Fire Protection, Services and Maintenance Management of Building

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Lecture - 45
Diagnosis of building by visual survey

So, continuing from where we stopped last time that is looking into you know objectives of condition survey.

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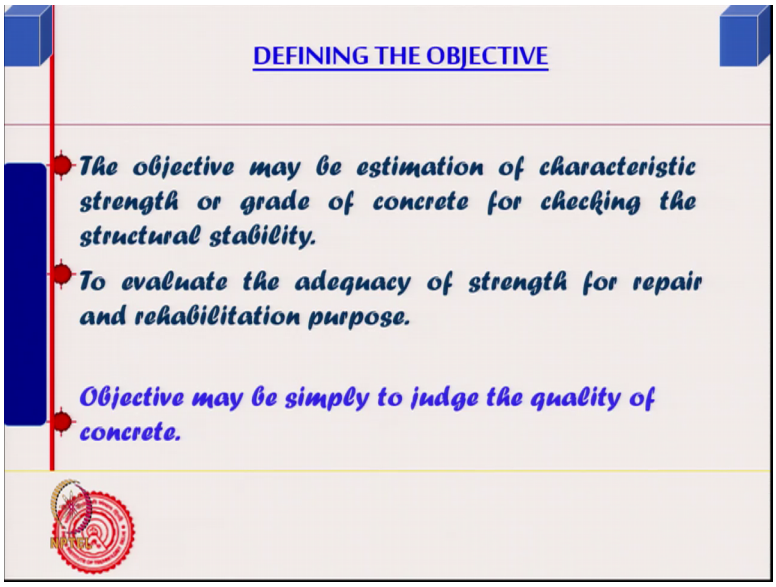

So, we said that objective maybe simply estimation of characteristic strength that is grade of concrete or for you know for the purpose of checking the structural stability. So, you might take those values, do a complete analysis of the building and see whether safe or not, will come to sometime later on. Then, sometime it could be simply find out the is it a strength is adequate. So, that I can undertake repair rehabilitation or retrofitting mode and the some other time for concrete, the objective may be simply does the quality of the concrete. So, no quantitative, but is it good concrete bad concrete poor concrete etcetera.

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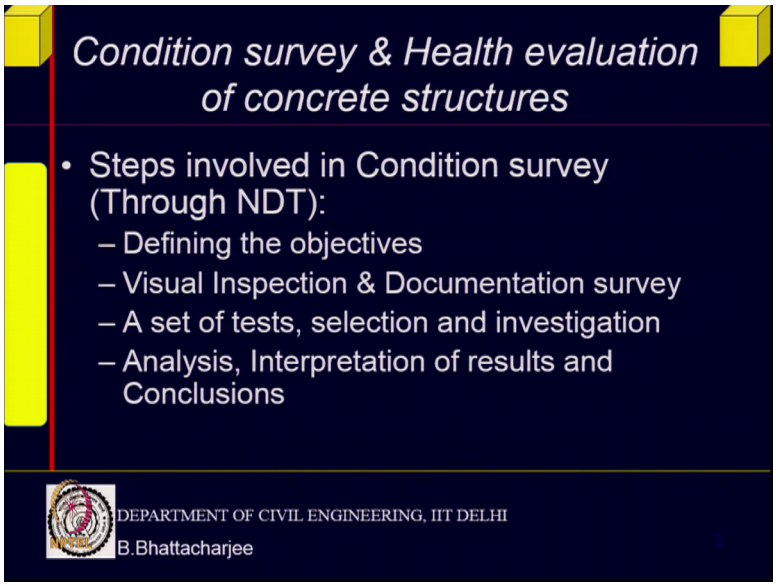

So, therefore, steps I said as mention in last class, I am just repeating them. First you must define the objective very clearly. Then, you must go for a visual inspection and document survey right and then set of test, go to select them and the complete the investigation. Once the investigation results are there, you do analysis, interpretation from the results. And obviously, you come to a conclusion that if you are diagnosing something you know according to your objective.

So, the conclusion should be either that cause of distress is so and so or it could be the strength is so much you know fck grade is so much, etcetera. When based on that you have your recommendations.

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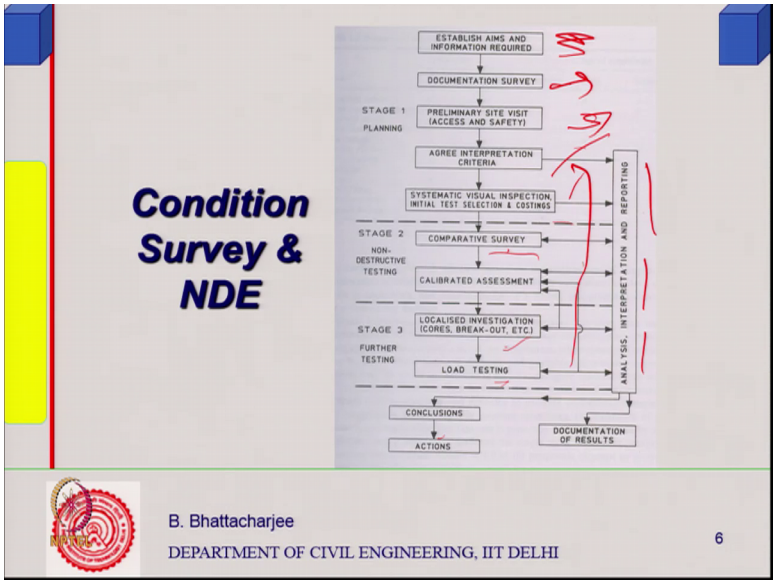

So, this is all you know in given in this flowchart sort of thing. So, if you see the top one, it will talk about first basically established aims and information required, establish aims and information required. So, that corresponds to the objective actually, then you do a document survey preliminary site visit or visual survey right.

