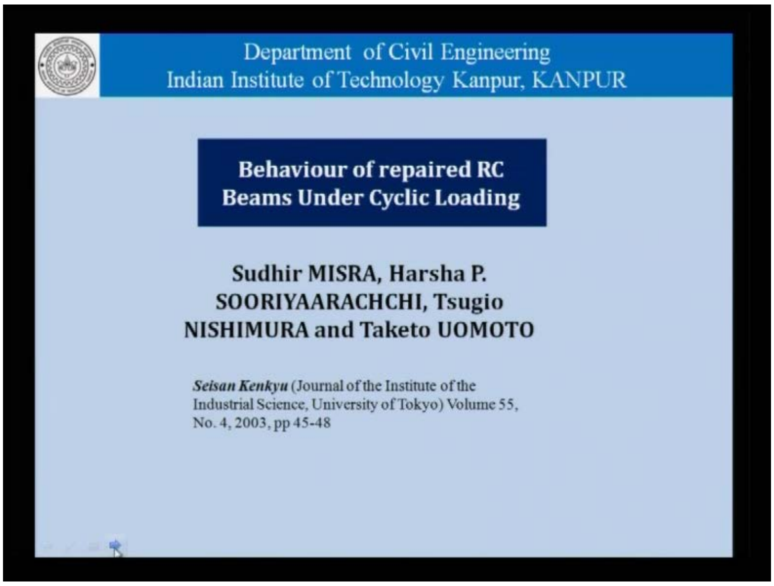

Now, coming to another experimental work which was an extension from the previous one where we studied the interface this one was behavior of repaired RCB in general cyclic loading this was also published in the Seisan Kenkyu.

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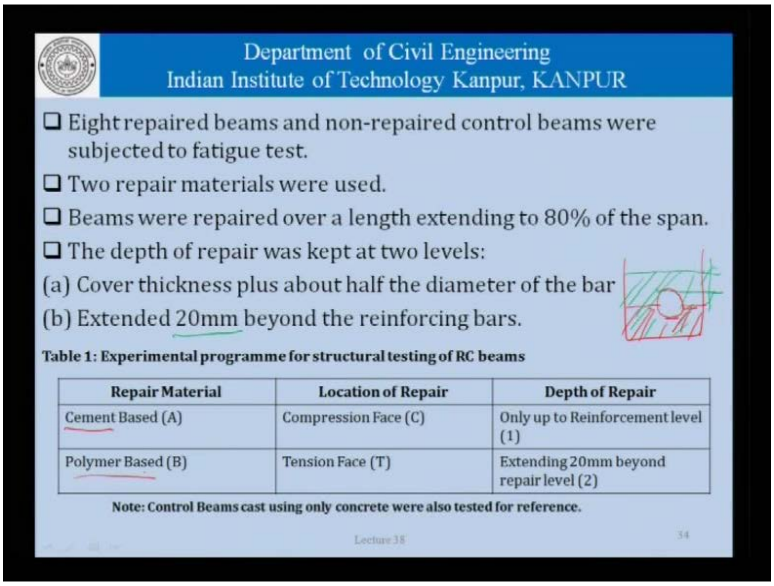

Here, eight beams were repaired and non-repaired control beams were there and they were tested to and they was subjected to fatigue that is repeated loading, we used to repair materials and the beams were repaired over length of 80 percent of the span the depth of repair was kept it two levels the cover thickness plus about half the diameter of the bar and in another case the repair thickness extended 20 millimeters beyond the reinforce in bars.

Now, this is similar to the kind of discussion that we had earlier about a good repair and bad repairs system in one case, if this is the bar the repair material was caused up to this point which is the cover depth plus half the diameter of the bar in another case the repair material extended all the wave beyond to the extent of 20 millimeters behind the bars, and as we said there were two materials used one was cement based and the other was polymer based.