And then, obviously, at this stage you may have to discuss with the client and all involved all organisation involved loaner client. Whoever it is, who are if there is a dispute all the parties and agree to the criteria of interpretation, what you will be using? Then you do a this systematic visual inspection followed by some survey non-destructive testing which should be comparative may be with something else you might compare and all calibrated assessment either way.

So, both can go on and all this you know would be followed by localised investigation if required because, first you have to some kind of investigation to identify local place where the damage is maximum may do or may not do depending upon the situation. So, if you it happens to be that the local area you want to demarcate where the damage is maximum, then do some more test. There might do code test, you know pull out test several of them and once you have done that, sometime the question comes that ok. Everything is apparently, but you might do a load test to see everything is all right or not.

This is also may be done after repair right, may be done both. I might do even after repair depending upon the situation. So, all that I am doing right from here that is interpretation criteria systematic in you know, this information should all going to

analysis interpretation. And finally, reporting the results once that has been done documentation of the results and also conclusions and whatever actions to be taken. So, that is the steps involved in visual survey, I mean condition assessment if you know in general.

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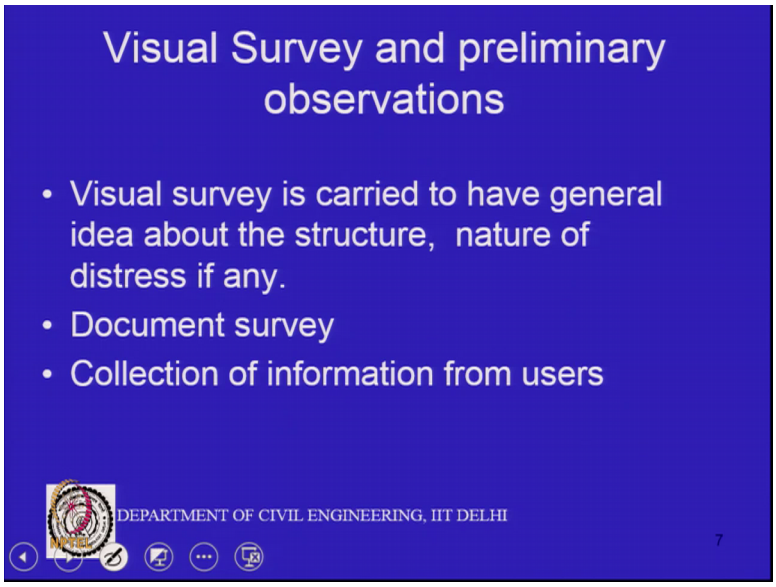

So, visual survey is carried out generally to have general idea about the structure nature of the distress. Document survey means drawings etcetera. Last class, as I mentioned and also sometime collect information from user you know which the user in that case could be simply the person whose basically a kind of a you know signatory personal or people who do the some maintenance and operation works maybe lift operators and so on.

So, you can find out some information from them as well and all this you know goes into your total making inferences related to why what exactly has happened and what has happened. So, what is the distress and when did it happened? Sometime, particularly time of the first visual first you know type of first detection of the defect that may come from people like you know security personnel or lift man or some similar people. So, that is what is the purpose of visual survey and document survey.

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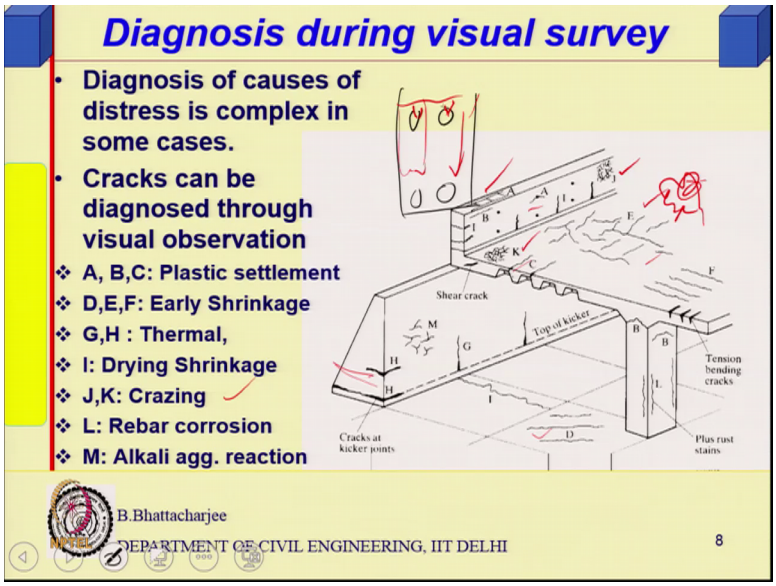

Then, I think I was talking about varieties of crack last class right and I just repeat them. There we looking at the cracks or distresses you should be able to or you know generally, what would be able to find? Why? What is the cause of it? For example, each type of distress manifest itself into a form of you know the different form of crack. For example, if it is a durable related crack, it will show up in a given manner. If it is a crack of the kind of let us say because of plastic shrinkage or drying shrinkage, they will manifest in different manner.