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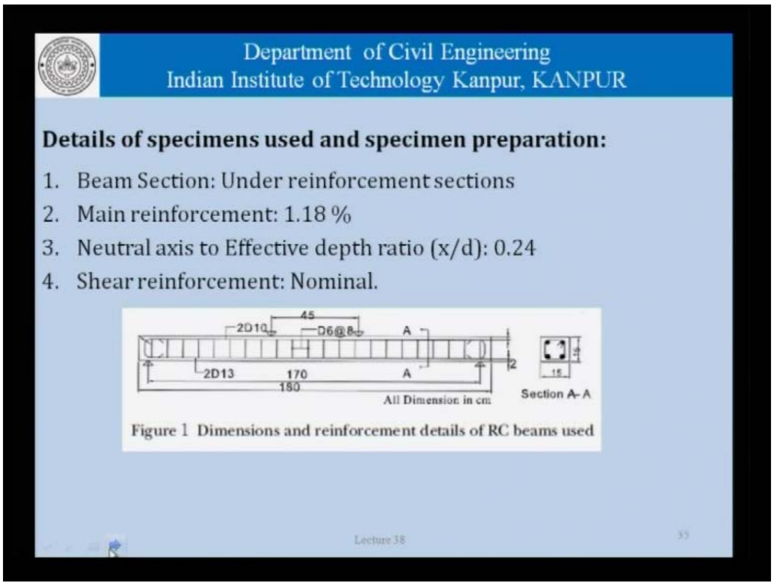

This is a typical sketch or the diagram which shows the dimensions and the reinforcement details of the reinforce concrete being used the beams were all under reinforced with the main reinforcement of about 1.18 percent, the x by d which is the neutral accesses to the effective depth of ratios about 0.24, nominal used nominal shear reinforcement being used these beams were finally tested for fatigue.

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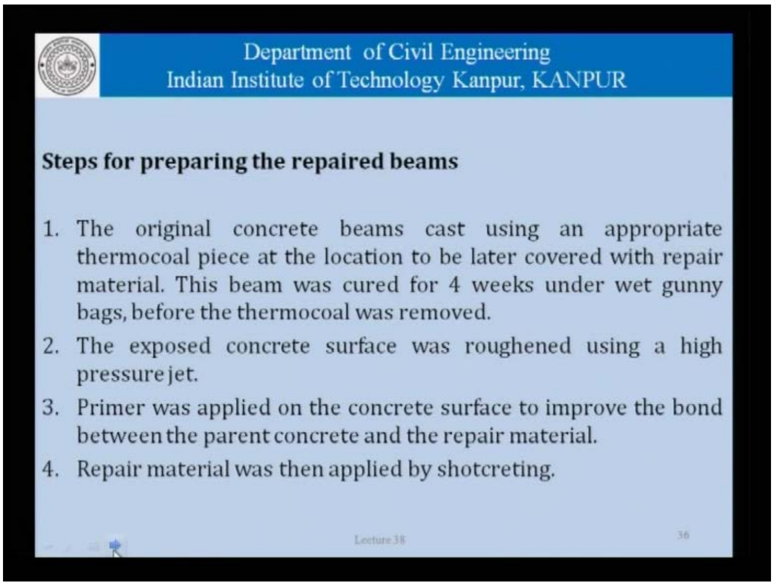

The original concrete beam were cast using the appropriate thermo coal piece at the location to be later covered with repair material is thermo coal peace was obviously removed and then there was obviously removed at the time of placing the repair material, the beam was cured for 4 weeks the exposed concrete surface was roughened using a high pressure water jet and primer was applied at the concrete surface to improve the bond between the parent concrete and the require material, and that is typically done even when we are carrying out the repair in reinforcement work in a site, and the repair material was applied using shotcrete. Whether, it was cement based or it was polymer based in this case the repair was done using shotcrete.

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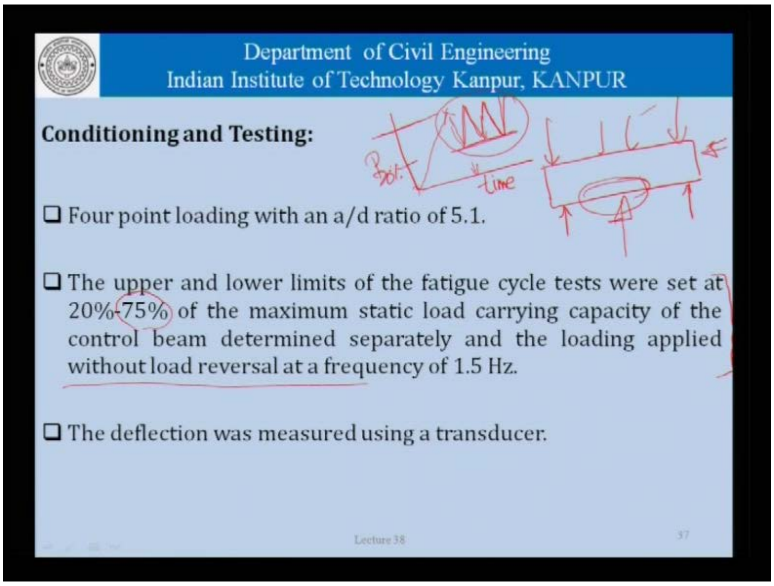

Four point loading test was carried out using an a by d ratio of 5.1. The upper in lower limits of fatigue cycle tests were set at 22 to 75 percent of the maximum static load and the frequency of load without load reversal is 1.5 hertz.

So, this really describes the fatigue test so we should remember that if we without getting into the details of fatigue tests were carried out how they should be carried out we just explained, the principle of fatigue test here when we are testing a reinforced concrete beam in static loading forget about fatigue loaded if its static loading, what we do is keep increasing in this load till the beam fails now in a fatigue load or repeated application of load we increase the load two a certain level and then cycle the weight is shown.

Now, this level which is the maximum load level has been kept at 75 percent of astatic load carrying capacity of the beam if this load level here is allowed to come to 0 and in fact the load could be a applied from the other side and that is what is going to happen in a true reversible test of a reinforce concrete beam, where the beam is subjected to loading from both sides and the top and the bottom loose there meaning in the sense that when the load is applied one side a certain side is in compression and the other side being intension and if the loads being applied from the other side the tension in compression faces change. In this case instead of being that without load reversal we continued the load to be only in a manner that this does not happen and this face continues to been tension all the time except that the extent of tension or the amount of tension changes as the load is being applied.

Now, this load level was kept at 20 percent of the static load carrying capacity so with this twenty percent and 75 percent serving as the bonds serving as the bounds of the load applied the test was carried out and the attempt was to the term in the number of cycles to failure the deflection as we were performing these test was also measured using normal transducers.

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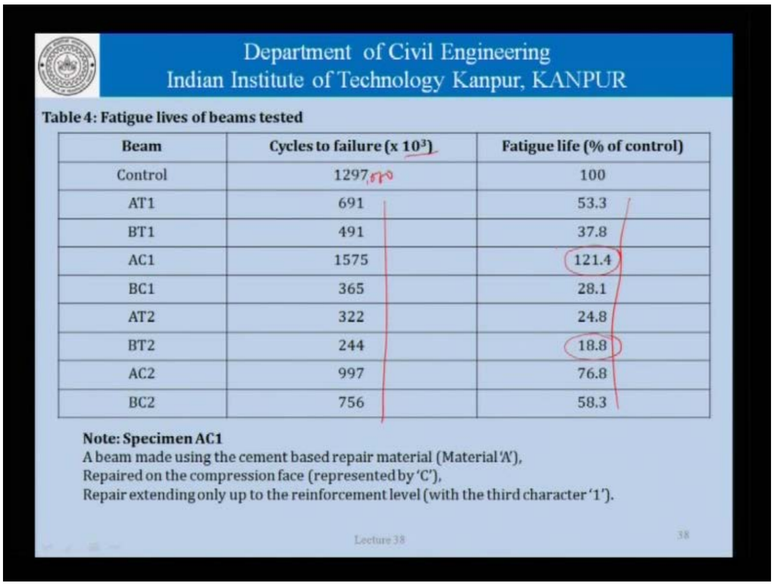

Beam	Cycles to failure (x 10^3)	Fatigue life (% of control)
Control	1297	100
AT1	691	53.3
BT1	491	37.8
AC1	1575	121.4
BC1	365	28.1
AT2	322	24.8
BT2	244	18.8
AC2	997	76.8
BC2	756	58.3

And, this here gives us the cycles to failure as far as the different beams are concerned, so instead of this is and 1000, so if add in other three zeros. Here, 1.27 a 1.3 million cycles for the control being this shows the number of cycles at which the beams failed and this gives us the percentage of the fatigue life of all these beams. Now, we will not get into the details of the discussion but, we must not that the values range from 18 percent or 18 and half percent to situations, where the beam has actually becomes stronger than the control beam. One must remember that these are after all only single beams that have been tested and that something which I wanted point out two flag to you, the importance of actually carrying out test which are more in number.

So, that we are more confident about the repeatability of posttests about the reliability of the results that we obtain. Except that in the case of fatigue testing to get even one point takes a long time, if we are testing at 1.5 hertz or 1 herts and the test goes on for million cycles I would leave it you to determined or estimate how much time has been spent when that beam and all that experimental operators has been occupied applying the load on the membrane, and in order carry out seven or eight tests to better understand the different materials that are being used if their efficiency and so on.