So, based on that we can identify, that is what we are saying. So, like here I said A B C, I explain that is A B C are plastic settlement cracks. This can occur sometime in yeah within first 40 hours you will see and if the bleeding is occurring now for example, you know like someone might come to you and tell you there is a crack over the slab you know like parking slab which are very long slab.

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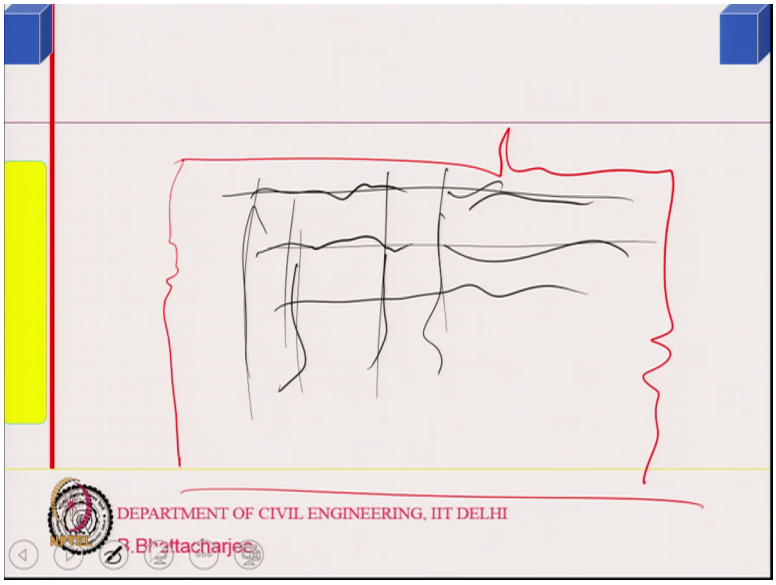

And the supposing this is your parking slab something like this and you know long parking slab and you might find cracks just quickly within 48 hours cracks, you might find cracks of this (Refer Time: 06:59) matching with the reinforcement.

So, you crack see cracks along this line along this line along this line. Now, this can happen again. For example, if a overdose of plasticizer might result in excessive bleeding. So, this reinforce crack almost along the line of reinforcement as shown in this diagram top here. So, you can see this portion this can be plastic settlement cracks. Now, this plastic settlement cracks will appear within first 48 hours also quickly because concrete would have subsided you know, as I said that here this is your reinforcement this is your concrete and enforcement here and there is a concrete right.

So, you know this should have concrete would have tried to settle like this sub. So, subsidence of the concrete, but this opposes the subsidence. Therefore, you see cracks of this kind right on top of it and they go along the bar. And therefore, something of this kind is plastic settlement cracks you might see them over aggregates might see them over aggregates. Some time, you will see them over haunches. So, but they will come quickly or similarly you have there is a column and you know slab junction.

So, some time you will see them very quickly. So, that is plastic settlement early shrinkage cracks are as I said D E F, they do come in thin sections right, because the curing is not proper or something of this kind. There of this form normally random orientation, but generally depending upon the situation. For example, the shrinkage

cracks that you know like shrinkage cracks can particularly if you have long thin wall. And long thin wall, let us say something like this, just I will have some example anyway.

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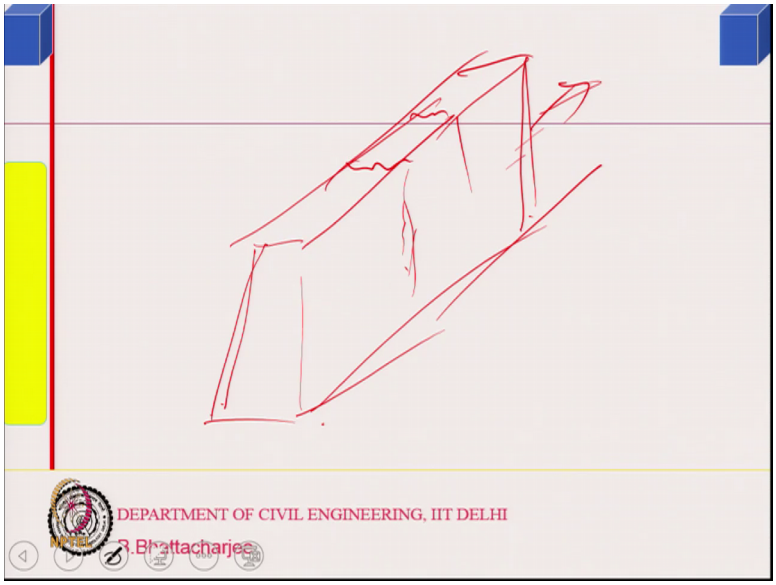

Supposing you have a long thin wall, you know thin wall of this form, thin wall of this form thin right, along thin wall and without construction join sometime you might see vertical cracks especially when summertime curing has not been done properly. So, you might see vertical cracks and this cracks may be simply through and through at equally nearly equal space because there is a construction joint; I mean no construction joint. So, this would like to shrink drying shrinkage and drying shrinkage is a function of volume to surface area. When this ratio is small, you know the shrinkage occurs more.