It is a very very time consuming excises takes not only time, but all kinds of a other resources, that is why it is important to understand to material behavior the interface behavior in terms of numerical models supported by experimental results, so that the basic design can be carried out based on the analytical results with the with only a few points on the periphery or bench marks being established using experimental results.

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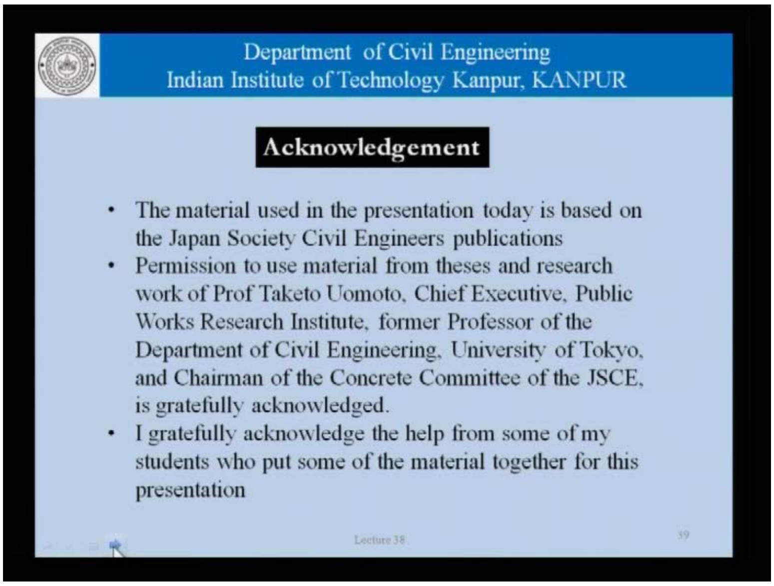

Before, we close the discussion today I would like to acknowledge the material used from the Japan society of civil engineers publications and the permeations from my adviser and group Professor Uomoto and also thanks some of the students, so we have been part of my classes to have together some of the material here, and as is usual before we finding close the discussion.

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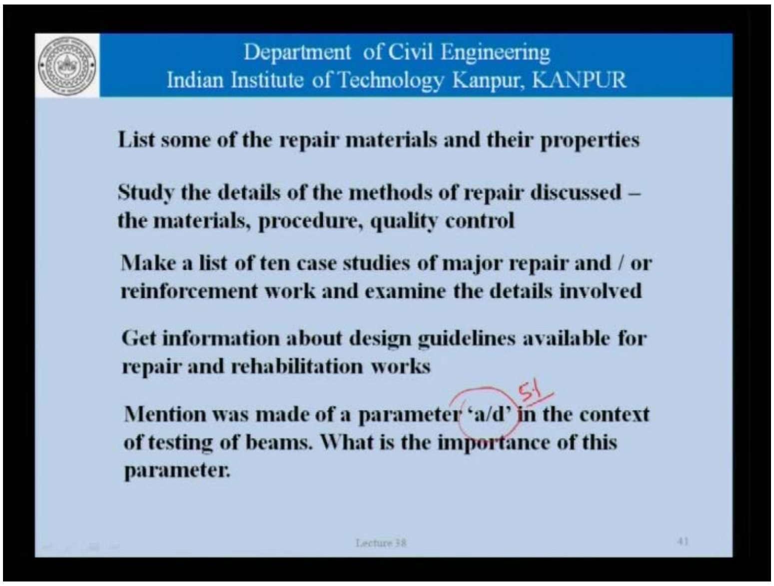

Let us take some things back home list some of the repair materials in the properties, how they properties effect the interfaces study the details of the methods of repair discussed materials, the procedure quality control, whether it is fiber rap, whether it is m s plate bonding, whether it is RC jacketing, and so on it could make a list of ten case studies of major repair on our reinforcement work which are reported in literature for different bridges for different buildings and examine the details there are case studies where crack injection and repair has been carried out on large damps.

We could get information about the design guidelines available for repair in rehabilitation work. And lastly mention was made of a parameter called a by d in the context of testing of beams, which were been tested for repeated loading. What is the importance of this parameter if you would remember the value that was used in the present study for a by d is given as 5.1. Now, what is the importance of a by d and y one should use numbers greater than 5 when we are testing reinforced concrete beams a something which you can in think about.

Thank you.