And this can result in because restraint shrinkage, this can result you know no construction joint long wall, no construction joint. There is a restraint in shrinkage and this can show a crack. So, these are in thin section cracks you might, thin section you might see even cracks of this form, but if it is somewhere over the slabs, you might see something of this form. Because, this has dried off from the top inside still moist relatively and drive you know relative differential shrinkage might have cause cracking. So, is the case here and F is you know D F is also E D is here, E is there F is somewhere there. So, you can see that kind of you know crack especially between the restraints.

So, one can you know from all information one can make good guess about this the diagnosed this one. For example, you can find out this the cracks who are what we call

they are dead they are not lying they not extend beyond a point. So, and would have occur all come within first 5 6 months of the life not beyond that because hardly shrinkage crack. They will come within not 48 hours not during the plastic to hardening state, but during the hardening process especially when curing is not proper summer months in Delhi or Northern India.

Then, thermal facts you find in those elements where volume is large compared to surface area. So, you have differential shrinkage differential contraction of the top thermal contraction inside still warm heat has not dissipated. So, these are the form of cracks which you might see in relatively thinner thin thick structures you might see vertical cracks or horizontal cracks depending upon the situation, then facing are actually fine mesh like you know mesh like cracks like J and K shown here J and K, the K. For example, this is crazing it is not a it is generally not a problem, but this also releases from shrinkage looks a bit ugly like here it is shown.

The looks pretty ugly a little bit ugly both on vertical and horizontal section, you might see very fine cracks not really harmful to that extent, but aesthetic is a problem if it is a long term affair after 6, you know couple of years you see cracks parallel to the reinforcement. This is plastic settlement is early. But, this is reinforcement corrosion will come somewhat later because, it requires first you know the concrete might be still might be passive to start with because concrete is alkaline no chloride or something, but in the long run, if it is get deep passivated and or some chloride comes from outside in that case corrosion would initiate.

So, there is a time for initiation followed by actual corrosion process when corrosion you know product will expand, rash product occupies more volume than the original steel volume and this will resultant in kind of cracking alkali. Aggregate reaction is also long term. You do not see them immediately, you see the much later and there generally you will find cracks around the aggregate themselves. But, important thing is that cracks are one thing in addition to this certain other symptoms you can you know find out and then you can diagnose.

For example, in case of re work corrosion it would be restraining at least moisture mark certain things you will see. So, you can put them to together to come out of the find out the cause similarly and it would not happen early that you understand. And similarly, if it

is alkali aggregate reaction, you know from your document survey or initial information from user you can find out whether new aggregate was used, what is the source of the aggregate was it tested.

And then, I can see when you look at the aggregate alkali aggregate reaction you know around aggregate around the aggregate, you will find white colour alkali silica gel. So, together with other things, you can actually looking at the crack you can diagnose right.

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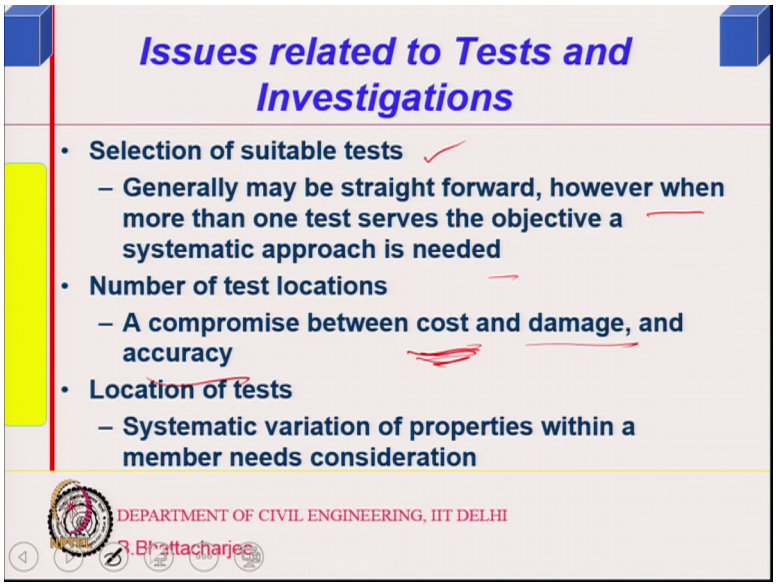

So, this is what is now coming to test selection of suitable test could be straight forward. However, you know first you if you look visual survey tells you that what is the likely cause of the problem first is objective. So, objective you know if it is not distress no problem, but if there are some form of distress, then you visually observe visual observation you know the cracks etcetera. And once you have done that then once you have done that visual observation, then you have identified or made some good gas about the cause of the distress. Then do the test specific to that particular one. So, the test the test that to be done would depend upon my objective.

If the objective is to determine fck, then I must do some amount of code test or some other test which is almost equally reliable. In fact, no other test can give you strength result or grade if you want to get the grade more reliably then core.

Student: (Refer Time: 15:04).

That is the direct test, indirectly there are things like cut and pull out test etcetera which comes quite close to them, but it is the core through which you can get the in situ strength through which you can get the in situ strength. So, if fck is a you know recommend, then you must do code test if fck is not a requirement just want to just the quality of concrete do not do not may not have to do code test.

But, you may have to do basically some other test. So, this is it will depend upon your objective first of all suitable test would depend upon objective. Now, if you have if you have seen the cracks and then you think that possibly re work corrosion is a problem, in that case you got to do the corrosion related test. But, we do not say any corrosion cracks. It is not own concrete why should you do corrosion test you should not be doing. So, this will depend upon what is a objective and then, say it may be straight forward, but may not be straight forward also.

Some cases you might have options to do more than one test right then you may have to do it(Refer Time: 16:12) you have to just like just you for example, same test might give I mean 2 3 or more test might give the same result, then which one do you choose? So, the issues that are involved are actually the cost of the test reliability of the test. So, cost reliability these are the issues actually. So, we get will see that actually how do you look into it. Number of test locations or number of test. Anyway, is based on cost damage and accuracy you know some cases, for example, you do code test you are at least partially damaging the concrete.

And cost of the test is important, but this cost will include a disruption cost also because direct test you know hiring in a agency and getting the core test done ok. So, you pay them something. Therefore, that is the direct cost, but there is an indirect cost because you the space cannot be used by people. So, you might be you know incurring some losses or at least functionally the building or space you know actual structure is you cannot use. So, this is related to you know this is the cost aspect direct as well as disruption cost and more the number of test you do accuracy will increase.

So, this is this is important we will see more of it actually later on systematic variation of concrete properties work concrete properties varies systematically from top to bottom of structures. Therefore, within member all also surface you know the strength will be property will be worst strength particularly will be worst near the surface. So, therefore,

we know the typical type of variation. So, you can you should select the location of test considering all this kind of aspect the other aspect is you should not supposing you are take a core do not take the core from the most vulnerable portion.

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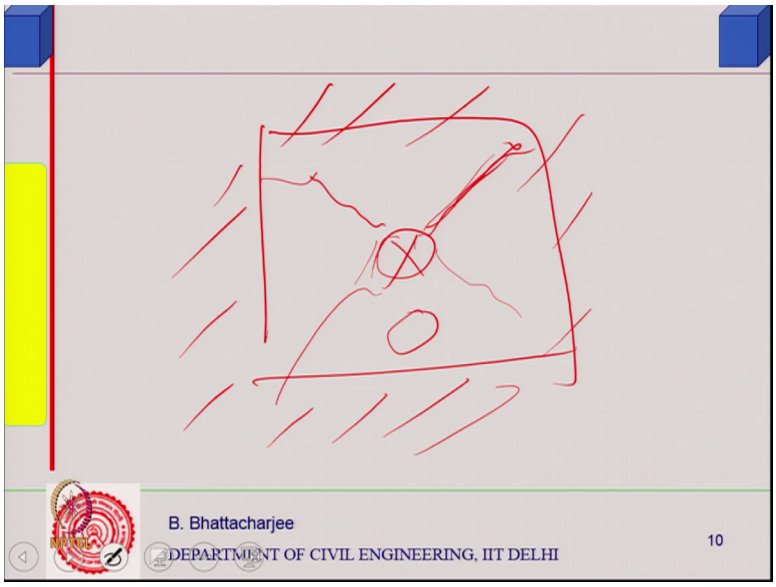

If you take for example, then a slab if you try to take it you know slab you know if you have a slab right, say it is a this is a 2-way slab, 2-way slab let us say it is a 2-way slab and you know the failure plane, I mean basically something like this crack would be something of this kind etcetera when it will be better to avoid a court location like this. So, that it does not lie on the expected you know yeah expected what is called in lines or you know crack lines or fracture lines or fail line failure planes and things like that.

So, this is one aspect. So, it possibly take from somewhere there, but then you have to see also damages were it is occurred. So, this is one aspect of it then other aspects of the locations are as I said the properties of concrete varies systematically from top to bottom.

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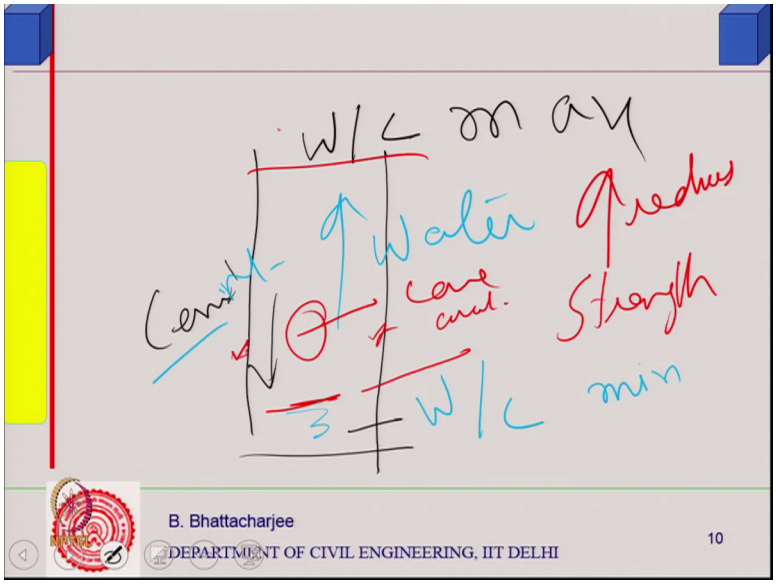

For some brief I have a section like this vertical section like this now water cement ratio will be maximum here maximum and cement because cement has a tendency to go down cement while water level tendency to go up water level tendency to go up water level tendency to go up cement will have a tendency to come down.

So, water cement ratio you know water is minimum cement is more here, it is minimum here. So, obviously, strength is likely to be more here strength is likely to be more here right strength is likely to be more strength higher strength is higher strength and it give reduces as it go up. So, strength will be likely to be list here. So, strength varies systematically from bottom to top similarly strength at the surface will be lower compared to core is better core concrete is better core concrete is better. So, while selecting location you cannot in a in columns you should not take all the locations all the you know testing location to be top of the column or bottom of the column.

Then you have biasing them. So, either randomized or depending upon what is your what is your requirement, I will come to that again maybe sometime more if I am talking of a case study. So, that is what it is.

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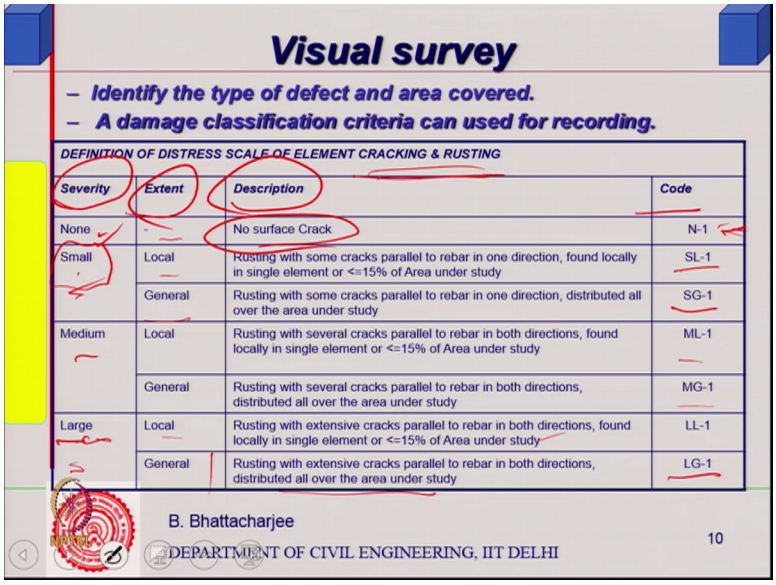

Now, we will come back to this location some of those some related to the formula related to number of test and the function of you know error will come to that, but let us look at a little bit more on the first part that is your visual survey right.

So, first identify purpose of this is to identify the type of defect and area covered, then you can actually start you know device a kind of damage classification criteria. This can be done and this is done for many structures for recording purpose you can do that something like this. For example, you can talk in terms of severity extent and description of what is happened and then you codify it. So, that recording becomes easier.

Student: Easier.

Recording becomes easier right. Now, as you can see if something like anticipated you know state matrix we talked about. So, here also we are doing something similar. Now, severity no surface cracks, then severity is none there is no question of extent and obviously, the code you will put it in your so, when you do a visual survey of a structure you can do it like this something like this.

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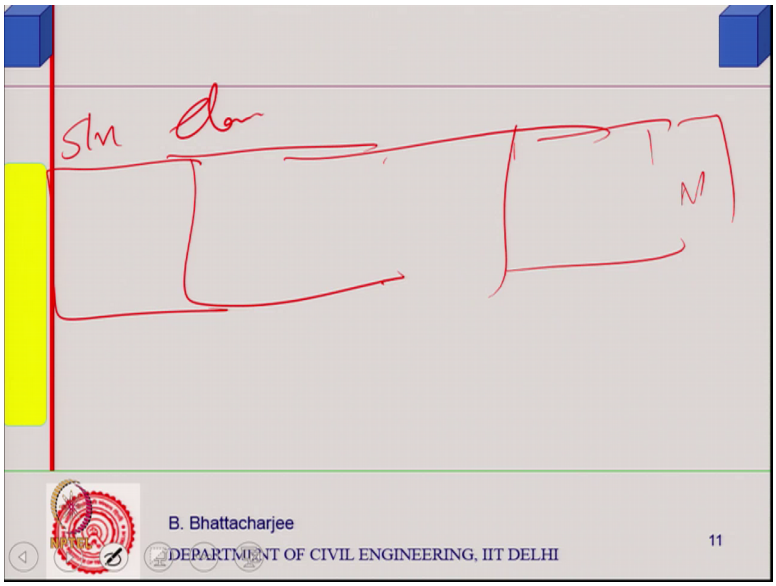

For example, you can write the you know in the tabular form right here, this column serial number, then element description, then you might even put a photograph if you like and then put the code. So, somewhere you can you know you can device your own sort of classification and put a code, maybe I have some examples. I will show you. So, if you see no surface crack in a given element, put the severity none small you know severity none and extent is not there and code is N 1 or simply put the code because this is already available to A.

So, element and the code you will be writing then if it is small you know scale cracking or rusting you have seen because this related to crack and rusting this can be there for all other type of distances as well. So, each table state matrix are there for every type of distress or every type of defect your likely to encounter even for let us say plastic shrinkage cracks. So, this is for cracking and rusting one can something for plastic shrinkage cracks right.

So, similarly if it is a small crack 1 or 2 localise in one local place rusting with some cracks parallel to the one direction found locally in single element less than 50 percent of the area under study in case of cracking rusting, I might call it local. So, severity small, this is local and this is 1.

If it is general over a larger space, then I can call it S G 1. So, this was N 1 and this is S G 1, then this is M L 1. 1 stands for rap cracking and rusting you can have others. For

example, you know plastic shrinkage you might give some other coding name similarly if you come to large one lot of lot of actually cracks. So, severity is large and it is local rusting with extensive crack parallel to river in both direction and in a single element less than 15 percent of the area.

So, this is local and if it is general then it will be rusting with eccentric extensive cracks parallel to river in both direction distributed all over the area under study that may be a slab or something like that. Then you put it at put it as large put it has large general one. So, one can you such kind of state matrix description etcetera and then codify them. So, the inspector who suppose to look at it he just puts for against each element puts the code which can be later on used for analysis right.

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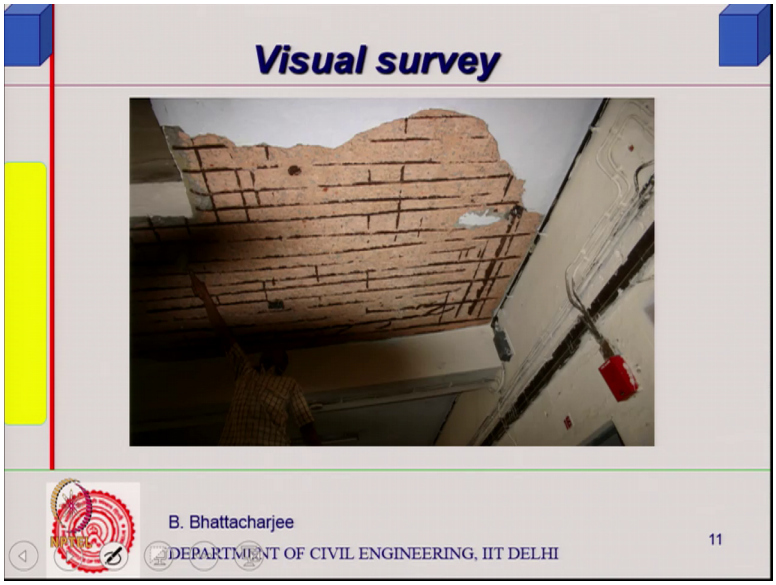

For example, you know this case rusting and you know cracking huge falling. So, this will fall into the category of this will fall into the category of actually the last 1 L G 1 large general all over the area 1 and this is this is very much there in you know, this will find in many places, actually many places you might find this.

So, one can do this kind of thing I have some possibly I have some case studies, I will look into it then look into some of the. So, one aspect that I am saying that you can use anticipated state matrix and these are available for one can generate them or available for most of the types of defects of distresses you are likely to find, then let us look at a little bit on intrinsic cracks.

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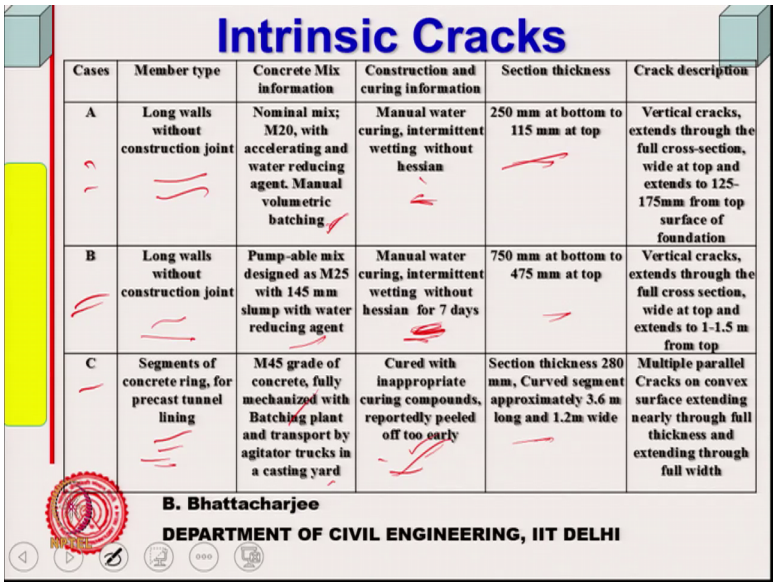

In case of intrinsic cracks, basically you can have cases like A B C say long walls without construction joints. Nominal mix in a using accelerators and water reducing agent manual volumetric batching etcetera section thickness is this much crack description vertical cracks extends through the full cross section wide you know. So, this is an example of an type a crack is a shrinkage type of crack, you know it is 125 etcetera long walls without construction joint vertical cracks.

So, this is kind of examples of intrinsic cracks. This is again shrinkage this is again a case of same intrinsic crack cases. There are 3 cases shown for intrinsic cracks cases A cases B and cases C. In the first case, you have these are 3 case studies, actually I will just show you a photograph for better understanding.

So, long walls without construction joint second one was long without long walls without construction joint this one also third one is segments of concrete ring is used for you know precast tunnel lining. So, underground tunnel lining precast tunnel lining the cracks. So, 3 cases we are discussing the concrete mix was this information was available documents, you know information from people or document it was M 20 grade this is a pumpable M 25 grade and this is a M 45 grade.

Now, this ware done by and large using accelerators and water reducing agent and manual and volumetric batching was used here you know largely. So, it is a almost non engineer construction manual and water curing intermittent not really proper curing as

well and the section thickness is 250 mm in the bottom and 150. So, it is a thin section as you can see and observation was vertical cracks section through the full cross section right, wide at top and extend 125 to 175 mm from top surface of the you know of the found foundation.

So, from the bottom almost up to the top about you know just about 120 to 175 mm from the bottom no cracks because thickness becomes more there then the second one manual water curing you see is manual you have both these cases, but this was a pumpable mix right and same again no construction joint and intermittent curing with hessian for 7 days. Here it was without hessian and then thickness is a 750 mm at the bottom and 475 mm at the top and again same vertical cracks through the cross full cross section wide at top and extend about 1 to 1.5 meter from the top.

Now, this case you see this is a good concrete M 45 grade of concrete fully mechanized construction with batching plant transported with agitator trucks and you know in the casting yard. So, curing is in the casting yard, but there was a little bit of problem with a curing cured with inappropriate curing compound curing compounds are one which are applied on the surface. So, when you apply them on the surface, they stop the evaporation of water. So, retains the original you know original water mix water and self-desiccation will occur.

But essentially, no evaporation losses will be there. Now, if you use do not use and then the peeled off, once the concrete dries of sufficiently, they peel peeled off from the surface. Now, if you are not used a proper kind of curing admission you know curing, curing compound at the surface and it peeled up early. Then, it would not stop the evaporation and this can happen if depending upon the type of curing compound you are using if it is wax based and it melts in at ambient temperature, then it will peeled off much earlier.

So, which can happen for example, in cold countries you might be use to you know you might use a particular type of curing compound which may not be suitable for exposed concrete in India or tropical countries.

So, therefore, this was the case here actually reported peeled off to early at there is a result curing was improper section thickness was 280 mm thin section again curved segments approximately 3.6 millimeter-long and 1.2 meter wide. So, multiple parallel

tracks on the convex surface will show it, you will see that extending nearly through full thickness and extending through the full width. So, this was the case these are 3 cases we are looking at early cracks some diagnosis right.

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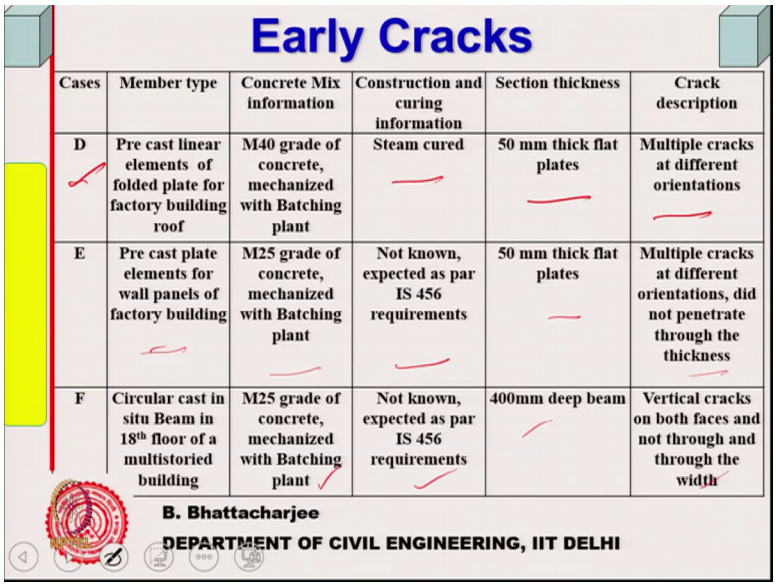

And, there are 3 more cases which will discuss one after another. This case D is of precast linear element of folded plate for factory building room and you see the 50 millimeter was the thickness of the plates these are steam cured, M 40 grade of concrete mechanised with batching plant multiple cracks at different orientations were seen ok. Actually, here the thickness was the major problem. Then these are precast plate elements for wall panels of factory building, this is a plate element, this is a linear element you know line element like beam or column sort of thing and this is M 25 grade concrete mechanised with batching plant, curing condition was not known.

So, to the expected that they will follow IS 455 and thickness again of the plate is very small. So, multiple cracks at different orientation of course, the crack did not penetrate deep into it then circular cast in situ beam 18 floor of a multi-storeyed building M 25 grade of concrete. And this was also mechanized curing conditions are not known 40 mm deep beam vertical cracks on both faces you know. So, not enough although width was not really enough. So, these are the kind of cases one can come across, right.